DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY,
CHHATRAPATI SAMBHAJINAGAR.

CIRCULAR NO.SU/PG/College./NEP/19/2024

It is hereby inform to all concerned that, the syllabi prepared by the Board of Studies/ Ad-hoc Boards & recommended by the Dean, Faculty of Science & Technology, **Academic Council at its meeting held on 08 April 2024 has accepted** the following Syllabi under the Faculty of Science & Technology **as per Norms of National Education Policy -2020** run at the Affiliated Colleges, Dr.Babasaheb Ambedkar Marathwada University as appended herewith.

Sr.No.	Courses	Semester
1.	M.Sc.Microbiology	IIIrd & IVth semester
2.	M.Sc.Botany	IIIrd & IVth semester
3.	M.Sc.Environmental Science	IIIrd & IVth semester
4.	M.Sc.Industrial Chemistry	IIIrd & IVth semester
5.	M.Sc.Biochemistry	IIIrd & IVth semester
6.	M.Sc.Chemistry Specialization Analytical Chemistry,Organic Chemistry, Inorganic Chemistry,Polymer Chemistry, Industrial Chemistry.	IIIrd & IVth semester
7.	MCA(Science)	IIIrd & IVth semester
8.	M.Sc (Forensic Science)	Ist to IVth semester
9.	M.Sc.Forensic Cyber	Ist to IVth semester

This is effective from the Academic Year 2024-25 and onwards.

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus,
Chhatrapati Sambhajinagar.
431 004.
REF.No.SU/2024/ 2446-54
Date:- 21.06.2024

* * * * * *

Deputy Registrar,
Academic Section

Copy forwarded with compliments to :-

1] **The Principal of all concerned Colleges,**
Dr. Babasaheb Ambedkar Marathwada University,

2] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

Copy to :-

1] **The Director, Board of Examinations & Evaluation,** Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

2] The Section Officer,[M.Sc.Unit] Examination Branch, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

3] The Programmer [Computer Unit-1] Examinations, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

4] The Programmer [Computer Unit-2] Examinations, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

5] The In-charge [E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

6] The Public Relation Officer, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

7] The Record Keeper, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, CHHATRAPTI SAMBHAJINAGAR

FACULTY OF SCIENCE & TECHNOLOGY

2 Years Programme in Science (M.Sc.)

As per National Education Policy-2020

(To be implemented from academic year 2024-25)

Course Structure and Curriculum

(Affiliated Colleges)

(Outcome based credit System)

SUBJECT: MICROBIOLOGY

INDEX

Preamble

National Education Policy (NEP) 2020 envisages Higher education plays an extremely important role in promoting human as well as societal wellbeing and in developing India. It expects that higher education must enable individual to study one or more specialized areas of interest at a deep level. The NEP also expects that higher education must prepare students for more meaningful and satisfying lives and work roles and enable economic independence. In view of this the new M.Sc. Microbiology program offered by the Dr. Babasaheb Ambedkar Marathwada University has been prepared as per the Credit Framework guidelines of National Education Policy (NEP) 2020.

This M.Sc. (Microbiology) Programme is of four semester, two years duration. These two years are divided into four semesters with the provision for exit at the end of first year. The evaluation of candidates will be done through various examinations under grade system during and at the end of each semester separately for theory and practical papers as per the credits offered for each course.

The M.Sc. (Microbiology) Programme is of total 88 credits, with 22 credits for each semester. Each semester is having three Discipline Specific Core (DSC) major courses along with their respective practical courses. Students have to choose one Discipline Specific Elective (DSE) along with its practical per semester from the list of Elective Course provided in pool/ basket. There will be a course related to skill or advanced technology in all these four semesters. Besides this there will be a course related to Research Methodology in First Semester. There will be separate credits for course related to On Job Training in second semester that can be completed by students in vacation period. Along with this there shall be course, Research Project RP-1 and RP-2 to be completed in III and IV Semester. The M.Sc. Microbiology programme shall include various learning activities viz., assignment, student seminar, group discussion, research paper reading and presentation. Students will be evaluated through Continuous Assessment (CA) and Semester End Examination (SEE). The Departmental Committee will develop the framework for research projects/dissertations and will be applicable to the course.

The M. Sc. Microbiology programme will enable students to develop deep level understanding to acquire ability to apply the process of science by formulating hypotheses and design experiments based on the scientific method. Student will be able to analyse and interpret results from a variety of microbiological experiments. They will be able to use quantitative reasoning by using mathematical calculations to solve problems in microbiology. Along with this the program aim to inculcate effective communication and collaboration skills with other disciplines.

More importantly it will result in developing understanding the relationship between science and society by recognizing and discussing logical, scientific and ethical issues in microbiology. The expected outcome of the program will be developing skilled persons with ability to pursue careers in the industry and applied research where microbial systems are increasingly used. The following pages of this document provide the structural framework, teaching scheme, evaluation schemes and the detailed contents of the syllabus.

ORDINANCE AND REGULATIONS:

- **Ordinance:**

➢ Any person with Bachelor's degree in Science from this University or the degree from any other statutory University recognized as equivalent shall be eligible for admission to the degree of Master of Science (M. Sc.) in Microbiology

➢ A student shall be held eligible for admission to the M. Sc. Microbiology Course provided she/he has passed the degree examination with Microbiology as a principal subject or with a Microbiology equivalent to all semesters.

- **Regulation:**

➢ As per NEP 2020 the M. Sc. degree will be awarded only after successful completion of written and practical university examinations.

➢ The entire course of M. Sc. shall be of 84 credits (2100 marks) for Theory + Practical. There shall be internal evaluation of 40% for theory papers.

➢ The theory examination shall be split up into four semesters.

➢ The commencement and conclusion of each semester shall be notified by the University from time to time.

➢ There shall be a University examination for theory at the end of each semester whereas there will be annual practical exam at the end of each year. The evaluation of examinations will be done by internal and external examiners.

➢ In each semester there shall be three theory major core papers and three practical based on core courses along with one elective theory and practical based on elective course

➢ There shall be mandatory on job training, Research methodology and Research project.

Infrastructure, instrumental library & other facilities required for M. Sc. Course in Microbiology (for 25 students intake capacity).

1. Two laboratories (for Part I and Part II) each measuring at least 1000 Sq. Ft. With sufficient no. of tables and Stools. Lab should be provided with basic Instruments such as autoclave, incubator, oven, pH meter, hot plate, cyclo mixers, water bath shakers, colorimeter, fridge, distillation plant etc.

2. A culture room with a laminar air flow measuring 300 Sq. Ft.

3. An Instrumentation Room with Double door, Air Conditioner for sophisticated Instruments measuring 500 Sq. Ft.

4. Two Lecture halls (for Part I and Part II) with Overhead projector facility and measuring 400 Sq. Ft. with tables and chairs.

5. A media preparation and a store room at least 400 Sq. Ft.

6. A computer Laboratory with 4 – 5 computers with printer and internet facility.

LIST OF BASIC INSTRUMENTS REQUIRED FOR M. Sc. PRACTICALS

1. Laminar Air Flow.
2. Compound Microscope
3. Autoclave
4. Incubators
5. Hot Air Oven.
6. BOD Incubators
7. pH Meter
8. Water Bath Incubator Shaker
9. Colorimeter
10. Spectrophotometer
11. Hot Plate.
12. Electrophoretic Apparatus
13. Orbital Incubator Shaker
14. High Speed Centrifuge - (10000 RPM)
15. Distillation Apparatus (Single & Double)
16. Refrigerators
17. Paper Chromatography Cabinet
18. Weighing Balances
19. Bacterial Filter Assembly
20. General Purpose Centrifuge.
21. Vortex Mixers
22. Magnetic Stirrers
23. UV Cabinet
24. TLC Apparatus
25. Water Bath Shakers
26. Rotary Shaker
27. Columns for Chromatography
28. Fraction Collector
29. Distillation Apparatus

OTHER REQUIREMENTS

The department should have required chemicals, dehydrated media, stains, acids, Solvents, fine chemicals, enzymes, anti-sera immunodiagnostic kits, and Specific microbial cultures with known genetic markers and glass-wares to implement and conduct the prescribed syllabus.

LIBRARY FACILITY

The library should have ample no of prescribed text books, reference books recommended in the prescribed syllabus and the library should also subscribe National and International and Scientific Magazines.

INSTRUCTIONS

1. M.Sc. Course of Microbiology is divided into four semesters.
2. Each Semester will have core theory, core practical papers and elective theory and practical.
3. The department should complete a minimum of 80% practical of each paper.
4. Theory of one credit paper will have 1 lecture each of 1 hr and practical will have 2 hrs duration per week
5. There should be regular seminars and tutorials on immerging topics of subject concerned for students.

Vision

To provide quality education and training in Microbiology, fostering innovation, excellence, and cutting-edge research in the field, while producing skilled professionals who contribute to advancements in healthcare and environmental sustainability. Make them enable to contribute to science in general and nation economy in particular.

Mission

- To impart knowledge and microbiology skill for making student ready for future,
- To develop the attitude of analytical thinking in students through various activities throughout the programme, such as seminar, group discussion, blended learning, research projects and practical.
- To provide a comprehensive and rigorous education in Microbiology, equipping students with a deep understanding of microbial life, its interactions, and applications. Through state-of-the-art research, interdisciplinary collaborations, and experiential learning, to cultivate a community of scientists capable of addressing global challenges, promoting scientific discovery, and improving the quality of life through microbiological advancements.
- To implement revised National Education Policy, and make systematic arrangements for learning and create learner friendly environment so that students will develop knowledge, skills and confidence to work for various organizations and for self-employment in this competitive world.

Program Outcomes (PO)

On completion of program students will be able to

1. Acquire ability to apply the process of science by formulating hypotheses and design experiments based on the scientific method.
2. Analyse and interpret results from a variety of microbiological experiments
3. Use quantitative reasoning by using mathematical calculations to solve problems in microbiology.
4. Communicate and collaborate with other disciplines effectively
5. Identify credible scientific sources to interpret and evaluate the evidences
6. Understand the relationship between science and society by recognizing and discussing logical, scientific and ethical issues in microbiology.
7. Exhibit ability to pursue careers in the industry and applied research where microbial systems are increasingly employed.

Program specific outcomes (PSO)

On completion of program students will be specifically able to

1. Prepare and view specimens for examination using light microscopy
2. Apply techniques to isolate, identify and maintain microorganisms.
3. Enumerate microorganisms from various samples
4. Independently handle microbiological equipment and methods.
5. Exercise Safe microbiology practices.
6. Plan, design, execute experiments and interpret, document and present findings.

Class: M.Sc. First Year Semester: First Semester Subject: MICROBIOLOGY

COURSE CODE	COURSE TITLE	Teaching Scheme (Hrs./ week)	Credits Assigned	NATURE OF COURSE	MODE OF INSTRUCTION
I SEMESTER					
MIC-UD/MJ/500 T	General Microbiology and Microbial Diversity	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/501 T	Bioenergetics and Enzymology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/502 T	Techniques in Microbiology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/503 T	Basic Biostatistics	**4**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/500 P	Lab Course Based On MIC-UD/MJ/500 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/MJ/501 P	Lab Course Based On MIC-UD/MJ/501 T	**2**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/MJ/502 P	Lab Course Based On MIC-UD/MJ/502 T	**2**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/DSE/504 A/B/C	A-Microbial Taxonomy	**2**	**2**	DSE/ELECTIVE	Theory
Any amongst the list	B-Biological Database Systems			DSE/ELECTIVE	Theory
	A Or B	**4**	**2**		Practical
	C-any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }	**4**	**4**	DSE/ELECTIVE	(IN CASE OF MOOC / NPTEL COURSE, RULES OF COURSE CONDUCTING AGENCY WILL BE BINDING)
MIC-UD/RM/505	Research Methodology	**4**	**4**	RESEARCH METHODS/ Mandatory	Theory

Class: M.Sc. First Year: MICROBIOLOGY
First Semester: (Choose any one from the pool of courses) - ***DSC-Based on specialisation**
1. **MIC-UD/MJ/500 T :** General Microbiology and Microbial Diversity

MIC-UD/MJ/500 P : General Microbiology and Microbial Diversity (Practical)
MIC-UD/MJ/501 T : Bioenergetics and Enzymology
MIC-UD/MJ/501 P: Bioenergetics and Enzymology (Practical)
MIC-UD/MJ/502 T: Microbial techniques
MIC-UD/MJ/501 P: Microbial techniques (Practical)
MIC-UD/MJ/503T: Basic Biostatistics
2. **MIC-UD/DSE/504** (T/P): (Choose any one from Pool /Basket)

A: Microbial Taxonomy (Theory 3 Cr. + Practical 1 Cr.)
B: Biological Databases System (Theory 3 Cr. + Practical 1 Cr.)
C: Any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits {with biology basis}
3. **MIC-UD/RM/505** Research Methodology in Microbiology (4 Cr.)

Class: M.Sc. First Year Semester: Second Semester Subject: MICROBIOLOGY

COURSE CODE	COURSE TITLE	Teaching Scheme (Hrs./ week)	Credits Assigned	NATURE OF COURSE	MODE OF INSTRUCTION
II SEMESTER					
MIC-UD/MJ/550 T	Virology, Bacteriology, Parasitology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/551 T	Microbial Physiology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/552 T	Food Microbiology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/553 T	Applied and Industrial Microbiology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/550 P	Lab Course Based On MIC-UD/MJ/550 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/MJ/551 P	Lab Course Based On MIC-UD/MJ/551 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/MJ/552 P	Lab Course Based On MIC-UD/MJ/552 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/DSE/554 A/B/C	Pharmaceutical Microbiology	**2**	**2**	DSE/ELECTIVE	Theory
	Bioethics, Biosafety and IPR				
	A or B	**4**	**2**	DSE/ELECTIVE	Practical
	any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }	**4**	**4**	DSE/ELECTIVE	(IN CASE OF MOOC / NPTEL COURSE, RULES OF COURSE CONDUCTING AGENCY WILL BE BINDING)
MIC-UD/OJT/555	On The Job Training/ Field Project	**4**	**4**	Core/Mandatory (CHOICE BASED)	INDUSTRIAL TRAINIG/FIELD WORK/ Practical/Lab work

Class: M.Sc. First Year: MICROBIOLOGY
Second Semester:
1. **MIC-UD/MJ/550 T**: Bacteriology, Virology, Parasitology

MIC-UD/MJ/550 P: Bacteriology, Virology, Parasitology (Practical)
MIC-UD/MJ/551 T: Microbial Physiology
MIC-UD/MJ/551 P: Microbial Physiology (Practical)
MIC-UD/MJ/552 T: Food Microbiology
MIC-UD/MJ/552 P: Food Microbiology (Practical)
MIC-UD/MJ/553T: Applied and Industrial Microbiology
2. **MIC-UD/DSE/504** (T/P): (Choose any one from Pool /Basket)

A: Pharmaceutical Microbiology/ Bioethics, Bio safety and IPR (Theory 3 Cr. + Practical 1 Cr.)
B: Pharmaceutical Microbiology/ Bioethics, Bio safety and IPR (Theory 3 Cr. + Practical 1 Cr.)
C: Any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits {with biology basis}
3. **MIC-UD/OJT/555** OJT/FP-1: (4 Cr.)

Class: M.Sc. Second Year Semester: Third Semester Subject: MICROBIOLOGY

COURSE CODE	COURSE TITLE	Teaching Scheme (Hrs./ week)	Credits Assigned	NATURE OF COURSE	MODE OF INSTRUCTION
III SEMESTER					
MIC-UD/MJ/600 T	Microbial Genetics	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/601 T	Molecular Immunology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/602 T	Bioprocess Engineering	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/603 T	Environmental Microbial Technology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/600 P	Lab Course Based On MIC-UD/MJ/600 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/MJ/601 P	Lab Course Based On MIC-UD/MJ/601 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/MJ/602 P	Lab Course Based On MIC-UD/MJ/602 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/DSE/604 A/B/C **Any amongst the list**	A-Bioentrepreneurship and IPR	**2**	**2**	DSE/ELECTIVE	Theory
	B-Agricultural Microbiology	**2**	**2**	DSE/ELECTIVE	Theory
	A Or B	**4**	**2**	DSE/ELECTIVE	Practical
	C-any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }	**4**	**4**	DSE/ELECTIVE	(IN CASE OF MOOC / NPTEL COURSE, RULES OF COURSE CONDUCTING AGENCY WILL BE BINDING)
MIC-UD/RM/605	Research Project	**8**	**4**	RESEARCH METHODS/ Mandatory	Practical

Class: M.Sc. Second Year: MICROBIOLOGY
Third Semester:

1. **MIC-UD/MJ/600 T :** Microbial Genetics
   MIC-UD/MJ/600 P: Microbial Genetics Practical)
   MIC-UD/MJ/601 T: Molecular Immunology
   MIC-UD/MJ/601 P: Molecular Immunology (Practical)
   MIC-UD/MJ/602 T: Bioprocess Engineering
   MIC-UD/MJ/601 P: Bioprocess Engineering (Practical)
   MIC-UD/MJ/603T: Environmental Microbial Technology

2. **MIC-UD/DSE/604** (T/P): (Choose any one from Pool /Basket)
   A: Bioentrepreneurship and IPR (Theory 2 Cr. + Practical 2 Cr.)
   B: Agricultural Microbiology (Theory 2 Cr. + Practical 2 Cr.)
   C: Any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits {withbiology basis}

3. **MIC-UD/RP/605** Research Project (4 Cr.)

Class: M.Sc. Second Year Semester: Fourth Semester Subject: MICROBIOLOGY

COURSE CODE	COURSE TITLE	Teaching Scheme (Hrs./ week)	Credits Assigned	NATURE OF COURSE	MODE OF INSTRUCTION
IV SEMESTER					
MIC-UD/MJ/650 T	Recombinant DNA Technology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/651 T	Fermentation Technology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/652 T	Enzyme Technology	**2**	**2**	Core/Mandatory	Theory
MIC-UD/MJ/650 P	Lab Course Based On MIC-UD/MJ/650 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/MJ/651 P	Lab Course Based On MIC-UD/MJ/651 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/MJ/652 P	Lab Course Based On MIC-UD/MJ/652 T	**4**	**2**	Core/Mandatory	Practical/Lab work
MIC-UD/DSE/654 A/B/C **Any amongst the list**	Bioinformatics	**2**	**2**	DSE/ELECTIVE	Theory
	Bionanotechnology	**2**	**2**	DSE/ELECTIVE	Theory
	A or B	**4**	**2**	DSE/ELECTIVE	Practical
	any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }	**4**	**4**	DSE/ELECTIVE	(IN CASE OF MOOC / NPTEL COURSE, RULES OF COURSE CONDUCTING AGENCY WILL BE BINDING)
MIC-UD/RP/655	ResearchProject	**12**	**6**	Core/Mandatory (CHOICE BASED)	Practical/Labwork

Class: M.Sc. Second Year: ICROBIOLOGYFourth Semester:

1. **MIC-UD/MJ/650 T**: Recombinant DNA Technology
   MIC-UD/MJ/650 P: Recombinant DNA Technology (Practical)
   MIC-UD/MJ/651 T: Fermentation Technology
   MIC-UD/MJ/651 P: Fermentation Technology (Practical)
   MIC-UD/MJ/652 T: Enzyme Technology
   MIC-UD/MJ/652 P: Enzyme Technology (Practical)

2. **MIC-UD/DSE/604** (T/P): (Choose any one from Pool /Basket)
   A: Bioinformatics (Theory 2 Cr. + Practical 2 Cr.)
   B: Bionanotechnology (Theory 2 Cr. + Practical 2 Cr.)
   C: Any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits {with biology basis}

3. **MIC-UD/RP/655** OJT/FP-1: (6 Cr.)

GENERAL MICROBIOLOGY AND DIVERSITY

MIC-UD/MJ/500 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To understand the microbial biodiversity
- To acquaint with ecology
- To understand the morphology, physiology, and significance of extremophilic microbes

Course Outcomes

After successful completion of this course, students will be able to:

- Comprehend the biodiversity
- Familiarize with various ecological niche and microbial interactions
- Recognize the morphology, physiology, and significance of extremophilic microbes

Unit - I

Ecology

Introduction to microbial biodiversity – distribution, abundance, ecological niche.Types- Bacterial, Archael and Eucaryal. General characters of actinomycetes, fungi, algae, protozoa and yeasts

Community ecology: community structure, benevolent interactions, control withinthe microbial communities of rhizosphere- antagonistic interactions, (competition,antibiosis, predation etc.). Rhizosphere. **Mycorrhiza:** Host-fungus specificity, host fungus interactions, rhizosphereenvironment and recognition phenomenon, interaction of mycorrhizal fungi with non-hostplants, functional capability.

Unit II

Thermophiles: hyperthermophilic habitats and ecological aspects.

Extreme ThermophilicArchaebacteria, Thermophily, commercial aspects of thermophiles.

Applications of thermozymes. Methanogens: Classification, Habitats, applications.

Unit III

Alkalophiles: Classification, alkaline environment, soda lakes and deserts, calciumalkalophily, applications.

Acidophiles: Classification, life at low pH, acidotolerence, applications.

Halophiles: Classification, cell walls and membranes – Purplemembrane, compatible solutes. Osmoadaptation / halotolerence. Applications of halophilesand their extremozymes.

Barophiles: Classification, high-pressure habitats, life under pressure, barophily,death under pressure.

GENERAL MICROBIOLOGY AND DIVERSITY (PRACTICAL)

MIC-UD/MJ/500 P **Credits 2** **Marks 50 (60 hrs)**

1. Isolation of thermophiles from hot water spring [Study at least one enzyme].
2. Studies on halophiles isolated from seawater. [Pigmentation and Salt tolerance]
3. Studies on alkalophiles isolated from Lonar water/sea water. [Study at least one enzyme]
4. Biogenic methane production using different wastes.
5. Isolation of *Thiobacillusferrooxidans*and *Thiobacillusthiooxidans*cultures from metal sulfides, rock coal and acid mine waters.
6. Estimation of microbial species diversity in microecosystem
7. Detection of siderophore production by *Azospirillum*and *Pseudomonas*
8. Slide culture technique for yeast isolation.
9. Cover slip culture technique for actinomycetes identification

REFERENCES:

1. Extremophiles by Johri B.N. 2000. Springer Verlag. , New York
2. Microbial Diversity by Colwd, D. 1999, Academic Press.
3. Microbial Life in Extreme Environments. Edited by D. J. Kushner. Academic Press.
4. Microbiology of Extreme Environments. Edited by Clive Edward. Open University Press. Milton Keynes.
5. Microbiology of Extreme Environments and its potential for Biotechnology. Edited by M.S. Da Costa, J.C. Duarate, R.A. D. Williams. Elsevier Applied Science, London.
6. Extreme Environment. Mechanism of Microbial Adaptation. Edited by Milton R. Heinrich. Academic Press.
7. Thermophiles. General, Molecular and Applied Microbiology. Edited by Thomas D. Brock. Wiley Interscience Publication.
8. Microbiology: Dynamics and Diversity by Perry.
9. Microbial Ecology. Fundamentals and Applications by. Ronald M. Atlas and Richard Bartha. 2nd and 4th Edition. The Benjamin Cummins Publication Co. Inc.
10. Microbial Ecology. 2nd Edition. by R. Campbell. Blackwell Scientific Publication.
11. Brocks Biology of Microorganisms. 8th Edition. (International Edition - 1997) by Michael T. Madigan, John M. Martinko. Jack Parker. Prentice Hall International Inc.
12. Advances in Applied Microbiology. Vol. 10. Edited by Wayne W. Umbreit and D. Pearlman. Academic Press.
13. Macan, T. T. (1974). Freshwater Ecology. Longman Group Ltd., London,.
14. Meadows, P. S. and J. I. Campbell. (1978). An introduction to Marine Science. Blackie & Son Ltd., Glasgow. 15. Richards, B.N. (1987). Microbiology of Terrestrial Ecosystems. Longman Scientific & Technical, New York.

Bioenergetics and Enzymology

MIC-UD/MJ/501 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To understand concepts of bioenergetics and metabolic pathways of microorganisms
- To study the metabolic pathways of industrially important fermentation product
- To know the properties, kinetics, and significance of microbial enzymes

Course Outcomes

After successful completion of this course, students will be able to:

- Elucidate the bioenergetics and microbial metabolic pathways
- Cognizant about the metabolic pathways of industrially important fermentation product
- Demonstrate the properties, kinetics, and significance of microbial enzymes

Unit – 1 Introduction to bioenergitics, Catabolic pathways and its regulation

Principles of Bioenergetics, laws of thermo dynamics, Central role of ATP in metabolism, , Concept of energy rich compounds and intermediates, Common types of reactions involved in metabolism

Carbon fuel and its oxidation

Catabolism of carbohydrates : EMP, HMP, ED, Phosphoketolase pathway, TCA cycle, Glyoxylate bypass. Anaplerotic sequences, overview catabolism of different carbohydrates (Fructose, Lactose, Mannose, Allose, Gluconate, Mannitol, Arabinose), Bacterial fermentations (alcohol and lactic acid), Catabolism of hydrocarbons and fatty acids.

Unit – 2 Biosynthesis of Macromolecules

Biosynthesis of amino acids (formation of glutamic acids, conversion of glutamic acid to glutamine, proline and arginine, formation of alanin, serinine, glycine and cysteine), aromatic amino acids, **Biosynthesis of Purines and Pyrimidines**. **Biosynthesis of fatty acids**, **Biosynthesis of carbohydrates** viz. glycogen, **enzymatic synthesis of reserve materials** - glycogen, polyphosphates and polyhydroxybutyrate (PHB)

Unit – 3 Introduction to Enzymes and Enzyme kinetics

Classification of enzymes into seven major groups with suitable examples, Enzyme kinetics: Michaelis - Menton equation and its significance in studies. Lineweaver-Burke plot, Haldane-Briggs relationship, sigmoidal kinetics, steady state kinetics and transient phases of enzyme reaction. Allosteric enzymes, Isozymes, Ribozymes, abzymes and Extremozymes

Bioenergetics and Enzymology (Practical)

MIC-UD/MJ/501 P **Credits 2** **Marks 50 (60 hrs)**

1. Quantitative estimation of amino acids by Rosen's method
2. Quantitative estimation of proteins by Folin-Lowry/Bradford's method
3. Quantitative estimation of sugars by Sumner's/ Anthrone's method
4. Production of $\alpha - amylase$ using submerged/solid-state fermentation
5. Production of protease by bacterial species using submerged/solid-state fermentation
6. Partial purification of $\alpha - amylase$/ protease
7. Studies on enzyme kinetics of $\alpha - amylase$/ protease (Optimization parameters viz. Substrate concentration, enzyme concentration, reaction temperature, reaction pH, Km, Vmax and metal ions as activators/inhibitors)

References

1. Understanding Enzymes by Trevor Palmer
2. Enzyme Kinetics by Paul Engel. 1977. John Wiley and Sons. Inc., New York.
3. Enzymes by Dixon and Webb, 3 rd Edition 1979. Academic Press, New York
4. Biochemistry by Stryer 5th Edition WH Freeman 2001
5. Laboratory techniques in Biochemistry and Molecular Biology by Work and Work.
6. Principles of Enzyme Kinetics. 1976. by Athel Cornish - Bowden.Butterworth and Co.
7. Fundamentals of Enzymology. 3rd Edition by Price
8. Biochemistry by Chatwal
9. Methods in Enzymology by Drolittle
10. Biochemistry by Garrett
11. Principles of Biochemistry. 2 nd Edition by Horton
12. Biochemistry by Voet.
13. Methods of Biochemical Analysis by David Glick, John Wiley and Sons, New York.
14. Biotechnology Vol. VIII and VII A edited by H. J. Rehmen and G. Reed.
15. Bacterial metabolism 2nd edition by H. W. Doelle
16. Advances in microbial physiology Vol. VII and XXIV edited by A. H. Rose, J Morris D. W. Tempest.

Techniques in Microbiology

MIC-UD/MJ/502 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To study the principles, need and care of laboratory instruments
- To understand theory, principles of chromatographic, electrophoretic, spectrophotometric and radioisotope techniques
- Get detail applications of various instrument and techniques in microbial field

Course Outcomes

After successful completion of this course, students will be able to:

- Explain the principles, need and SOP of laboratory instruments
- Pertain the theory, principles of chromatographic, electrophoretic, spectrophotometric and radioisotope techniques
- Demonstrate various instruments and techniques

Unit – 1,Chromatographic techniques

Planar chromatography- theory, principle of separation, resolution, types of planar chromatography

Paper chromatography and thin layer chromatography- principle, working and applications, HPTLC- construction, working, advantages

Column chromatography- theory, principles of separation, resolution, retention time, retention volume, gel filtration chromatography, ion-exchange chromatography, affinity chromatography, hydrophobic interaction chromatography

High performance liquid chromatography- principle, construction, working, sampling devices, chromatographic matrices and columns, detectors, result interpretation

Gas chromatography- GLC and GSC, principle, working, sampling devices, chromatographic matrices and columns, detectors, result interpretation

Unit– 2Microscopy and Electrophoretic techniques

Optical microscopy- types (compound light, dark field microscopy, phase-contrast microscopy, fluorescence microscopy, confocal microscopy), principles, construction, optical design, image formation, magnification, resolution

Electron microscopy- types (transmission electron microscopy, scanning electron microscopy), principles, construction, electron sources, lenses, apertures, optical design, image formation, magnification, resolution, staining techniques, visualization of biological specimens, chemical analyses (energy dispersive spectroscopy), immunocytochemistry, advantages and limitations of electron microscopy.

Probe microscopy- scanning tunnelling and atomic force microscopy with respect to principles, construction, working, imaging of biological specimens, applications, advantages and limitations.

Electrophoresis- theory, principles of separation, resolution, types of electrophoresis- zone electrophoresis and moving boundary electrophoresis

Paper electrophoresis- theory, construction, working and applications

Gel electrophoresis- theory, types of gels (starch, agarose, poly acrylamide, native and denaturing) with advantages and disadvantages, construction, working, sample preparation, staining

Electrophoretic techniques- preparative and non-preparative, isotachophoresis, gradient gel, tube gel electrophoresis, isoelectric focusing, capillary, microchip and 2-D electrophoresis, autoradiography

Applications of electrophoresis- bioseparations, bioanalyses

Unit– 3 Spectroscopy

Components of electromagnetic radiation and their applications, spectroscopy- general principles Spectroscopic techniques with respect to principle, construction, techniquesand applications- UV-visible, fluorescence, turbidometry, nephlometry, infra-red, Raman, nuclear magnetic resonance, atomic absorption and atomic emission, mass

Techniques in Microbiology (Practical)

MIC-UD/MJ/502 P **Credits 2** **Marks 50 (60 hrs)**

1. Studies on pH titration curves of amino acids/ acetic acid and determination of pKa values and Handerson-Hasselbach equation.

2. Separation of bacterial lipids/amino acids/sugars/organic acids by TLC

3. Separation of bacterial lipids/amino acids/sugars/organic acids by Paper Chromatography

4. Separation of proteins/nucleic acids by horizontal/vertical gel electrophoresis

5. Study of UV absorption spectra of macromolecules (protein, nucleic acid, bacterial pigments)

6. Demonstration of HPLC/GC for separation of sample components

7. Demonstration of PCR for DNA amplification

8. Separation of proteins by column chromatography

References

1. Instrumental Methods of Analysis. 6th Edition by H.H. Willard, L.L. Merritt Jr. and others. 1986. CBS Publishers and Distributors.
2. Instrumental Methods of Chemical Analysis. 1989 by Chatwal G and Anand, S. Himalaya Publishing House, Mumbai.
3. A Biologists Guide to Principles and Techniques of Practical Biochemistry. 1975 by Williams, B.L. and Wilson, K.
4. Spectroscopy. Volume 1.Edited by B.B. Straughan and S. Walker.Chapman and Hall Ltd.
5. Gel Electrophoresis of Proteins- A Practical Approach by Hanes.
6. Chromatography: Concepts and Contrasts- 1988 by James Miller. John Wiley and Sons. Inc., New York.
7. Analytical Biochemistry by Holme.
8. Introduction to High Performance Liquid Chromatography by R. J. Hamilton and P. A. Sewell.
9. Spectroscopy by B.P. Straughan and S. Walker.
10. Practical aspects of Gas Chromatography and Mass Spectrometry 1984 by Gordon M. Message, John Wiley and Sons, New York.
11. Gel Chromatography by TiborKremmery. Wiley Publications.
12. Douglas B. Murphy, Fundamentals of light microscopy and electronic imaging, 2001, Wiley-Liss, Inc. USA.
13. David B. William and C. Barry Carter, Transmission electron microscopy- a textbook for material science, Springer US, 2nd ed., 2009.

Basic Biostatistics

MIC-UD/MJ/503 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To understand various statistics terminologies and their significance in microbiology
- To get familiar with various computation tools of biostatistics
- To know-how about research methodology

Course Outcomes

After successful completion of this course, students will be able to:

- Apply the principles of statistics for designing microbiological experiment, statistical analysis, and interpretation of results
- Operate and solve exercise using computation statistics software
- Get acquitted with basic approach of research methodology

Unit –1 Introduction to Biostatistics

Basic definitions and applications. Sampling: Representative sample, sample size, sampling bias and sampling techniques. Data collection and presentation : Types of data, methods of collection of primary and secondary data, methods of data presentation, graphical representation by histogram, polygon, ogive curves and pie diagram.

Unit –2 Measures of central tendency

Mean, Median, Mode.

Measures of variability: Standard deviation, standard error, range, mean deviation and coefficient of variation. Correlation and regression: Positive and negative correlation and calculation of Karl-Pearsons co-efficient of correlation. Linear regression and regression equation and multiple linear regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation.

Unit – 3 Tests of significance

Tests of significance : Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error. Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) Computer oriented statistical techniques. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard Deviations, t test , correlation coefficient

Practical learning using Microsoft Excel

1. Representation of statistical data by
   A) Histogram B) Ogive Curve C) Pie Diagram
2. Determination of statistical averages/ central tendencies
   A) Arithmetic mean B) Median C) Mode
3. Determination of measures of dispersion
   A) Mean deviation B) Standard deviation and Coefficient of variation
4. Tests of significance
   A) Chi square test B) t-Test C) Standard Error

References

1. Statistics in biology, Vol. 1 by Bliss, C.I.K. (1967) McGraw Hill, NewYork.

2. Practical Statistics for experimental biologist by Wardlaw, A.C. (1985).

3. Statistical Methods in Biology - 2000 by Bailey, N.T. J. English Univ. Press.

4. Biostatistics - 7th Edition by Daniel

5. Fundamental of Biostatistics by Khan

6. Biostatistical Methods by Lachin

7. Statistics for Biologist by Campbell R.C.(1974)Cambridge University Press ,UK.

A) MICROBIAL TAXONOMY (T)

MIC-UD/DSE/504 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To understand microbial diversity and their significance in microbiology
- To get familiar with various methods for identification and classification of bacteria and viruses
- To acquaint with Bergey's Manual, molecular phylogenetic

Course Outcomes

After successful completion of this course, students will be able to:

- Explain the principles, need and significance of classification
- Use knowledge for identification of bacteria
- Use tools for phylogenetic analysis

Unit I

General characteristics and outline of classification of Archaea

Extremophiles: general characteristics of acidophilic, alkaliphilic, barophilic microorganisms

General characteristics and outline classification of Actinomycetes

Fungi: General characteristics and outline of classification of fungi,

Unit II

Outline and overview of classification of microorganisms- Haeckel three Kingdom classification, Whittaker fiveKingdom classification, and Woese's three domain classification, classification offungi, and virus.

Virus classification: LHT System, Baltimore and ICTV classification of virus.

Unit III

Bacterial classification (Bergey's Manual of systematic Bacteriology). Bacterial taxonomy– Binomial Nomenclature, Identificationcharacters-morphological, staining, physiological, biochemical and molecular (mol % G+C,nucleic acid hybridization, 16SrRNA sequencing) characters, methods-Numerical, nucleic acid and Phylogenetics.

MICROBIAL TAXONOMY (P)

MIC-UD/DSE/504 P **Credits 2** **Marks 50 (60 hrs)**

1. Isolation and identification of Halophilic/acidophilic/alkaliphilic/thermophilic bacteria
2. Determination G+C content of DNA.
3. Study of ICTV database
4. Construction of Phylogenetic tree

REFERENCE BOOKS

1. Introductory Mycology by C. J. Alexopoulus (7th ed) Wiley Eastern Pvt. Ltd., New Delhi.

2. Bergey's Manual of Systemic Bacteriology (2nd ed) Springer, USA.

3. Basic Bacteriology (3rd ed) by C. Lamanna and F. Mallette The William and Wilkins Company. Calcutta.

4. Fundamental Principles of Bacteriology (3rd ed) by A. J. Salle TMH Publishing Company, New Delhi.

5. The Yeasts by A.H. Rose

6. General Microbiology (5th ed) by R. Y. Stanier and others

7. The Prokaryotes: A handbook on the Biology of Bacteria by Martin Dworkin (Editor- in- Chief) and others Springer

8. Developmental Microbiology by J. F. Peberdy Blackie & Sons, Glasgow

B) **BIOLOGICAL DATABASE SYSTEMS (T)**

MIC-UD/DSE/504 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To understand biological databases and their applications in microbiology
- To acquaint with various nucleic acid, protein, sequence and structure databases
- To familiarize with sequence and structure file format

Course Outcomes

After successful completion of this course, students will be able to:

- Use various databases
- Use knowledge for specific retrieval of sequence information
- Frame queries for retrieval of desired information from databases

Unit- I Bioinformatics and its Applications

Introduction to Bioinformatics: Introduction and overview of History of Bioinformatics, relationship between molecular evolution and bioinformatics. Structure function relationship, Nature of biological data, Applications of Bioinformatics

Unit – II

Biological Databases: Types and importance

Nucleotide sequence databases; Primary nucleotide sequence databases- EMBL, GenBank, DDBJ (Sequence file format, sequence submission and retrieval of information).

Overview of Secondary nucleotide sequence databases,Protein sequence database – SWISS PROT, TrEMBL, PIR, MIPS

Unit – III

Protein Family database – PFAM, PROSITE, PRINTS, BLOCKS,

Protein Structure database – PDB

Protein structural classification database - SCOP, CATH

B) BIOLOGICAL DATABASE SYSTEMS (PRACTICAL)

MIC-UD/DSE/504 P **Credits 2** **Marks 50 (60 hrs)**

1. Use of Internet /software for sequence nucleotides and protein databases.
2. Studies of public domain databases for nucleic acid and protein sequences.
3. Sequence retrieval from nucleic acid databases.
4. Protein structure retrieval from PDB.
5. Protein structure visualization by using RASMOL, CN -3D software

REFERENCES

1. Bioinformatics. 1998 by Baxevanis
2. Bioinformatics 2000 by Higgins and Taylor OUP.
3. Nucleic acid Research 2001. Jan. Genome database issue.
4. The Internet and the new Biology: Tools for Genomics and Molecular Research by Peruski, Jr. and Peruske (ASM) 1997.
5. Functional Genomics. A Practical Approach Edited by Stephen P Hunt and Rick Liveey (OUP) 2000.
6. DNA microarrays: A practical approach edited by Mark Schena (OUP)
7. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis.
8. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgis.
9. Bioinformatics - from Genomes to drug. 2 volumes by Lenganer.
10. Bioinformatics Methods and Protocols - Misener.

MIC-UD/DSE/504 P **Credits 2** **Marks 50 (60 hrs)**

C) Any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }

Research Methodology

MIC-UD/RM/505 T **Credits 4** **Marks 100 (60 hrs)**

Course Objectives:

1. To define research and describe the research process and research methods
2. To understand qualitative research and methods used to execute and validate qualitative research
3. To know how to apply the basic aspects of the research process in order to plan and execute a research project.
4. To provide insight into the processes that lead to the publishing of research.
5. To be able to present, review and publish scientific articles

Course Outcomes:

Students will be able to -

1. understand and explain research process
2. Do systematic literature survey, formulation of a research topic, study design, analysis and interpretation of data.
3. To design a research approach for a specific research issue of their choice.
4. Select a suitable analytical method for a specific research approach.
5. Demonstrate a good understanding of how to write a research report.
6. critically assess published quantitative research with regard to the statistical methods and approaches adopted
7. create a research document for implementation research project

Course Contents:

Part – 1 (02 credits : 30 Contact Hours)

Unit - I: Research Fundamentals: (10 Hrs.)

Introduction: Definition, objectives of the research, characteristics of research, importance of research**,** types of research- Qualitative, Quantitative, descriptive, analytical, fundamental/basic, applied, conceptual, empirical, limitations encountered in research, research methodology and research methods.

The process of research-Research Methodology: Literature search, sources of literature, types of literature, cross-referencing, keeping records, selection of research problem, hypothesis and hypothesis testing, research design, planning experiments, independent and dependent variables, experimental controls, data analysis and interpretation, concept of measurement and problems in measurement, levels of measurement- nominal, ordinal interval, ratio, validity and reliability, reporting the findings- progress/project report/thesis/dissertation.

Unit- II: Research funding- writing proposals and reports (10 Hrs.)

Research institutes, research funding agencies, reasons for funding research, expectations of funding agencies, profile of investigators, interdisciplinary and collaborative research.

Writing a research proposal/research scheme/concept note/synopsis- topic of research, background to the research, definition of the problem, current status of work (National and

International), hypothesis, objectives, plan of work (monthly/quarterly, yearly), experimental methods including special facilities/instruments, available facilities, sampling methods, field visits, data processing/analyses, interpretation, budgetary requirements- manpower, equipment, chemicals/consumables, proposed time frame, expected outcome, limitations, if any.

Writing a project report (annual report/completion report)- title, table of contents, background/introduction, methodology, results and interpretation, conclusions, future directions, appendices, bibliography, outcome of the project, publications/patents emanating from the research work, audited statement of accounts/final utilization.

Unit – III: Scientific writing and presentation- thesis/dissertation, research paper (10 Hrs.)

Writing a thesis/dissertation- classic 5-chapter model- abstract, table of contents, background to the research, review of literature/introduction, research design and implementation OR material and methods, presentation and analysis of findings OR results, discussion and conclusions, referencing styles and list of references, appendices, acknowledgements

Writing a research paper- title, author names and affiliations, abstract, key words, introduction, material and methods, results, discussion, acknowledgements, references, formatting guidelines, ethics of writing a research paper, plagiarism, language, avoiding common mistakes, journal metrics, impact factor, citations.

Data presentation- Objectives of presentation, presentation style, effective communication skills, scales used for presentation (nominal, ordinal, interval, percentage, ratio), pie charts, bar charts, histogram, line graphs, tables.

Part – 1 (02 credits: 30 Contact Hours)

Presentations, Case studies, Assignments, Tutorials based on Module I to III **(30 Hrs.)**

Students are expected to do the Following:

i) Select Broad topic of Research Project (to be implemented from second semester onwards)
ii) Read the Basic concepts / fundamentals of broad topic
iii) Identify 05 SCOPUS / WEB OF SCIENCE Indexed Journals related to broad topic
iv) Search and download 20 research articles from above research Journals
v) Do systematic review of above 10 research articles
vi) While doing review of each of above mentioned 20 research articles, students are expected prepare notes on following points

a) What are the objectives of the research article?
b) What methodology has been adopted?
c) What are prominent results?
d) How these results of relevant to the latest development of the subject?
e) What is novelty of research article?
f) What are prominent shortcomings of this research a presented in this research article?
g) What are your plans to address those shortcoming?

vii) Draft the title of research project
viii) Draft hypothesis

ix) Draft Objectives and Methodology
x) Draft expected outcome of the research project

At the end of the assignment, students are expected to prepare a report having following points

i) Fine-tuned title of Research Project
ii) Background to the research topic with current National and International status
iii) Hypothesis
iv) Objectives
v) Material and Methods
vi) Detailed Experimental plan
vii) Expected outcome
viii) References

References:

1. Research Methodology by Dr. S. L. Gupta, Hitesh Gupta; International Book House Pvt Ltd **(2013),** ISBN-10: 8191064278, ISBN-13: 978-8191064278
2. Basic Research Methods-Gerard Guthrie SAGE Publications, India, Pvt Ltd, New Delhi **(2010),** ISBN-10: 8132104579, ISBN-13: 978-8132104575
3. Research Methodology-methods and techniques By C. R. Kothari, New Age International Publishers **(2011)** ISBN 978-81-224-1522-3
4. Principles of Research Methodology- Phyllis G. Supino, Jeffrey S. Borer; Springer, Verlag New York **(2012),** ISBN-ebook: 1461433592, ISBN (Hardcover): 978-1461433590
5. Research Design Qualitative, Quantitative. and Mixed Methods Approaches- John W. Creswell; SAGE Publications Ltd, UK **(2011),** ISBN-9780857023452
6. Research Methodology -A Step-by-Step Guide for Beginners- Ranjit Kumar; Sage Publications Ltd**(2010)**, ISBN- 1849203016.
7. Scientific Writing and Communication- Angelika Hofmann; Oxford University Press, US **(2010),** ISBN-13-: 978-0 199947560, ISBN-10: 01 99947562
8. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded- Joshua Schimel, Oxford University Press, **(2011)**, ISBN: 9780199760237
9. Handbook of Scientific Proposal Writing- A.YavuzOruc; CRC Press, Taylor & Francis group **(2011)**, ISBN: 9781439869185

Virology, Bacteriology, Parasitology

MIC-UD/MJ/550 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To aware the virus, classification, and their significance
- To abreast about bacteriology and Parasitology
- To understand the viral multiplication and pathogenic role of viruses, bacteria and parasites along with control of virus and newly emerging virus

Course Outcomes

After successful completion of this course, students will be able to:

- Explicate the virus, classification, and their significance
- Comprehend the viral multiplication and pathogenic role of viruses, bacteria and parasites.
- Understanding about diagnosis and control of virus, bacteria and parasites

Unit 1 Virology

History of virology, general characteristics Ultrastructure of virus,classification of viruses(LHT, Baltimore system, ICTV), viroids, prions, satellite virus.
Mechanism of virus adsorption and entry into the host cell,
Bacteriophages – Molecular basis of Lytic and lysogenic replication;One step growth curve
DNA and RNA viruses– Overview of mechanism of genome replication, Transcription and translation.
Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses Adenovirus, Herpes virus, Picorna virus, Poxvirus and Orthomyxovirus, Oncogenic viruses.
Control of viral infections: Viral vaccines and chemotherapeutic agents.
Virus neutralization by antibody and interferons

Unit 2 Bacteriology

Overview Ultrastructure of bacteria cell;
Pathogenic Bacteria: Morphological characteristics, Pathogenesis and Laboratory diagnosis includingrapid methods of following pathogenic bacteria;
Klebsiella pneumoniae; Pseudomonas aeruginosa: Streptococcus pneumoniae.
New emerging infections:-*community associated Methicilin resistantStaphylococcus aureus* (MRSA), *Multi drugresistant tuberculosis.*

Unit 3 Parasitology

Basic concept of Host-pathogen interaction, Basic concept of Parasites,
Classification of Parasites, Host, Types of host, Relationship between host and parasites.
Introduction, A-etiology, pathogenicity, life cycle, lab diagnosis and treatment:
Leishmania, Amoeboids (*Entamoeba histolytica*), Sporozoans (*Plasmodium* spp), *Giardia lamblia; Plasmodium vivax,Trepanoma,*Echinococcus, Ascaris,
Lab Diagnosis: Different specimens of parasitology, Collection & transportation.
Processing of parasitological specimens

Virology, Bacteriology, Parasitology (Practical)

MIC-UD/MJ/550 P **Credits 2** **Marks 50 (60 hrs)**

1. Isolation of Bacterial/ Plant/ Animal Viruses
2. Plaque assay
3. One step growth curve for determination for virus titre.
4. Cultivation and assay of viruses using embryonated eggs and Tissue culture Technique.
5. Isolation and identification of following pathogenic bacteria and parasites:
    a. *Klebsiella pneumoniae; Pseudomonas aeruginosa: Streptococcus pneumoniae,*
    b. Demonstration of parasites in pathological sample

REFERENCES: -

1. Introduction to modern virology 4 th Edition by Dimmock N J, Primrose S. B. 1994. Blackwell scientific publications. Oxford.
2. Virology 3rd edition by Conrat H. F. ., Kimball P. C. and Levy J. A. 1994. Prentice Hall, Englewood Cliff, New Jersy.
3. Text Book on Principles of Bacteriology, Virology and Immunology, Topley and Wilson 1995.
4. Applied Virology. 1984. edited by EdnordKurstak. Academic Press Inc.
5. Introduction to Modern Virology by Dimmock.
6. Virology : principles and applications by John Carter and Venetia Saunders.
7. Principles of virology ,—4th edition by Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, with Lynn W. Enquist.
8. Stainer, R.Y, Ingraham, J.L, Wheelis, M.L, and Painter, P.R (2013). General Microbiology,MacMillan Press Ltd. UK.
9. Ananthanarayan, Paniker and ArtiKapil (2013) *Textbook of Microbiology,* 9th Edition. Universities Press.
10. Fundamentals of Baceriology- A. J. Salle
11. Prescott's Microbiology , 11th Edition
12. Medical parasitology' by Chatarjee, 3th edition
13. Medical Microbiology and Immunology' by Warren Levinson, eighth Edition, Lange Medicalbooks/ McGraw-Hill Publication

Microbial Physiology

MIC-UD/MJ/551 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To acquaint various life process like photosynthesis, respiration and fermentation, anaerobic respiration, and bacterial sporulation
- To understand bacterial membrane transport
- To understand the concept of chemolithotrophy and nitrogen metabolism

Course Outcomes

After successful completion of this course, students will be able to:

- Understand various life process like photosynthesis, respiration and fermentation, anaerobic respiration, and bacterial sporulation
- Elucidate bacterial membrane transport
- Discuss the concept of chemolithotrophy and nitrogen metabolism

Unit – 1 Photosynthesis

Energy consideration in photosynthesis, light and dark reaction, electron carriers in photosynthesis, Organization of photo system I and II, cyclic and non-cyclic flow of electrons, Z scheme, Hill reaction, photolysis of water. Bacterial photosynthesis: scope, electron carriers, Photosynthetic reaction center, cyclic flow of electrons, bacterial photophosphorylation in various groups of phototrophic bacteria, electron donors other than water in anoxygenic photosynthetic bacteria.

Unit – 2 Bacterial Respiration and chemolithotrophy

Aerobic Respiration: Mitochondrial electron transport chain, structure and function of ATPase (bacterial and mitochondrial), generation and maintenance of proton motive force, oxidative phosphorylation, inhibitors and un-couplers of electron transport chain and oxidative phosphorylation, Atkinson's energy charge, phosphorylation potential and its significance, Energy generation in all groups of chemolithotrophs- oxidation of molecular hydrogen by *Hydrogenomonas*species, ferrous and sulfur/sulfide oxidation by *Thiobacillus* species.

Anaerobic Respiration: Concept of anaerobic respiration, oxidized sulfur compounds, and nitrate as electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogenesis, Biochemistry of ammonia oxidation, ammonia oxidation by members of Genus Nitroso group, nitrite oxidation by Nitro group of genera.

Unit –3 Bacterial Permeation

Structure and organization of membrane, functions of biological membrane

Different models of biological membrane, glyco-conjugants and proteins in membrane systems, solute transfer in bacteria- passive diffusion, facilitated diffusion, different mechanisms of active transport (Proton Motive Force, PTS, role of permeases in transport, transport of amino acids and inorganic ions in microorganisms and their mechanisms.

Microbial Physiology (Practical)

MIC-UD/MJ/551 P **Credits 2** **Marks 50 (60 hrs)**

1. Development of Winogradsky column for growth of different groups of bacteria

2. Isolation of Photosynthetic bacteria

3. Glucose uptake by *E. coli*/*Saccharomyces cerevisiae*by passive diffusion

4. Glucose uptake by *E. coli*/*Saccharomyces cerevisiae*by active transport

5. Determination of Iron Oxidation Rate of *Thiobacillus.*

6. Determination of Sulfur Oxidation Rate of *Thiobacillus*

7. Microbial degradation, decolorization and adsorption of organic dyes (by free and immobilized cells).

8. Demonstration of utilization of sugars by oxidation and fermentation techniques.

References

1. Microbial Physiology and Metabolism by Caldwell D.R. 1995, Brown Publishers.

2. Microbial Physiology by Moat A.G. and Foster J. W. 1999. Wiley.

3. Prokaryotic Development by Brun. Y.V. and Shimkets L.J. 2000.ASM Press.

4. Advances in Microbial Physiology. Volumes.Edited by By A.H. Rose. Academic Press, New York.

5. Applied Microbial Physiology by Rhodes.

6. Biosynthesis by Smith.

7. The Bacteria. Volumes by I.C. Gunsalus and RogeryStanier, Academic Press.

8. Microbial Physiology by Benjamin

9. Bacterial Metabolism by H.W. Doelle

10. Segel Irvin H. (1997) Biochemical Calculations 2nd Ed., John Wiley and Sons, New York.

11. Voet Donald and Voet Judith G. (1995) Biochemistry, 2nd Ed..John Wiley and sons New York.

12. White Abraham, Handler Philip, Smith Emil, Hill Rober, Lehman J. (1983) Principles of Biochemistry, Edition 6, Tata Mc-Graw Hill Companies, Inc.

13. White David (2000) Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press, New York. 14. Zubay Geoffrey (1998) Biochemistry, 4th Ed., W. C. Brown, New York.

FOOD MICROBIOLOGY

MIC-UD/MJ/552 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To understand concepts in fermentation microbiology
- To complement the students with the knowledge of microbiology of food preservation and spoilage
- To acquaint the students with food preservation methods

Outcomes

After successful completion of this course, students will be able to:

- Know the concepts related to popular fermented food products, its microbiology and spoilage
- Understand fermented food products, food spoilage and contamination
- Understand various methods for food preservation

Unit – 1 Industrial Food fermentations

Introduction, food fermentation, the science and technology.

Oriental fermented foods (Soya sauce, Natto, Miso), Cerel products, mixed preparations (Idle, Dhokala, Khamang, Papadam and Jilebies), Fermented cassaea flour, fermented pea nut milk, and grape based fermented products- wine (pre fermentating, fermentative and post fermentative practices, general methods of wine preparations) , Fermented vegetables – Saurkraut, Fermented Meat – Sausages

Unit –2 Food preservation methods

Food preservation by Radiations (UV, Gamma and microwave), Food preservation by low and high Temperature, chemicals and naturally occurring antimicrobials

Biosensors in food industry.

Unit – 3 Food spoilage and Quality assurance

Food borne infections and intoxications (bacterial) with examples of infective and toxic types –, *Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter, Listeria*.

Mycotoxins in food (Types, structures, producer organism and its toxicity).Laboratory

Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, ISI.

FOOD MICROBIOLOGY (Practical)

MIC-UD/MJ/552 P **Credits 2** **Marks 50 (60 hrs)**

1. Production of fermented batter of Idli, Khaman Dhokla, Jilebies and study of bacteria involved in them
2. Saurkraut fermentation and study of bacteria involved in it
3. Production of fermented soy sauce and pea nut milk and study of bacteria involved in them
4. Isolation and study of food infection/ food poisoning bacteria/ fungi from contaminated foods
5. Extraction and detection of toxins from food
6. Preservation of potato/onion by UV radiation
7. Rapid analytical techniques in food quality control using microbial biosensors

REFERENCES

1. Food Microbiology. 2nd Edition By Adams
2. Basic Food Microbiology by Banwart George J.
3. Food Microbiology: Fundamentals and Frontiers by Dolle
4. Biotechnology: Food Fermentation Microbiology, Biochemistry and Technology. Volume 2 by Joshi.
5. Fundamentals of Dairy Microbiology by Prajapati.
6. Essentials of Food Microbiology. Edited by John Garbult.Arnold International Students Edition.
7. Microbiology of Fermented Foods. Volume I and II. By Brian J. Wood.Elsiever Applied Science Publication.
8. Microbiology of Foods by John C. Ayres. J. OrwinMundt. William E. Sandinee. W. H. Freeman and Co.
9. Dairy Microbiology by Robinson. Volume II and I.
10. Food Microbiology: Fundamentals and Frontiers. 2nd Edition by Michaell P. Doyle, Larry R. Beuchat and Thomas I. Montville (Eds.), ASM Publications.
11. Bacterial Pathogenesis A Molecular Approach. 2 nd Edition.2001 by Abigail A.Salyers and Dixie D. Whitt.ASM Publications.
12. Advances in Applied Microbiology by D. Pearlman, Academic Press.
13. Microbial biotechnology- principles and applications- by Lee Yuan Kun
14. Biotechnology Vol. III and V edited by H J Rehman and G Reed
15. Applied dairy microbiology edited by Elmer Marth and James Steele.

APPLIED AND INDUSTRIAL MICROBIOLOGY

MIC-UD/MJ/553 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To understand concepts in milk microbiology
- To complement the students with the basic knowledge of food microbiology
- To acquaint the students with food preservation techniques

Outcomes

After successful completion of this course, students will be able to:

- Know the concepts related to popular/common milk products, milk examination and spoilage
- Comprehend knowledge regarding fermented food products, food spoilage and infection
- Understand diverse strategies for food preservation

UNIT – 1 Industrial Dairy fermentations.

Taxonomy of lactic acid bacteria present in fermented products, Acid fermented milks (Acidophilus milk, yoghurt), Slightly acid fermented milks (Cultured butter milk), Acid-alcoholic fermented milk (Kefir). Fermented milk production with extended self life (labneh). Starter cultures for fermented dairy products (*Strptococcus thermophillus, Lactobacillus bulgaricus*). Metabolism of starter cultures, biochemical changes in fermented milk (Fermentation of lactose to lactic acid, production of aromatic compounds, hydrolysis of proteins and lipids and Vit. B content).

Cheese- biological entities in cheese systems (Mlk, microorganisms, enzymes and other additives). Cheese production (Milk quality and composition, steps involed in mfg of cheese, preservation, classification and nutritional aspects)

Unit - 2 Advanced Food and dairy Microbiology

Genetically modified foods.Probiotic role of lactic acid bacteria and fermented milk products. Applications of microbial enzymes in dairy industry [Protease, Lipases], microbial anti oxidants, microbial polysaccharides as stabilizers and thinkers, flavors (esters, diaacetyl, pyrazines, lactones and terpenes, monosodium glutamate and microbial colors from molds). Production and application of Bakers Yeast, Tea, coffee and vinegar fermentation, Utilization and disposal of dairy by-product - whey.

Unit-3 Quality Control in Dairy Industry

Dye reduction test (Methylene blue Reduction Test, Resazurin Test) Pasteurization methods, Microbial counts: Methods and significance, Milk borne diseases, Lactose intolerance

References:

1. Fundamentals of Dairy Microbiology by Prajapati

2. Dairy Microbiology by Robinson. Volume I and II.

3. Microbial biotechnology- principles and applications- by Lee Yuan Kun

4. Biotechnology Vol. III and V edited by H J Rehman and G Reed

5. Applied dairy microbiology edited by Elmer Marth and James Steele.

A) Pharmaceutical Microbiology (T)

MIC-UD/DSE/554 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To develop practical skills involved in interpretation of microbiological materials and data
- To promote development of entrepreneurship and build up Professionals in Pharmaceutical Analysis, and R&D work
- To understand quality assurance validation

Course Outcomes

After successful completion of this course, students are expected to:

- Conversant in practical skills involved in interpretation of microbiological materials and data
- Explain the development of entrepreneurship and build up Professionals in Pharmaceutical Analysis, and R&D work
- Aware about quality assurance validation.

Unit I: Principles of Antimicrobial chemotherapy.

Introduction and selection of antimicrobial agents

Concept of Bioassay, therapeutic index, MIC and $LD_{50.}$

Penetrating defenses, as cellular permeability barriers, Cellular transport system and drug diffusion.

Definition and classification of antibiotics, with respect to their mechanism of action, Antibacterial spectrum, Structural activity and relationship (SAR), acquisition of drug resistance, pharmacokinetics and adverse drug effect β- Lactum(Penicillin, Amoxicillin, cefuroxime), aminoglycosides (Streptomycin, Gentamicin), Tetracyclines (Tetracyclin, doxicyclin) , Macrolides (Erythromycin, Azethreomycin), Peptide antibiotics (Bacitracin, polymixin,), Sulphonamides (sulfamethoxazole), co-trimoxazole and quinolones (ciprofloxacin) Chloramphenicol, trimethoprim.

Unit II: Molecular aspects of Antimicrobial Chemotherapy.

Definition, classification, Mechanism of action and examples of chemical disinfectants, antiseptic and preservatives.

Definition, classification, Mechanism of action and examples of antiviral (Acyclovir, zidovudine), Antifungal (amphotericin B, Fluconazole) and Antitumor (Bleomycin, ductinomycin) antibiotics.

Drug delivery system in gene therapy. Approaches and safety considerations associated with gene therapy. Immunological problems associated to gene therapy. Pre-requisites and candidate

diseases for human gene therapy.Drug carrier, Macromolecular, cellular, and synthetic Viral and non viral mediated gene delivery.

Introduction, concept and types of drug targeting, cellular level events of drug targeting, targeting ligands, blood cell receptors for endogenous compounds/ ligands, carrier and vesicular system for targeting, specialized liposomes for cellular drug targeting.

Unit III: Microbial Production and spoilage of Pharmaceutical Products.

Manufacturing procedure and in-process control of Pharmaceutical products: Bacterial and Viral vaccine, sterile injectables, Solid dosage forms, liquid orals and Ointments

New Vaccine production: DNA vaccines, synthetic, peptide vaccines, multivalent subunit vaccines, edible vaccines and their trials.

Microbial production and applications of therapeutic / diagnostic enzymes: Asparaginase, Streptokinase, beta lactamases

Microbial production contamination and spoilage of Pharmaceutical products (sterile injectables, ophthalmic preparations and implements) and their sterilization

Applications of Biosensors in pharmaceutical industries.

A) Pharmaceutical Microbiology (P)

MIC-UD/DSE/554 P **Credits 2** **Marks 50 (60 hrs)**

1. Isolation and screening of antibiotic producing micro-organisms (Bacteria)
2. Isolation and screening of antibiotic producing micro-organisms (Actinomycetes)
3. Production, purification and bioassay of Rifamycin/Streptomycin.
4. Bioassay of vitamin B12/B2.

REFERENCES

1. Pharmaceutical Microbiology- Edited by W. B. Hugo & A.R. Russel Sixth Edition. Blackwell Scientific Publications.
2. Lippincott's illustrative Reviews: Pharmacology Edition: 02 Maryjnycck by Lippincott's review Publisher Pheladelphia 1997.
3. Principles of medicinal chemistry Vol. 1 by Kadam S.S., Mahadik K.R., Bothra K.G. Edition: 18, Nirali Publication.
4. Pharmacognosy by GokhleS.D., KoKateC.K.. Edition: 18, Nirali Publication.
5. Biotechnology – Expanding Horizon by B.D. Singh , First Edition, Kalyani Publication, Delhi.
6. Analytical Microbiology- Edited by Fredrick Kavanagh volume I &II. Academic Press New York.
7. Pharmaceutical Biotechnology by S. P. Vyas& V.K. Dixit. CBS publishers & distributors, New Delhi.
8. Quniolinone antimicrobial agents- Edited by David C. Hooper, John S. Wolfson. ASM WashingtonDC.
9. Quality control in the Pharmaceutical industry - Edited by Murray S. Cooper Vol. 2, Academic Press New York.
10. Biotechnology- Edited by H.J. Rhem& Reed, vol 4 VCH publications, Federal Republic of Germany.
11. Good manufacturing practices for Pharmaceuticals. By Sydney H. Willing, Murray M. Tuckerman, Willam S. Hitchings IV. Second edition Mercel Dekker NC New York.
12. Advances in Applied Biotechnology series Vol.10, Biopharmaceutical in transition, Industrial Biotechnology Association by Paine Webber,. Gulf Publishing Company Houston.
13. Drug carriers in biology & medicine Edited by Gregory Gregoriadis. Acedemic Press New York. Quality Assurance in Microbiology by Rajesh Bhatia, Rattan LalIhhpunjani.CBS publishers & distributors, New Delhi.

B) **BIOETHICS, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS**

MIC-UD/DSE/554 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives

- To give introduction to bioethics and biosafety.
- To give in-depth information about containment.
- To give knowledge about regulatory affairs of pharmaceuticals and GMO.
- To provide information about Intellectual rights.

Course outcome

After successful completion of this course, students will be able to:

- Understand bioethics and biosafety
- Understand contaminants in production a
- Understand issues related to GMO
- Use knowledge about intellectual property rights

UNIT - I

Bioethics - Introduction to Bioethics, Biosafety - Definition, biosafety consideration, types of containments, personal practices, primaryand secondary containment barriers (biosafety levels 1, 2, 3, 4), containment for production activities, practical consideration, possible hazards from industrial production and use of pathogens.

UNIT - II

Issues related to use of genetically modified microorganisms andtheir release in to the environment, special procedures for recombinant DNA based products.Regulatory affairs - regulatory requirements for drugs and biological products. Ethical issues related to industrial genetically manipulated microorganisms (GMM).Guidelines on biosafety in conducting research in biology / biotechnology; Ethics in use of animalsfor scientific research;

UNIT - III

Intellectual property rights - Importance of Intellectual property, history of patent concept,composition of a patent, general patent information - patent laws, patentable subject matter, apply forpatent, requirements for patentability, patent prosecution, appeals and interference proceedings,

. Patent laws in India.

B) **BIOETHICS, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS P**

MIC-UD/DSE/554 P **Credits 2** **Marks 50 (30 hrs)**

1. Sterility testing
2. Validation of Laminar air flow unit
3. Validation of Autoclave
4. Monitoring of Laboratory environment (air/water)
5. Survey of any subject related patent/s
6. Documentation about any GM organism and or its product and associated ethical issues.

References:
1. Intellectual property rights on Biotechnology. K. Singh BCII, New Delhi.
2. Biotechnologies in developing countries present and future. 1993. A. Sasson. UNESCO Publishers.

MIC-UD/DSE/554 T **Credits 2** **Marks 50 (30 hrs)**

C) Any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }

MIC-/OJT/555

On Job Training/ Field Project

MICROBIAL GENETICS

MIC/UD/MJ/600T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives:

1. **Fundamentals of Microbial Genetics**: To provide students with a solid foundation in the principles and concepts of microbial genetics.
2. **Microbial Genome Organization**: To teach students about the structure, function, and organization of microbial genomes, including plasmids and bacteriophages.
3. **Genetic Variation and Mutation**: To explore the mechanisms of genetic variation and mutation in microorganisms.
4. **Regulation of Gene Expression**: To provide an understanding of how gene expression is regulated in microorganisms.

Course Outcomes:

1. **Understanding Microbial Genetics Principles**: Students will demonstrate a comprehensive understanding of the basic principles and concepts of microbial genetics.
2. **Knowledge of Genome Organization**: Students will be able to describe the structure, function, and organization of microbial genomes, including the roles of plasmids and bacteriophages.
3. **Insight into Genetic Variation**: Students will understand the mechanisms that drive genetic variation and mutation in microorganisms.
4. **Regulation of Gene Expression**: Students will have a clear understanding of the regulatory mechanisms controlling gene expression in microorganisms.

Unit –I Structure, properties and function of DNA

DNA: Structure of DNA (Primary structure -linear polynucleotide, Secondary structure- double stranded helical structure, Tertiary Structure); Topological properties of DNA; Physical characteristics of DNA (Buoyant density, UV-absorption, denaturation, renaturation and hybridization, Cot curve); Forms of DNA (A, B, C and Z forms) Gene, chromosome, genome, Comparative account of genome organization of prokaryotic, archaea & Eukaryotic cell; C-Value and C-value paradox,

Mutation: Mechanism of mutation (Random and Non adaptive phenomenon); Types of mutation - Base substitution (Transition and transversion), Frame shift mutation (Deletion, Insertion, inversion); Missense, Silent, Non-sense mutation

Molecular basis of mutation – (i) Spontaneous mutation- DNA polymerase errors, mutation due to recombination, mutation due to tautomerization of nitrogen bases, mutation due to deamination nitrogen bases; (ii) Induced mutations - Chemical mutagens (Base analogue, Nitrous oxide, Hydroxylamine, alkylating agents, and acridine orange); Physical mutagens (Ionizing radiation, non-ionizing radiation

DNA repair: Types of repairs - Photoreactivation, Base excision repair, Mismatch repair, Nucleotide excision repair, SOS-Inducible repair.

Transposable elements – Discovery, General types of transposons,

Bacterial transposable element – IS element and Complex transposons (Composite transposon, Tn3 transposon, Transposable phages)

Mechanism of transposition Conservative and Replicative model

Recombination - Homologous and non-homologous recombination, Gene mapping using bacterial recombination - Co-transformation, Co-transduction, and Mapping by conjugation (Intermittent matting experiment with Hfr cell)

Unit -II Central dogma

Prokaryotic DNA replication: Meselson and Stahl experiment, Replication Initiation, replication elongation and termination; Mechanism of rolling Circle replication; Types of DNA polymerases, Post replication process (Methylation of DNA).

Mechanism of gene expression: Transfer of Genetic Information (Central Dogma); Polycistronic RNA (prokaryotes)

Transcription in Prokaryotes: RNA Polymerase, Upstream, Promoter, downstream region, consensus sequences, Initiation of RNA chains, elongation of RNA chains, termination of RNA chains (Rho dependent & Independent); Types of RNA **(m**RNA, tRNA, rRNA, snRNA, miRNAs);Transcription inhibitors.

RNA processing: Differences in Prokaryotic & Eukaryotic RNA Processing, Processing for t-RNA & r-RNA. Polyadenylation, capping of mRNA, and introns splicing

Prokaryotic translation – Genetic code; Ribosome and ribosome subunits; Activation of tRNA, Initiation, elongation, and termination of protein synthesis

Post translational modification- modifications in primary proteins, role of chaperons; Inhibitors of protein synthesis

Unit – III Regulation Of Gene Expression

Gene expression: Gene induction and repression; Gene expression product, types of gene regulation (Constitutive and inducive gene regulation) and Significance gene regulation, and levels of gene regulation (Transcriptional regulation, translational regulation, post transcription/post translation regulation), Gene silencing

Operon: Lac operon, Positive regulation of Lac opera on, Negative regulation of lac operon, Lac mutants Genetic attenuation (Trp operon) – Positive and negative regulation; Arabinose operon

Phage gene regulation: Molecular mechanism of lysogenic regulation in lambda phage

MOLECULAR MICROBIAL GENETICS LAB COURSE

MIC/UD/MJ/600P Credits 2 Marks 50 (30 hrs)

1. Isolation and Purification of bacterial genomic DNA.
2. Isolation and purification of bacterial Plasmid
3. Estimation of DNA: UV method, Spectrophotometric confirmation of DNA purity
4. Estimation of DNA: Diphenyl amine Method,
5. Isolation and purification of RNA from yeast
6. Estimation of RNA: Orcinol method.
7. Determination of LD50 value for E. coli using ultraviolet radiations (UV survival pattern of E. coli/yeast)
8. Studies on light and dark repair mechanisms in E. coli/yeast using UV radiations
9. Isolation of antibiotic resistant mutants / auxotrophic mutant. (Replica plate method)
10. Studies on regulation of synthesis of inducible enzyme beta galactosidase in E. coli
11. Studies on gene transfer by conjugation\Transformation in E. coli.

REFERENCES

1. Lewin B. (2013) Gene XI, Pearson Prentice Hall, Pearson Education, Inc., NT, USA
2. Clark, David P. and Nan Pazdernik (2013) Molecular biology, (2e) Academic Press and Elsevier
3. Malacinski GM (2003) Freifelder'S Essentials of Molecular Biology, 4th edn., Jones & Batiett, London
4. David Freifelder (2004) Molecular Biology, Narosa Publishing House.
5. Ulhas Patil, JS Kulkarni, AB Chaudhari and SB Chincholkar (2021) Foundations in Microbiology, (10^{th} ed) Nirali Prakashan, Pune
6. Watson JD, Baker JA, Bell SP, Gann A, Lewin M, Losick R (2004) Molecular Biology of the Gene, Benjamin Cummings- CSHL Press, USA.
7. Berg JM, Tymoczko, JL, Stryer, L (2012) Biochemistry 7th edn. W. H. Freeman & Co.New York.
8. Wink M. (2006) An Introduction to Molecular Biotechnology, Wiley-VCH Verlag Gmbh & Co., Weinheim, Germany
9. Weaver, RF (1999) Molecular Biology, WCB McGraw-Hill Co. Inc., NY (ISBN:

0-697- 14750-9).

10. Nelson DL & Cox MM (2005) Lehninger's Principles of Biochemistry, 4th edn., McMillan Worth Publ. Inc. NY.
11. Russell, PJ (1998) Genetics, 5th edn, Benjamin-Cummings Publ. Co. Inc., NY
12. Klug, WS and Cummings, MR (2003) Concepts of Genetics, 7th edn., Pearson Education Inc.,
13. David Plummer, (2017) An Introduction to Practical Biochemistry | 3rd Edition McGraw Hill

*****

MOLECULAR IMMUNOLOGY

MIC/UD/MJ/601T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives for Molecular Immunology

1. **Fundamental Concepts**: To provide students with a thorough understanding of the basic principles of immunology, including the molecular and cellular components of the immune system.
2. **Immune System Mechanisms and Signal Transduction**: To explore the mechanisms of immune recognition, response, and regulation at the molecular level and To introduce students to the signaling pathways involved in immune cell activation and regulation
3. **Molecular Techniques**: To familiarize students with the molecular techniques and methodologies used in immunology research, including flow cytometry, ELISA, and PCR.
4. **Immune Disorders**: To provide insights into the molecular basis of immune disorders.
5. **Vaccines and Immunotherapy**: To discuss the development and application of vaccines and immunotherapies based on molecular immunology principles.

Course Outcomes for Molecular Immunology

1. **Comprehensive Knowledge**: Students will demonstrate a comprehensive understanding of the fundamental concepts and principles of molecular immunology.
2. **Signal Transduction Pathways**: Students will be able to describe the key signaling pathways involved in immune cell activation and regulation.
3. **Proficiency in Molecular Techniques**: Students will gain proficiency in using molecular techniques commonly employed in immunology research and be able to interpret the results.
4. **Understanding Immune Disorders**: Students will be able to identify and explain the molecular basis of various immune disorders and their clinical implications.
5. **Application of Immunology Principles**: Students will be knowledgeable about the development and application of vaccines and immunotherapies, understanding their molecular underpinnings.

Unit I:

Overview of Immune system-cells and organs of Immune system. Three fundamental concepts in immunology: Specificity, discrimination of self from non-self and memory.

Immunoglobulins: Structure and function of immunoglobulins**.** Molecular mechanisms responsible for generating diversity of antibodies and T cell receptors

Immune cell receptors: Detailed structure and development of B cell (Ig) and T cell (TcR) receptors;, cellular adhesion molecules (ICAM, VCAM, MadCAM, selectins, integrins); Pattern Recognition Receptors (PRRs) and Toll-like receptors (TLR).

Hybridoma technology and monoclonal antibodies, antibody engineering.

Unit II

Immune response and signaling: overview of Humoral and cell-mediated immune response; Innate immune response and pattern recognition; Antigen processing and presentation.

Tolerance and autoimmunity: Central and peripheral tolerance, and their mechanism; Mechanisms of autoimmunity; Autoimmune components of diabetes mellitus (DM), multiple sclerosis (MS), experimental autoimmune encephalitis (EAE).

Immunological disorders and hypersensitivity: Deficiencies / defects of T cells, B cells, complement and phagocytic cells; Comparative study of Type I-V hypersensitivities with examples.

Unit III

Transplantation immunology: Alloreactive response; Genetic organization of MHC-I and MHC-II complex (both HLA and H-2). Structure of CD4, CD8, MHC-I, MHC-II molecules Graft rejection and GVHD; HLA-matching; Immune Mechanism underlying graft rejection.

Complement Proteins: complement activation pathways and the role of complement in immune response.

Immunological Techniques: Application and Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, Western blotting, Radioimmunoassay Immunofluorescence, ELISA, ELISPOT.

MOLECULAR IMMUNOLOGY LAB COURSE

MIC/UD/MJ/601P **Credits 2** **Marks 50 (30 hrs)**

1. Diagnostic immunologic principles and methods

Precipitation method

- Immunodiffusion.
- Immunoelectrophoresis.

Agglutination method

- Widal test.
- Haemagglutination.
- ELISA method.

2. Separation of serum protein by submerged agarose gel electrophoresis.

3. Purification of human immunoglobulins from serum and confirmation of its antigenicity.

4. Identification of *S. typhi* by serotyping. [Purification of H and O antigens from *S.typhi*]

5. Clinical diagnosis of Rheumatoid arthritis by purifying immunoglobulins and albumins and confirmation by lattice agglutination test.

6. Estimation of Alkaline phosphatase from patient's serum.

REFERENCE:

1. Essential of Immunology by Riott I. M. 1998. ELBS, Blackwell Scientific Publishers, London.
2. Immunology 2 nd Edition by Kuby J. 1994. W. H. Freeman and Co. New York.
3. Immunology – Understanding of Immune System by Claus D. Elgert. 1996. Wiley –Liss , New York.
4. Fundamentals of Immunology by William Paul.
5. Cellular and Molecular Immunology. 3 rd Edition by Abbas.
6. Immunobiology: The immune system in Health and Diseases. 3rd edition by Travers.
7. Immunology – A short course. 2 nd Edition by Benjamin.
8. Manual of clinical laboratory and Immunology 6th Edition. 2002 by Noel R. Rose, Chief editor: Robert G. Hamilton and Barbara Detrick (Eds.), ASM publications.
9. Pocket Guide to Clinical Microbiology. 2 nd Edition. 1998 by Patrick R. Murray. ASM Publications

BIOPROCESS ENGINEERING AND TECHNOLOGY

MIC/UD/MJ/602 T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives:

1. **Fundamental Principles**: To provide students with a solid understanding of the fundamental principles of bioprocess engineering, including the basics of biological systems and chemical engineering principles.
2. **Bioreactor Design and Operation**: To teach students about the design, operation, and optimization of bioreactors and other bioprocess equipment.
3. **Downstream Processing**: To introduce the principles and techniques involved in the recovery and purification of bioproducts.
4. **Bioprocess Control and Monitoring**: To provide knowledge on the various control and monitoring techniques used to ensure efficient and stable bioprocess operations.
5. **Scale-up and Scale-down**: To discuss the principles and challenges involved in scaling up and scaling down bioprocesses from laboratory to industrial scale.

Course Outcomes:

1. **Understanding of Bioprocess Principles**: Students will demonstrate a comprehensive understanding of the fundamental principles of bioprocess engineering and technology.
2. **Proficiency in Bioreactor Design**: Students will be able to design, operate, and optimize bioreactors and other bioprocess equipment for various applications.
3. **Downstream Processing Skills**: Students will gain proficiency in the principles and techniques of downstream processing for the recovery and purification of bioproducts.
4. **Bioprocess Control and Monitoring**: Students will be able to implement and utilize various control and monitoring techniques to ensure efficient and stable bioprocess operations.
5. **Scale-up and Scale-down Proficiency**: Students will understand the principles and challenges of scaling up and scaling down bioprocesses, and be able to apply these principles in practical scenarios.

Unit-I: Introduction to Industrial Bioprocess Engineering and growth kinetics

Definition of bioprocess engineering, bioprocess engineer, biotechnology and bioprocess engineering, approach of biologist and engineers towards research, regulatory constraints of bioprocess. Batch growth (growth pattern and kinetics in batch culture, environmental factors affecting growth kinetics), Monod's equation, continuous culture, Chemostat and turbitostat (construction and working), mixed culture in nature and its industrial utilization.

Unit-II : Bioreactor and Mass transfer

Design of basic bioreactor, individual parts, baffles, impellers, foam separators, spargers, culture vessel, cooling and heating devices, probes for on-line monitoring, computer control of fermentation process, Ideal batch reactor, ideal continuous flow stirred tank reactor, packed bed reactor, bubble column reactor, fluidized bed bioreactor, Trickle bed reactor (Their basic construction, working, and distribution of gases).

Transport phenomena in bioprocess system: Gas liquid mass transfer in cellular systems, basic mass transfer concept, Rate of metabolic oxygen utilization, Determination on oxygen transfer rates, determination of K_La, aeration / agitation and its importance.

Unit III: Upstream and downstream processes

Upstream processes: Formulation of production media, Sterilization of bioreactors, nutrients and air supply, Inoculum development, maintenance of stock culture, scale up of the process from shake flask to industrial level, immobilization of cell systems.

Downstream processes: Recovery of particulates (filtration, centrifugation, sedimentation, emerging technologies for cell recovery), product isolation , extraction, solvent extraction , aqueous two phase system , sorption , precipitation , reverse osmosis, ultra filtration.

BIOPROCESS ENGINEERING AND TECHNOLOGY LAB COURSE

MIC/UD/MJ/602 P **Credits 2** **Marks 50 (30 hrs)**

1. Isolation of industrially important microorganisms for microbial processes (citric / lactic/ alpha amylase) and improvement of strain for increase yield by mutation.
2. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) for microorganisms for design of a sterilization process.
3. [A] Determination of growth curve of a supplied microorganism and also determine substrate degradation profile. [B] Compute specific growth rate (m), growth yield (Y1/2) from the above.
4. Extraction of Citric acid / Lactic acid by salt precipitation.
5. Monitoring of dissolved oxygen during aerobic fermentation.
6. Preservation of industrially important bacteria by lyophilization.
7. Product concentration by vacuum concentrator.
8. Cell disruption for endoenzymes by sonication.

REFERENCES:

1. James E .Bailey and David F Ollis, Biochemical Engineering Fundamentals, McGraw Hill Publication.
2. Shuler and Fikret Kargi, Bioprocess Engineering basic concepts, 2nd edition , Prentice Hall Publication.
3. Stanbury PF, Whitekar, A And Hall SJ, Principles of fermentation Technology, Pergamon Press. 4. Peppler and Perlmen , Microbial Technology, Vol I and II , Academic Press.
5. Cruger and Cruger , Biotechnology : A text Book of Industrial Microbiology.
6. Fermentation- A practical Approach
7.Bioprocess Technology: Fundamentals and Applications, Stockholm KTH.
8. Biochemical Reactors by Atkinson B., Pion Ltd. London
9. Fermentation Biotechnology: Industrail Perspectives by S. Chand and Co.
10. Biotechnology : A text book of Microbiology by Cruger
11.Biotechnology, Vol. 3 Edited by H.J. Rehm and G.Reed Verlag Chemie 1983.
12. Advances in Biochemical Engineering by T.K. Bhosh, A. Fiechter and N. Blakebrough, Springer, Verlag Publications, New York.
13. Bioprocess Engineering Kinetics, Mass Transport, Reactorsand Gene Expressions by Veith, W.F., John Wiley and Sons.
14. Applied Microbiology Series.
15. Industrial Microbiology by L.E. Casida, Wiley Eastern.

16. Bioseparation: Down Stream Processing for Biotechnology by Belter P.A., Cussler E.L. and Hu W.S., John Wiley and Sons, New York.

17. Separation Processes in Biotechnology by Asenjo J.A., Eds. Marcel dekker, New York.

18. Bioprocess Engineering Priciples by Doran, Academic Press, London.

19. Bioprocess Engineering Principles by Neilsen J. and Villadesen, Plenum Press, New York.

20. Fermentation, Biocatalysis and Bioseperation, Encyclopedia of Bioprocess technology by Chisti Y., Vol. 5, John Wiley and Sons., New York.

ENVIRONMENTAL MICROBIAL TECHNOLGY

MIC/UD/MJ/603T **Credits 2** **Marks 50 (30 hrs)**

Course Objective:

The course objective is to learn the principles of an environment, the interaction of organisms with the environment and other organisms. Role of microorganisms in control of environmental damage.

Course Outcomes:

The student after completion of the course will be able to:

1. Get acquainted with the environment, ecosystems and natural habitats.
2. Understand how organisms interact among themselves and with other organisms and various environmental factors.
3. Understand the important role microbes play in an ecosystem and its significance.
4. Get in-depth knowledge of different types of solid-liquid waste and their management.
5. Get familiar with pollution problems and technologies to overcome the problems.

Unit – I Environment and Ecosystems

Definitions, biotic and abiotic environment. Interaction between biota and its environment, Environmental segments. Composition and structure of the environment. Concept of Habitat, Concept of biosphere, communities and ecosystems. Ecosystem characteristics structure and function. Terrestrial and Aquatic ecosystem,

Food chains, food webs and trophic structures. Ecological pyramids. Homeostasis of the ecosystem, Ecological Succession, Biodiversity and its conservation,

Unit – II Water pollution and eutrophication

Water pollution and its control: Need for water management. Sources of water pollution. Measurement of water pollution.

Eutrophication: Definition, causes of eutrophication, and microbial changes in eutrophic bodies of water induced by various inorganic pollutants. Effects of eutrophication on the quality of water environment, Qualitative characteristics and properties of eutrophic lakes, factors influencing eutrophication. Measurement of degree of eutrophication. Physicochemical and biological measures to control eutrophication.

Microbiology of wastewater and solid waste treatment: -Waste-types-solid and liquid waste characterization, physical, chemical, biological: aerobic, anaerobic, primary, secondary and tertiary treatments. Aerobic processes: Activated sludge, Trickling filters. Anaerobic processes: Anaerobic digestion, anaerobic filters.

Unit – III Bioremediation of Xenobiotics and Environmental problems 15 L

Definition of recalcitrant/ xenobiotic compounds, their presence in the natural ecosystem, Concept and consequences of biomagnification of DDT, Microbiology of degradation of xenobiotics in the environment, ecological considerations, Challenges in xenobiotic degradation.

Concept of sustainable development. Need and Role of Microbial technology for achieving sustainable development, Improving and restoration of Barron/ degraded lands. Greenhouse effect and acid rain, their impact.

Genetically Modified Organisms released and its environmental impact assessment and ethical issues.

REFERENCES:

1. Bioremediation by Baker K.H. and Herson D.S. 1994, McGraw Hill Publications, New York.
2. Waste Water Engineering- Treatment, Disposal and Re-use by Metcalf and Eddy, Tata McGraw Hill, New York
3. Pollution: Ecology and Biotreatment by Ec Eldowney S., Hardman D.J. 1993 Longman Scientific Technical.
4. Environmental Microbiology edited by Ralph Mitchell, John Wiley and Sons., New York.
5. Waste Water Microbiolgy, 2 nd Edition by Bitton.
6. Chemistry and Ecotoxicology of Pollution, Edited by Des. W. Connell, G.J. Miller, Wiley Interscience Publications.
7. Environmental Biotechnology Edited by C.F. Forster and D.A. John Wase, Ellis Horwood Ltd.
8. Advances in Waste water Treatment Technologies 1998 Vol. I and II by R.K. Trivedy, Global Science Publications.
9. Biocatalysis and Biodegradation: Microbial transformations of organic compounds. 2000, by Lawrence P. Wacekett, C. Douglas Hershberger, ASM Publications
10. A Manual of Environmental Microbiolgy 2 nd edition 2001 by Christon J. Hurst(Chief Editor), ASM Publications.
11. Biodegradation and Bioremediation, Academic Press, San Diego.
12. Biotechnology in the sustainable environment, Plenum Press, New York.
13. Basic Principles of Geo Microbiology by A.D. Agate, Pune.

BIOENTRENEURSHIP AND IPR

MIC/UD/DSE/604 A T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives:

1. **Understanding Bio-Entrepreneurship:**
    - Comprehend the fundamentals of entrepreneurship within the microbiology and biotechnology sectors.
    - Learn the process of starting and managing a microbiology-based business.
2. **Business Planning and Strategy:**
    - Develop skills to create effective business plans and strategies tailored to the microbiology industry.
    - Understand market analysis, funding strategies, and business development in microbiology.
3. **Intellectual Property Rights (IPR):**
    - Gain knowledge about various types of intellectual property (IP) and their importance in microbiology.
    - Learn about the processes involved in securing and managing IPR for microbiological innovations.
4. **Ethical and Social Considerations:**
    - Understand ethical issues and social responsibilities related to bio-entrepreneurship in microbiology.
    - Learn to navigate the ethical challenges in microbiology commercialization.

Course Outcomes:

1. **Entrepreneurial Skills:**
    - Ability to identify and evaluate business opportunities in the microbiology sector.
    - Competence in creating and presenting a comprehensive business plan for microbiology-based ventures.
2. **IPR Management:**
    - Proficiency in understanding and managing intellectual property rights specific to microbiology.
    - Ability to navigate patent applications, trademarks, and copyrights for microbiological innovations.
3. **Regulatory Knowledge:**
    - Comprehensive understanding of the regulatory requirements for microbiology products and businesses.
    - Skills to ensure compliance with relevant laws and regulations.
4. **Ethical and Social Awareness:**
    - Increased awareness of ethical considerations in microbiology.
    - Ability to make informed decisions that consider social impact and ethical implications.

UNIT I:

Introduction to Bio-Entrepreneurship

- Overview of microbiology and entrepreneurship
- Characteristics of successful bio-entrepreneurs
- Case studies of microbiology startups

Business Planning and Strategy

- Elements of a microbiology business plan
- Market analysis and competitive landscape
- Funding strategies: venture capital, angel investors, grants

UNIT II: IPR and Regulatory Aspects

Intellectual Property Rights (IPR)

- Types of intellectual property: patents, trademarks, copyrights, trade secrets
- Patent filing process and strategies
- IP management and licensing for microbiological innovations

Regulatory and Legal Aspects

- Overview of biotech regulations specific to microbiology
- Regulatory bodies and compliance requirements
- Legal structures for microbiology companies

Commercialization and Technology Transfer

- Pathways for commercialization of microbiological innovations
- Technology transfer offices and their roles
- Licensing agreements and partnerships

UNIT III

Ethical and Social Considerations

- Ethical issues in microbiology and bio-entrepreneurship
- Social impact of microbiological innovations
- Navigating ethical dilemmas in business decisions

Case Studies

- Analysis of successful and failed microbiology startups

Case Studies:

Biocon India

- **Overview:** Explore the journey of Biocon, India's leading biopharmaceutical company, from its inception to becoming a global player.
- **Focus:** Examine the entrepreneurial strategies of founder Kiran Mazumdar-Shaw, challenges faced, and the company’s growth in the Indian and global markets.

- **Reference:**"Biocon India Group: A Pioneer in the Biopharmaceutical Industry" - Harvard Business School Case Study.

Genentech

- **Overview:** Investigate the founding and growth of Genentech, one of the first biotechnology companies.
- **Focus:** Understand the role of innovation and venture capital in the company's early years, and its impact on the biotech industry.

Reference:"Genentech: After the Acquisition by Roche" - Harvard Business School Case Stud

Ginkgo Bioworks

- **Overview:** Study the business model and strategy of Ginkgo Bioworks, a company specializing in custom microorganisms for industrial applications.
- **Focus:** Analyze their business plan development, market research, and competitive analysis.
- **Reference:**"Ginkgo Bioworks: Organism Company" - Harvard Business School Case Study.

Bharat Biotech

- **Overview:** Examine Bharat Biotech's approach to vaccine development, particularly the launch of the COVID-19 vaccine, Covaxin.

Reference:"Bharat Biotech: Innovating at the Frontier" - Indian School of Business F**ocus:** Discuss regulatory challenges, business planning, and the strategies employed to bring the vaccine to market in India Case Study.

Guest Lectures and Industry Interaction

- Guest lectures from industry experts and successful bio-entrepreneurs in microbiology
- Networking opportunities with industry professionals
- Insights into current trends and future directions in bio-entrepreneurship and IPR in microbiology

BIOENTRENEURSHIP AND IPR

MIC/UD/DSE/604 A P **Credits 2** **Marks 50 (30 hrs)**

1. Market Research Techniques

Lab Activity: Develop a market research survey and analyze the results. By conducting surveys and interviews, analyzing market trends and identifying target markets.

2. Competitive Analysis

Lab Activity: Perform a SWOT analysis for a selected biotechnology company. By Identifying competitors and performing the SWOT analysis (Strengths, Weaknesses, Opportunities, Threats)

3. Business Plan Development

Lab Activity: Draft a business plan for a hypothetical biotechnology startup. By preparing an executive summary, product or service description, market analysis, marketing, and sales strategies

4 Financial Projections and Budgeting

Lab Activity: Create financial projections and budgets for a biotechnology business plan. By creating Income statements, doing cash flow analysis and break-even analysis

5. Funding Strategies

Lab Activity: Prepare a funding proposal for a biotechnology startup. Using various types of funding (venture capital, angel investors, grants, etc.) and
preparing funding proposals

6. Financial Risk Management

Lab Activity: Analyze financial risks and develop mitigation strategies for a biotechnology venture. By identifying financial risks and using risk mitigation strategies.

7. Pitching to Investors

Lab Activity: Develop and deliver a pitch deck to a mock panel of investors. By crafting an elevator pitch, preparing pitch decks and using effective communication skills

8. Regulatory Considerations

Lab Activity: Research and present regulatory requirements for a specific biotechnology product in different markets. By using an overview of biotechnology regulations (global and Indian perspectives) and compliance and regulatory strategies

9. Strategic Planning and Execution

Lab Activity: Create a strategic plan for a biotechnology startup and outline key performance indicators (KPIs). By setting business goals and objectives, developing strategic initiatives and monitoring & evaluating business performance

Textbooks and Reference Books:

1. Biotechnology Entrepreneurship: Bootcamp for Scientists" edited by Michael S. Kinch
2. Building Biotechnology: Biotechnology Business, Regulations, Patents, Law, Policy, and Science" by Yali Friedman
3. The Business of Biotechnology: From the Bench to the Street" by R. Mark Adams
4. Bioentrepreneurship: Principles and Practice" edited by Hermann J. Heipieper, Jurgen Springer, and Thomas Steinbuchel
5. From Bench to Market: The Evolution of Chemical Synthesis" by K. C. Nicolaou
6. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies" by Craig Shimasaki
7. Biotechnology Entrepreneurship: From Science to Solutions" by Cynthia Robbins-Roth
8. Bioentrepreneurship: The Scientist's Role in Commercializing Innovation" by Craig D. Shimasaki
9. Entrepreneurship for Scientists and Engineers" by Paul J. H. Schoemaker and Steven C. Rogers
10. Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs" by Rodney J.Y. Ho and Milo Gibaldi
11. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries.

Articles & Case Studies:

1. "Biocon India Group: A Pioneer in the Biopharmaceutical Industry" - Harvard Business School Case Study
2. "Genentech: After the Acquisition by Roche" - Harvard Business School Case Study
3. "Ginkgo Bioworks: Organism Company" - Harvard Business School Case Study
4. "Bharat Biotech: Innovating at the Frontier" - Indian School of Business Case Study
5. "Moderna: Beyond COVID-19" - Harvard Business School Case Study
1. "Dr. Reddy's Laboratories: Realizing a Vision" - Harvard Business School Case Study

Online Resources:

- Coursera: Biotechnology Entrepreneurship Specialization
- MIT OpenCourseWare: New Enterprises

AGRICULTURAL MICROBIOLOGY

MIC/UD/DSE/604 B T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives for Agricultural Microbiology

1. **Introduction to Microbial Biofertilizers and Biopesticides**: To provide students with a thorough understanding of the principles, concepts, and types of microbial biofertilizers and biopesticides.
2. **Microbial Interactions with Plants**: To explore the beneficial interactions between microorganisms and plants, including mechanisms of nutrient uptake and pest resistance.
3. **Production and Formulation**: To teach students the methods of producing and formulating microbial biofertilizers and biopesticides for agricultural use.
4. **Application Techniques**: To familiarize students with the various application techniques and best practices for using microbial biofertilizers and biopesticides in different crops and environments.

Course Outcomes for Course Outcomes for Agricultural Microbiology

1. **Understanding of Biofertilizers and Biopesticides**: Students will demonstrate a comprehensive understanding of the principles, types, and roles of microbial biofertilizers and biopesticides in agriculture.
2. **Knowledge of Plant-Microbe Interactions**: Students will be able to explain the beneficial interactions between microorganisms and plants, including how these interactions enhance nutrient uptake and pest resistance.
3. **Proficiency in Production and Formulation**: Students will gain practical skills in the production and formulation of microbial biofertilizers and biopesticides, including culture techniques and formulation strategies.
4. **Application Skills**: Students will be proficient in the application techniques of microbial biofertilizers and biopesticides, understanding how to apply them effectively in different agricultural settings.

UNIT-I

a) **Introduction to biofertilizers**, Biofertilization processes - Decomposition of organic matter and soil fertility and vermicomposting. Mechanism of phosphate solubilization and phosphate mobilization. Nitrogen fixation - Free living and symbiotic nitrogen fixation. Ecto and endomycorrhizae and their importance in agriculture. Biotechnological application in nitrogen fixation.

b) **Microorganisms as biofertilizers:** Biofertilizers and symbiotic associations; Rhizobium - taxonomy, physiology, host-*Rhizobium* interaction, mass cultivation; Associative and non symbiotic association-*Azospirillum, Azotobacter*, Cyanobacteria (Nostoc and Anabaena) Mycorrhiza and actinorrhiza in plant nutrition and stress tolerance; Interaction of mycorrhiza with *Rhizobium* and *Pseudomonas;* Commercial production of biofertilizers, formulations and BIS specifications; their applications and limitations for Indian agriculture.

UNIT-II

Nitrogenous Biofertilizers - Isolation and purification of Azospirillum and Azotobacter, mass multiplication of Azospirillum and Azotobacter, formulation of inoculum of Azospirillum and Azotobacter, application of inoculants of Azospirillum and Azotobacter. Isolation and purification of Rhizobium, mass multiplication and inoculum production of Rhizobium, Methods of application of Rhizobium inoculants.

UNIT-III

Microorganisms as biopesticides: Microbiology of plant surfaces; Principles and mechanism of biological control; biocontrol agents for insect pest and weed control. Commercial production of biopesticides with reference to *Bacillus thuringiensis*; integrated pest management; Their applications and limitations for Indian agriculture

AGRICULTURAL MICROBIOLOGY LAB COURSE

MIC/UD/DSE/604 B P **Credits 2** **Marks 50 (30 hrs)**

1. Isolation of *Azotobacter sp*.from rhizospheric soils
2. Isolation of *Rhizobium sp*. from root nodules of leguminous plants
3. Isolation of *Azospirillum* sp.
4. Mass production of *Azotobacter/Rhizobium/ Azospirillum*
5. Preparation and application of *Azotobacter/Rhizobium/ Azospirillum biofertillizer*

Reference Books :

- Bagyaraj, D.J. and A. Manjunath. 1990. Mycorrhizal symbiosis and plant growth, Univ. of Agricultural Sciences, Bangalore, India.
- Purohit, S.S., P.R. Kothari and S.K. Mathur, 1993. Basic and Agricultural Biotechnology, Agro Botanical Pub. India.
- Subba Rao, N. S. 1988. Biological nitrogen fixation: recent developments, Mohan Primlani for Oxford and IBH Pub. Co. (P) Ltd., India.
- Subba Rao, N.S., G.S. Venkataraman and S. Kannaiyan 1993. Biological nitrogen fixation, ICAR Pub., New Delhi.
- Somani, L.L., S.C. Bhandari, K.K. Vyas and S.N. Saxena. 1990. Biofertilizers, Scientific Publishers - Jodhpur.
- Tilak, K.V.B. 1991. Bacterial Biofertilizers, ICAR Pub., New Delhi.
- Agrios G. N. 1997. Plant Pathology. Academic Press, San Diego.
- Cook R. J. & Baker K. F. 1983. The Nature and practice of Biological Control of Plant Pathogens.
- Amereca Phytopathological Society Press, St. Paul, MN.
- Forster C. F. & John DA 2000. Environmental Biotechnology. Ellis Horwood Ltd. Publication.
- Christon J. H. 2001. A Manual of Environmental Microbiology. ASM Publications.
- Rao, N.S.S. 1999. Soil Microbiology. Oxford & IBH Publishing Co., New Delhi.
- The nature and properties of soil. Authors- Harry buckman and Nyle C. brady.
- Introduction to soil Microbiology Internationals. Authors- Martin Alexander.

MIC-UD/DSE/604 C T **Credits 4** **Marks 50 (30 hrs)**

A) Any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }

MIC-/UD/RM/605

On Job Training/ Field Project

RECOMBINANT DNA TECHNOLOGY

MIC/UD/MJ/650T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives for Recombinant DNA Technology

1. **Fundamentals of Genetic Engineering**: To introduce students to the basic principles and concepts of genetic engineering and recombinant DNA technology.
2. **Molecular Biology Techniques**: To familiarize students with essential molecular biology techniques, including DNA extraction, cloning, and transformation.
3. **Gene Manipulation**: To provide knowledge on gene manipulation methods, including restriction digestion, ligation, and polymerase chain reaction (PCR).
4. **Vector Design and Selection**: To teach students about the design, selection, and application of vectors used in recombinant DNA technology.
5. **Applications of Recombinant DNA Technology**: To discuss various applications of recombinant DNA technology in medicine, agriculture, and industry.

Course Outcomes for Recombinant DNA Technology

1. **Understanding of Genetic Engineering Principles**: Students will demonstrate a solid understanding of the basic principles and concepts of genetic engineering and recombinant DNA technology.
2. **Proficiency in Molecular Biology Techniques**: Students will gain proficiency in essential molecular biology techniques, including DNA extraction, cloning, and transformation.
3. **Gene Manipulation Skills**: Students will be able to perform gene manipulation techniques such as restriction digestion, ligation, and PCR.
4. **Vector Utilization**: Students will understand the design, selection, and application of vectors used in recombinant DNA technology.
5. **Application Awareness**: Students will be knowledgeable about the various applications of recombinant DNA technology in different fields such as medicine, agriculture, and industry.

Unit – 1 Introduction, Core technique and Enzymes in gene manipulation

Classical genetics to Modern Genetics, Approaches to genetic engineering, advantages and limitations, Common steps and core technique. Enzymes in gene manipulations (DNA/RNA): Classification, types, properties and mechanism of action of-Restriction endonuclease, ligase (T4 & E.coli ligase), Reverse transcriptase. Role of alkaline phosphatase, polynucleotide kinase, Nucleotidyl transferase, Bal 31 and S1 nuclease, DNA polymerase, RNAse , Ribozymes etc. in gene manipulation, Site directed mutagenesis.

Unit-2 Tools and Techniques involved in genetic engineering

Restriction mapping, DNA sequencing-Maxam-Gilbert, Sanger's dideoxy and automated methods of DNA sequencing. Gene silencing, Principle, technique and applications of chromosome walking, chromosome jumping, RFLP, RAPD, AFLP, DNA fingerprinting

PCR alternative to gene cloning- advantages, principle and Procedure, optimization of PCR, Designing of primers, Identification of PCR products, Variations in basic PCR- Inverse, asymmetrical, multiplex, Hot start, ligation mediated, RT , Real-time quantitative PCR, and Immuno PCR.

Unit-3 Vectors used in gene cloning

Strategies of -Cloning vectors and expression vectors

Vectors of E.coli: Plasmid vectors: Properties of plasmids, PBR 322-genetic evolution, map and function, pUC vectors

Phage vectors: Lambda phage vectors, M13 mp vectors

High capacity vectors: Cosmids, Phagmid, BAC, YAC, blue script vectors

High level expression/production vectors, Shuttle vectors: SV 40 plasmid vectors, retrovirus vectors.

Vectors of plant: Ti plasmid vector

Isolation of gene of desired interest: Physical and Enzymatic

Chemical synthesis of genes and methods of joining the fragments into vectors, Ideal hosts in gene cloning, Different methods of transformation, Isolation of recombinant clones.

Construction of genomic and cDNA libraries: concept of library construction,

Selection and Identification of clones containing recombinant vectors: Selectable and scorable markers, Insertional inactivation, colony hybridization, plaque lift assay,

Southern hybridization, Northern hybridization, Screening for protein expression- Reporter gene expression, Phage display.

RECOMBINANT DNA TECHNOLOGY LAB COURSE

MIC/UD/MJ/650P **Credits 2** **Marks 50 (30 hrs)**

1. Isolation of Genomic DNA from E. coli
2. Agarose Gel Electrophoresis.
3. Isolation of Plasmid DNA from E. coli.
4. DNA Denaturation and Determination of Tm and G + C content of Genomic DNA of E. coli.
5. Restriction Digestion of λ DNA.
6. Gene Cloning
7. Southern Hybridization.
8. RAPD – Rapid Amplification of Polymorphic DNA
9. RFLP Analysis.

References

1. Principles of Gene Manipulations 1994 by Old and Primrose Blackwell Scientific Publications.
2. DNA Cloning: A Practical Approach by D.M. Glower and B.D. Hames, IRL Press, Oxford. 1995.
3. Molecular Biotechnology 2nd Edition by S.B. Primrose. Blackwell Scientific Publishers, Oxford. 1994.4. Genetic Engineering and Introduction to Gene Analysis and Exploitation in Eukaryotes by S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford 1998.
5. PCR Technology - Principles and Applications for DNA Amplification by Henry A. Erlich (Ed.) Stockton Press. 1989.
6. Biotechnology: A Guide to Genetic Engineering by Peters.
7. Weaver Molecular Biology.
8. Genetic Engineering – 2000 by Nicholl.
9. Recombinant DNA and Biotechnology: Guide for Teachers. 2nd Edition by Helen Kreuz. 2001.ASM Publications.
10. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 2 nd Edition. 1998 by Bernard R. Glick and Jack J. Pastemak, ASM Publications.
11. From genes to clones by Winnaker.
12. Manipulations and expression of recombinant DNA by Robertson.
13. Gene targeting – A practical approach by Joyner.

FERMENTATION TECHNOLOGY

MIC/UD/MJ/651T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives for Fermentation Technology

1. **Fundamentals of Fermentation**: To provide students with a comprehensive understanding of the basic principles of fermentation processes, including microbial growth, metabolism, and the biochemical pathways involved.
2. **Types of Fermentation**: To familiarize students with different types of fermentation processes, including batch, fed-batch, and continuous fermentation, and their respective advantages and applications.
3. **Product Recovery and Purification**: To educate students on the methods of downstream processing, including product recovery, purification, and quality control of fermentation products.
4. **Industrial Applications**: To expose students to the industrial applications of fermentation technology in various sectors such as pharmaceuticals, food and beverages, biofuels, and waste treatment.

Course Outcomes for Fermentation Technology

1. **Understanding of Fermentation Principles**: Students will be able to explain the fundamental principles of microbial fermentation and the biochemical pathways involved.
2. **Proficiency in Fermentation Types**: Students will be able to distinguish between different types of fermentation processes and select the appropriate method for specific industrial applications.
3. **Downstream Processing Knowledge**: Students will gain knowledge in downstream processing techniques for the recovery and purification of fermentation products, ensuring product quality and compliance with industry standards.
4. **Application of Fermentation Technology**: Students will understand the wide range of industrial applications of fermentation technology and be able to apply this knowledge in real-world scenarios.

Unit – 1 Microbial Fermentations

Strain Improvement Programme, Media formulation, industrial production, Downstream Processing, Biosynthesis, Regulation and metabolic control of:

Organic acid -Citric acid, Enzyme –proteases, Organic solvent - Vinegar fermentation, Amino acids - glutamic acid.

Therapeutic compounds (Streptomycin, Rifamycin and Tetracycline), Biotransformation of steroids and antibiotics, Vitamin B12 and riboflavin fermentation.

Unit – 2 Modern trends in microbial production:

Modern trends in microbial production of bioplastics (PHB, PHA), biopolymer (dextran and xanthan), Biosurfactants, Single Cell Protein and single cell oil and Biofuel (Biomethane, bioethanol, biohydrogen and biodiesel)

Unit – 3 IPR and Patents

Intellectual Property Rights (IPR), Patents - Patenting of biological materials, obligations with patent applications, implication of patenting, current issues, hybridoma technology etc., Trademarks, Copyrights, Secrets, Trademarks and geographical indications; IPR and plant genetic resources (PGRs) Patenting of higher plants and animals, transgenic organisms and isolated genes, patenting of genes and DNA sequences, plant breeders right and farmers rights.

FERMENTATION TECHNOLOGY LAB COURSE

MIC/UD/MJ/651P **Credits 2** **Marks 50 (30 hrs)**

1. Citric acid fermentation by using *A. niger*,
   a. Production and purification.
   b. Qualitative detection by titratable acidity and paper chromatography.
   c. Quantitative estimation of citric acid by Pentabromoacetone method.
   d. Effect of different carbon, nitrogen sources and metal ions on citric acid production.
2. Microbial production of glutamic acid.
3. Production, purification and bioassay of Rifamycin/Streptomycin.
4. a. Production, distillation and estimation of ethanol using various Organic wastes /raw Material (e.g. agro wastes, different fruit juices, etc.) from free cells of yeast.
   b. Ethanol fermentation using immobilized yeast cells.
5. Microbial production, purification, qualititative and quantitative estimation of polysaccharide from Leuconostoc mesenteroides/ Pseudomonas
8. Microbial production of single cell protein by algae/bacteria/yeast.
9. Bioassay of vitamin B12/B2.

References: -

1. Biotechnological Innovations in Chemical Synthesis. BIOTOL. Publishers / Butterworth - Heinemann.
2. Industrial Microbiology by G. Reed (Ed), CBS Publishers (AVI Publishing Co.)
3. Biology of Industrial Microorganisms by A.L. Demain.
4. Genetics and Biotechnology of Industrial Microorgansims by C.l. Hershnergey, S.W.Queener and Q. Hegeman. Publisher. ASM. Ewesis ET. Al. 1998. Bioremediation Principles. Mac Graw Hill.
5. Annual Reports in Fermentation Processes by D. Pearlman, Academic Press.
6. Fundamentals of Biochemical Engineering by Bailey and Ollis.
7. Annual Review of Microbiology by Charles E. Cliffton (Volumes)
8. Biotechnology, A textbook of industrial Microbiology by Creuger and Creuger, Sinaeur associates.
9. Manual of industrial Microbiology and Biotechnology 2nd edition by Davis J.E. and Demain A.L. ASM publications.

ENZYME TECHNOLOGY

MIC/UD/DSE/652T **Credits2** **Marks50(30 hrs)**

Course Objectives:

1. **Fundamentals of Enzyme Technology:**
   - Understand the basic principles of enzyme structure, function, and kinetics.
   - Learn about the role of enzymes in biological systems and industrial processes.
2. **Enzyme Production and Purification:**
   - Gain knowledge of various methods used for the production and purification of enzymes.
   - Understand the techniques for enzyme isolation, characterization, and assay.
3. **Enzyme Catalysis and Mechanisms:**
   - Study the mechanisms of enzyme catalysis and the factors affecting enzyme activity.
   - Learn about enzyme-substrate interactions and enzyme inhibition.
4. **Applications of Enzymes:**
   - Explore the diverse applications of enzymes in industries such as pharmaceuticals, food and beverage, textiles, and biofuels.
   - Understand the use of enzymes in medical diagnostics and therapy.

Course Outcomes:

1. **Comprehensive Understanding of Enzyme Function:**
   - Ability to describe the structure and function of enzymes and explain the principles of enzyme kinetics.
   - Proficiency in understanding the role of enzymes in metabolic pathways and industrial applications.
2. **Proficiency in Enzyme Production and Purification:**
   - Skills to produce and purify enzymes using various biotechnological methods.
   - Ability to perform enzyme assays and characterize enzyme activity.
3. **Expertise in Enzyme Catalysis:**
   - Knowledge of enzyme catalysis mechanisms and factors affecting enzyme function.
   - Ability to analyze enzyme kinetics data and understand enzyme inhibition.
4. **Application of Enzymes in Industry:**
   - Understanding of how enzymes are used in various industrial processes.
   - Capability to identify and solve problems related to enzyme applications in different industries.

Unit I Enzyme Purification and Kinetics

Importance of enzyme purification, different sources of enzymes. Extra cellular and intracellular enzymes. Physical and chemical methods used for cell disintegration. Concentration of the enzyme extract, Enzyme fractionation by precipitation using salts and solvents, liquid – liquid extraction, ion exchange chromatography, gel filtration, affinity chromatography and other special purification methods. Analysis of purity, Enzyme crystallization techniques, Criteria for purity of enzymes, tests of homogeneity of purified enzymes.

Enzyme Inhibition- Irreversible and reversible enzyme inhibitions. Competitive, uncompetitive and non competitive enzyme inhibitions with suitable examples and their kinetic studies.

Allosteric inhibition- Positive and negative cooperativity, sigmoidal kinetics and allosteric enzymes. Models accounting cooperativity – Hill, Adair, MWC and KNF models. Cooperative binding of oxygen to haemoglobin – significance of sigmoidal behaviour. Types of allosteric inhibition and their kinetic studies and significance in metabolic regulation. Aspartate transcarbamoylase as allosteric enzyme.

Unit II Enzyme/Protein Engineering

Objectives of Protein Engineering, basic strategy of enzyme engineering. Protein engineering versus enzyme engineering as a biocatalyst. Techniques of Protein Engineering, Chemical modification and Site directed mutagenesis to study the structure- function relationship of industrially important enzymes. Hybrid enzymes. Examples of Protein Engineering applications- Improvement in stability, catalytic efficiency, selectivity and substrate specificity, purification and biopharmaceutical applications etc.

Unit III Clinical Enzymology

(i) Enzymes in clinical diagnostics (Blood Glucose, Blood Urea, Cholesterol, Diagnosis of liver disorders and heart disorders like Myocardial infarction). Enzymes and inborn errors, their use as markers in cancer and other diseases.

(ii) Enzyme sensors for clinical purposes. Enzyme immunoassay.

(iii) Enzyme therapy – Treatment of genetic deficiency diseases, Enzymes in cancer therapy, Enzyme inhibitors and drug design, therapeutic importance of ribozymes and abzymes

ENZYME TECHNOLOGY LAB COURSE

MIC/UD/DSE/652P **Credits2** **Marks50(30 hrs)**

1. Microbial production, extraction, purification and confirmation of α- Amylase/ Protease/Lipase/ Invertase/ Urease.
2. Determination of efficiency of enzyme purification by measuring specific activity at various stages viz. Salt precipitation, Dialysis, Electrophoresis etc.
3. Studies on activation and inhibition of extracted enzyme. (Effect of heavy metal ions, chelating agents, activators and inhibitors)
4. Immobilization of cells and enzyme using Sodium alginate/ egg albumin and measurement of enzyme activity of immobilized α- Amylase/ Protease/Lipase/ Invertase/ Urease.
5. Impact of immobilization on enzyme activity in terms of temperature tolerance, Km/ Vmax using various forms of α- Amylase/ Protease/Lipase/ Invertase/ Urease.
6. Determination of molecular weight of enzymes using PAGE technique.
7. Preparation of Urease biosensor and determination of its activity.
8. Determination of blood glucose by glucose oxidase biosensor.

REFERENCES

1. Methods in Enzymology Volume 22- Enzyme purification and related techniques. Edited by William B. Jakoby, Academic Press, New York.
2. Allosteric Enzymes – Kinetic Behaviour, 1982 by B.I. Kurganov, John Wiley and Sons. Inc., New York.
3. Biotechnology Volume 7A – Enzymes in Biotechnology, 1983. Edited by H.J. Rehm and G.Reed, Verlag Chemie.
4. Handbook of Enzyme Biotechnology by Wiseman.
5. Enzyme as Drugs Edited by John S. Holcenberg and Joseph Roberts, John Wiley and Sons. Inc., New York.
6. Methods of Enzymatic Analysis by Hans Ulrich, Bergmeyer, Academic Press
7. Methods in Enzymology by W.A.Wood, Academic Press
8. Advances in Enzymology by Alton Meister, Interscience Publishers.
9. Topics in Enzyme and Fermentation Biotechnology by L.N. Wiseman, John Wiley and Sons. Inc., New York.
10. Fundamentals of Enzymology by Nicholas C. Price and Lewis Stevens, Oxford University Press.
11. Biocatalysts and Enzyme technology by Klaus Buchholz, Volker Kasche, Uwe T. Bornscheuer, Wiley- VCH Verlag GmbH and Co., Germany.
12. Protein Purification techniques Edt. Simon Roe, Oxford University Press.
13. Enzymes- Biochemistry, Biotechnology, Clinical chemistry by Trevor Palmer. East- West Press Edition.

BIOINFORMATICS, MICROBIAL GENOMICS AND PROTEOMICS

MIC/UD/DSE/654A T **Credits 2** **Marks 50 (30 hrs)**

Course objectives:

1. **Understand the Fundamentals of Bioinformatics:**
   - Grasp basic principles of bioinformatics including the concepts of sequence alignment, database searching, and molecular evolution.
   - Learn about various types of biological data and their sources.
2. **Explore Genomics and Proteomics:**
   - Understand the principles of genomics and proteomics.
   - Learn about genome sequencing technologies, proteomic techniques, and their applications.
3. **Apply Bioinformatics to Real-World Problems:**
   - Understand the role of bioinformatics in areas such as personalized medicine, evolutionary biology, and biotechnology.
   - Learn to apply bioinformatics techniques to solve biological and biomedical problems.

Course Outcomes:

1. **Proficiency in Bioinformatics Tools:**
   - Ability to use bioinformatics software for sequence alignment, phylogenetic analysis, and structural biology.
   - Competence in utilizing databases such as GenBank, EMBL, and PDB.
2. **Expertise in Computational Methods:**
   - Capability to develop and implement algorithms for bioinformatics applications.
   - Skill in statistical analysis and machine learning techniques applied to biological data.
3. **Critical Thinking and Problem-Solving:**
   - Enhanced ability to apply bioinformatics knowledge to solve complex biological problems.
   - Improved skills in interpreting and visualizing complex datasets.
4. **Research and Practical Experience:**
   - Hands-on experience in conducting bioinformatics research projects.
   - Development of skills necessary for academic and industrial research careers.
5. **Preparedness for Advanced Studies and Careers:**
   - Readiness to pursue further studies or careers in bioinformatics, computational biology, or related fields.

- Strong foundation for contributing to interdisciplinary research and development in biotechnology, healthcare, and environmental science.

UNIT- I BIOINFORMATICS, GENOME ANALYSIS AND ITS APPLICATIONS Introduction to Bioinformatics: Introduction and overview of History of Bioinformatics, Biological Databases: Types and importance

Human genome project, uses and application, Genome information and special features, coding sequences, (CDS), Untranslated regions (UTR'S), Expressed sequence Tags (EST). Approach to gene identification, Gene Prediction- Importance and Methods.

Genomic and cDNA library, Bacterial Artificial Libraries, Shotgun Libraries and sequencing, Conventional sequencing (Sanger, Maxam and Gilbert method), Automated sequencing.

UNIT – II SEQUENCE ANALYSIS (0.8 Credit)

Sequence Alignment, Algorithms; uses and applications, Local and Global sequence alignment, Pairwise alignment:

Dynamic programming – Needleman – Wunsch, Smith- waterman

Scoring Matrix – PAM, BLOSUM,

Heuristic Methods- FASTA, BLAST

Multiple Sequence Alignment; ClustalW, Annotation of Gene, Open reading frames (ORF),

Phylogenetic tree

UNIT- III DNA – GENE EXPRESSION, MICROARRAY AND PROTEOMICS

Concept of expression analysis, SAGE, DNA micro array, Spotted arrays, Oligonucleotide arrays, Designing the experiment, Two – colour micro array experiments, Computational analysis of microarray data.

Analysis of SNP Using DNA chips. Overview of tools for microarray analysis:- xCluster, MADAM,

Protein sequence information, composition and properties, Two dimensional separation of total cellular protein, isolation and sequencing, Analysis individual protein spot by Mass spectroscopy (MALDI-TOF), Electro Spray Ionization (ESI), Tandem mass spectroscopy (MS/MS) tryptic digestion and peptide Mass finger printing(PMF), 3D structure prediction methods; Homology, ab initio

Advantage, disadvantage and application of microarray.

BIOINFORMATICS, MICROBIAL GENOMICS AND PROTEOMICS LAB COURSE

MIC/UD/DSE/654A P **Credits 2** **Marks 50 (30 hrs)**

Use of Internet /software for sequence analysis of nucleotides and proteins.

1. Studies of public domain databases for nucleic acid and protein sequences.
2. Protein structure prediction by Homology modelling
3. Genome sequence analysis by using BLAST and FASTA algorithm
4. Protein sequence analysis by using BLAST algorithm
5. Multiple Sequence analysis (ClustalW)

References

1. Bioinformatics. 1998 by Baxevanis
2. Bioinformatics 2000 by Higgins and Taylor OUP.
3. Nucleic acid Research 2001. Jan. Genome database issue.
4. The Internet and the new Biology: Tools for Genomics and Molecular Research by Peruski, Jr. and Peruske (ASM) 1997.
5. Functional Genomics. A Practical Approach Edited by Stephen P Hunt and Rick Liveey (OUP) 2000.
6. DNA microarrays: A practical approach edited by Mark Schena (OUP)
7. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis.
8. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgis.
9. Bioinformatics - from Genomes to drug. 2 volumes by Lenganer.
10. Bioinformatics Methods and Protocols - Misener.
11. Bioinformatics: Sequence and Genome analysis.
12. Introduction to Bioinformatics by Altwood.
13. Proteome Research: New Frontiers in Functional Genomics: Principles and Practices.
14. Genomics: The Science and Technology behind the human project.
15. Protein Biotechnology. Edited by Felix Franks. Humana Press, Totowa, New Jarsey.
16. Protein Engineering: Principles and Practice by Cleland.
17. Computer analysis of sequence data by Colte.
18. Bioinformatics and molecular evolution – P.G. Higgs & T. K. Attwood, 2005 Blackwell Publishing
19. Bioinformatics by David Mount
20. Bioinformatics- Introduction to Bioinformatics by Pevzner
21. Microarray- Gene expression Data analysis by Causton, Brazma 2003 Blackwell Publishing
22. Essential Bioinformatics by JIN XIONG 2006 Cambridge University press.
23. Microarray Data Analysis Methods and Applications Edited by Michael J. Korenberg 2007 Humana Press Inc.

BIONANOTECHNOLOGY

MIC/UD/DSE/654B T **Credits 2** **Marks 50 (30 hrs)**

Course Objectives for Bionanotechnology:

1. **Understand the fundamentals of nanotechnology:**
   - Explain the principles and basic techniques of nanotechnology.
   - Describe the unique properties of nanomaterials and their applications.
2. **Integrate biological systems with nanotechnology:**
   - Explore the interface between biology and nanotechnology.
   - Discuss how biological molecules and systems can be integrated with nanomaterials.
3. **Examine applications of BioNanotechnology:**
   - Investigate current and emerging applications of BioNanotechnology in medicine, biotechnology, and environmental science.
   - Analyze case studies and examples of successful applications.
4. **Develop practical skills in BioNanotechnology:**
   - Perform basic laboratory techniques relevant to BioNanotechnology.
   - Interpret experimental data and results using nanotechnological tools.

Course Outcomes for Bionanotechnology:

1. **Knowledge Acquisition:**
   - Demonstrate a comprehensive understanding of nanotechnology principles and techniques.
   - Describe the interactions between biological systems and nanomaterials.
2. **Application Skills:**
   - Apply theoretical knowledge to design experiments and solve problems in BioNanotechnology.
   - Demonstrate proficiency in using nanotechnological tools and techniques in practical settings.
3. **Critical Thinking:**
   - Analyze and evaluate scientific literature and research in BioNanotechnology.
   - Critically assess the potential benefits and risks of BioNanotechnology applications.
4. **Communication and Collaboration:**
   - Effectively communicate scientific concepts and experimental findings related to BioNanotechnology.
   - Collaborate with peers in laboratory settings and group projects.

Unit 1: Introduction to nanotechnology and bionanotechnology

Brief history of nanotechnology, nanomaterials and nanoparticles, size dependent properties of nanoparticles, advantages of nanotechnology, nanotechnology in nature, bionanotechnology- interface between biology and nanotechnology.

Unit 2: Nanoparticles

Types of nanoparticles- based on size,shape andstructure, chemical nature and properties;

synthesis of nanoparticles- top-down and bottom-up approaches, physical, chemical and biological methods of synthesis, stabilization of nanoparticles;functionalization of nanoparticles,characterization of nanoparticles- visual, UV-visible spectrophotometry, electron microscopy, probe microscopy.

Unit 3:Applications of nanotechnology

Applications of nanotechnology in different fields, viz. materials science- surface coatings, catalysis, electronics (one or two examples of each); environmental sciences- detection of pollutants, removal of pollutants(one or two examples of each), biomedical sciences- diagnosis and treatment of diseases (one or two examples of each), targetted drug delivery, food technology- preservation of food, detection of food pathogens (one or two examples of each), toxicity of nanoparticles.

BIONANOTECHNOLOGY LAB COURSE

MIC/UD/DSE/654B P **Credits 2** **Marks 50 (30 hrs)**

1) Calculation of surface area to volume ratio for particles of different size
2) Synthesis of silver/gold/iron based nanoparticles by chemical method- any one method
3) Detection of nanoparticles in colloidal suspensions using UV-visible spectrophotometer
4) Effect of chemicals on the stability of silver/gold nanoparticles (salt, acid/alkali, detergents)
5) Stabilization of silver/gold nanoparticles using chemical and/or biological agents and its effect on UV-vis absopriton spectrum/plasmon resonance.
6) Effect of high/low temperature on the stability of silver nanoparticles
7) Green synthesis of silver/gold nanoparticles using bacteria/fungi/yeasts- any one method
8) Green synthesis of silver/gold nanoparticles using plant extract/s
9) Antimicrobial activity of silver nanoparticles on bacteria/fungi
10) Decolorization/removal of dye from solution using nanoparticles
11) Biocompatibility of nanoparticles (hemolytic assay)
12) Analysis of SEM, TEM and AFM images

References:

Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, Springer, Switzerland (2014)

Edward L. Wolf, Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Wiley-VCH (2006).

C. Bre´chignac P. Houdy M. Lahmani, Nanomaterials and Nanochemistry, Springer Berlin Heidelberg, Germany (2006).

Guozhong Cao, Nanostructures &Nanomaterials Synthesis, Properties, Applications, World Scientific Publishing Pvy. Ltd., Singapore 2004

M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, Nanotechnology: Basic science and Emerging technologies, Overseas Press India Pvt Ltd, New Delhi, First Edition, 2005.

C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), The chemistry of nanomaterials: Synthesis, properties and applications, Wiley VCH VerlagGmbh&Co, Weinheim, 2004.

Kenneth J. Klabunde (Eds), Nanoscale Materials Science, John Wiley & Sons, Inc., 2001.

C.S.S.R.Kumar, J.Hormes, C.Leuschner, Nanofabrication towards biomedical applications, Wiley –VCH Verlag GmbH & Co, Weinheim, 2004.

G.Cao, Nanostructures and Nanomaterials: synthesis, properties and applications, Imperical College Press, 2004.

T. Pradeep, Nano: The essentials, understanding Nanoscience and Nanotechnology, Tata McGraw Hill, 2007.

Michael J. O'Connell, Carbon nanotubes: Properties and Applications, CRC/Taylor & Francis, (2006).

Kewal K. Jain , The Handbook of Nanomedicine,Humana Press, (2008).

Zhang, Nanomedicine: A Systems Engineering Approach" 1st Ed., Pan Stanford Publish, (2005).

Boca Raton, G. L. Hornyak, H. F. Tibbals, J. Dutta and J J. Moore,Introduction to nanoscience and nanotechnology, CRC Press, Tylor and Francis Group.

Mirkin Chad, Nanobiotechnology: Concepts, Applications and Perspectives, Wiley

Nanobiotechnology in Food: Concepts, Applications and Perspectives by J.M. Hoda, Springer

Cato T. Laurencin, Temenoff J. S. and Mikos A. G., Biomaterials: The Intersection of Biology and Materials Science‖, Pearson, New Delhi, 2009.

Grassian V.H, "Nanoscience and Nanotechnology – Environmental and health impacts", John Wiley & Sons, 2008

Ram.M, Andreescu.S.E, Hanming.D, "Nanotechnology for Environmental Decontamination", 2011, McGraw Hill

Wiesner M and Bottero J.Y, "Environmental Nanotechnology", McGraw-Hill, 2007.

Geoffrey Hunt and Michael D. Mehta ―Nanotechnology: Risk, Ethics and Law, Arthscan/James & James publication (2006)

Mark. R. Weisner and Jean-Yves Bottero ―Environmental Nanotechnology applications and impact of nanomaterial, The McGraw-Hill Companies (2007).

MIC-UD/DSE/654 T **Credits 4** **Marks 50 (30 hrs)**

B) Any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }

MIC-/UD/RM/655

On Job Training/ Field Project