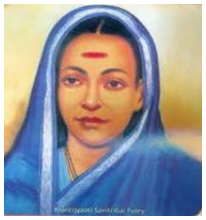

Savitribai Phule Pune University

(Formerly University of Pune)

Syllabus for

Post Graduate Course in Microbiology

M. Sc. Part I (Microbiology)

Under

Faculty of Science and Technology

(As per NEP 2020 Guidelines)

For

University Department of Microbiology, SPPU

With effect from AY 2024-2025

Contents

I. About the Department:

The Department of Microbiology, at Savitribai Phule Pune University was established in 1977. It is now widely recognized as a Centre of Excellence in Microbiology, both with respect to teaching and research. The department has also received infrastructural support under the Department of Science and Technology (DST - FIST) scheme of Government of India. More than a thousand students have completed their Master's program and more than 50 have completed the Doctoral program from the department. The alumni of the department occupy positions of great responsibility in various academic and research institutions, and industries all over the world.

The Department is dedicated to advancing the cause of higher education and creating a center of academic excellence in the field of education and research in Microbiology. It also provides a sound academic background for overall development of personality for a successful career in the field of Life sciences. The Department has been providing an environment that fosters continuous improvement and innovation in the subject by inculcating required skills in students towards their self-development through its activities like contact group sessions, Saturday Meets, visits to research facilities and industries, Science Exhibition, and public service programs. The Department, served by highly accomplished faculty and friendly administrative staff strives to nurture high moral values in students to live up to their civic responsibilities.

II. Introduction to NEP (CBCS) and Scope:

Microbiology is a rapidly growing interdisciplinary field with diverse avenues such as Bacteriology, Mycology, Molecular Biology, Biochemical Engineering, Microbial Biotechnology, Medical Microbiology, Immunology, and Applied and Environmental Microbiology. The Department regards that the proclivity of the program outcome, and therefore the syllabus, must be acclimatized to keep pace with developments in the global scenario. To this end, of priority is a syllabus that emphasizes technology as well as hands-on-experience along with a sound foundation of the basics of biology. Elaborate laboratory exercises to compliment theory will help aspirants to avail myriad opportunities available as career options. These aspects will enable students to begin working in applied fields without the necessity of additional training. The result will be trained and skilled manpower.

Under the National Education Policy (NEP) 2020, the choice-based credit system (CBCS) offers the students a variety of options to choose from prescribed courses comprising of core and elective courses. Evaluation of these courses follows the grading system which is better than the conventional marks system. The Cumulative Grade Point Average (CGPA), based on student's performance in examinations, enables the student to move across institutions of higher learning. This uniformity is also beneficial to employers in assessing candidates' performance.

Consequently, the syllabus has been restructured. This restructured syllabus encompasses principles of basic microbiology, biochemistry, molecular and cell biology, genetics, immunology, analytical tools, biostatistics, and bioinformatics. These principles are spread over a two-year post-graduate program. Additionally, the elective courses offer the students to hone their skills in the field of medical, industrial, and environmental microbiology. The NEP also offers the student the option of exiting after completion of one year with a post-graduate diploma or continuing to the second year, after completion of which the student will be awarded a post-graduate degree. The diploma equips the student to be employed in a wide variety of applied and industrial jobs. The degree offers a wider spectrum of job opportunities in the area as well as careers in research and academia.

III. Definitions:

1. Academic Program - An entire course of study comprising its Program structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/ Centre.
2. Course - A segment of a subject that is part of an Academic Program.
3. Program Structure - A list of courses (Major Core OR Elective) that makes up an Academic Program, specifying the syllabus, credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the program etc. prepared in conformity to University Rules, eligibility criteria for admission.
4. Core Course - A course that a student admitted to a particular program must successfully complete to receive the degree and which cannot be substituted by any other course.
5. Elective Course - An optional course to be selected by a student out of such courses offered in the same or any other Department/Centre under the School of Life Sciences.
6. Credit -The value assigned to a course which indicates the level of instruction; teaching semester shall be for 15 weeks. One Theory Credit equals 15 hours teaching, running for 15 weeks and one-hour lecture per week; One Practical Credit equals 30 hours lab exercises running for 15 weeks and mostly two-hour lectures per week per batch.
7. GPA - Grade Point Average is calculated by adding all the numbered grades received and dividing them by the number of credits taken.
8. 'CGPA' - Cumulative Grade Points Average is calculated in the last year of the course by clubbing together the GPA of two years, i. e. four semesters.

IV. Program Objectives (POs):

After the completion of the masters' program, the student will have developed wide-spread knowledge in various areas of Microbiology and be instilled with a sense of scientific inquiry towards Microbiology and allied life sciences. The course aims to cover the fundamental and applied subjects with special focus on frontier technologies such as Omics, Nanotechnology, Bioinformatics, Computational Biology, and also inculcating skills in entrepreneurship, IPR. The program will prepare the student to execute and accomplish projects inspiring self-confidence and self-reliance. The program will equip students with excellence in skills thus enabling them to engage in a career of their choice.

V. Program Specific Outcomes (PSOs):

At the end of the two-year program the student will be able to summarize, interpret and express information about the various branches of Microbiology. The student will be able to execute, implement and deduce protocols based on applications of Microbiology such as Environmental Microbiology, Industrial Microbiology, Food Microbiology, and Microbial Pathogenicity. He/she will also be able to hypothesize, experiment, and solve problems related to Basic Microbiology, Immunology, Molecular Biology, Recombinant DNA Technology, and Microbial Genetics. This will acquire proficiency in biochemical and molecular biology techniques and also exposure to handle high-end equipment such as microbial identification system, fluorescence microscopes, pilot scale fermenters, FACS, GC, HPLC, real-time PCR and working experience in BSL-II, animal tissue culture facilities. This will equip students to execute a research project incorporating basic and advanced techniques under supervision. This will include hypothesis

formulation, experimental design, data analysis and effective communication of scientific findings through written reports, presentations, and discussions. Finally, the student will be prepared to commence a suitable job in industry or academia, or a fellowship to pursue a career in research.

VI. Program Details:

1. **Title of the Program**: M.Sc. Microbiology
2. **Intake capacity**: 40
3. **Duration**: Two years (Four semesters) Full-time Post - Graduate Degree Program.
4. **Total Credits:** A full Master's degree course in science is of 88 credits.
5. **Exit Option**: After successful earning of 44 credits offered by the Department for the first two semesters (First year- Sem I and II), a student will have the option of exit from the program. In this case, the student will be conferred with PG Diploma in Microbiology.
6. **Course Structure:** There are four semesters, at each semester there are 22 credits total for theory courses (Major core/elective), practical courses (Major core/elective), and other compulsory courses. A student will have to opt for any one of the three elective courses (Theory + Practical) offered in each semester. Other compulsory courses are as follows: Sem I- Research Methodology (RM) - 4 credits; Sem II-On Job Training (OJT) - 4 credits; Sem III - Research Project - 4 credits; Sem IV- Research Project - 6 credits. The distribution of courses is given below.

Course Structure for PG Microbiology

Level	Semester	Credits Related to Major		Research Methodology (RM)	Internship/ On Job Training (OJT)	Research Project (RP)	Total
		Major Core	Major Elective				
6.0	I	8 (T) + 6 (P)	2 (T) + 2 (P)	2 (T) + 2 (P)	0	0	**22**
	II	8 (T) + 6 (P)	2 (T) + 2 (P)	0	4	0	**22**
Exit option: Award PG Diploma on completion of 44 credits after three years UG Degree **OR** continue with PG second year							
6.5	III	8 (T) + 6 (P)	2 (T) + 2 (P)	0	0	2 (T) + 2 (P)	**22**
	IV	12 (T) + 0 (P)	4 (T)	0	0	6 (P)	**22**
Total 4 Years		**54**	**16**	**4**	**4**	**10**	**88**
2 years- 4 Sem. Award PG Degree on completion of 88 credits after Three Year UG Degree. OR 1 Year- 2 Sem. Award PG Degree (44 credits) after Four Year UG degree.							

7. Course Code: Course Numbers are designed to indicate the subject, semester, course serial number, and the nature as theory, practicals, or others.
MB – Microbiology; MJ – Major theory course; MJP Major practical course; RM- Research Methodology; OJT- On Job Training/ Internship; RP- Research Project.
1st digit (5 or 6) indicates the year of graduation; 2nd digit indicates odd (3) or even (4) semester. Last digit indicates the serial number of courses for the semester.
eg. MB 531 MJP- M.Sc. I, ODD semester, 1st course that is a Major Practical course.
MB 642 MJ - M.Sc. II, EVEN semester, 2nd course that is a Major Theory course.

8. Course Conduct:

a) A student will have to attend 1-hour classroom teaching per week for one credit of theory and 2 hours lab work/problem-solving session/related activities per week for one credit of practical.

b) Practical sessions (lab work/problem-solving session/related activity) will be conducted in batches. A batch for such sessions will be of size maximum of 10 students.

c) **On Job Training (OJT):** In this course, the students are expected to do the On-Job Training

(OJT) or field project in appropriate industries, research institutes, NGOs, diagnostic labs etc. to get hands-on experience in the respective field. The department may conduct necessary lectures/workshops/seminars as a part of OJT. The course will be conducted as per the guidelines of the Department/the University and the Government of Maharashtra.

d) **Research Project (RP):** The course is to be completed under the supervision and guidance of an in-house research mentor. In case required, the mentor may collaborate with other institutes to permit the student to carry out part of the research project outside the department. Plan of work and literature review of project work to be carried out will be presented by the student in Semester III. Actual project will be carried out in Semester IV. The modus-operandi for the assigning research mentors, conduct, and evaluation of a Research Project will be decided by the Departmental Committee (DC) in majority from time to time as per the needs. The department may conduct necessary lectures/workshops/laboratory training exercises as a part of RP.

e) The DC in its meeting with the majority may introduce/design additional course(s) and include/exclude/modify the existing course(s) to accommodate the then developments from time to time.

9. Course Evaluation:

a) Each course will be evaluated for 25 marks per credit of which 50% will be based on continuous assessment (CA) and the rest will be based on end semester examination (ESE).

b) The CA will be based on minimum two internal tests for each course, of which at least one shall be a written test. In addition, a teacher may consider one or more of the following- Home Assignment(s), Seminar/Presentation (Individual/Group); Laboratory assignment; Group Discussions/Oral; Research Paper Review; Quiz competition etc.

c) For both OJT and RP, the CA will be based on grades awarded by mentor while the ESE will be based on presentation/oral/discussion/any other criterion decided by the DC.

d) For passing a course, a student has to score a minimum of 30% marks in each of the CA and ESE separately and a minimum of 40% marks in the combined grading of CA and ESE.

e) Results at the end of the semester will be declared using a grade point system as per the University rules.

10. ATKT Rules: A student who wishes to take admission to the second year of M. Sc. Microbiology program must have earned at least 22 credits from the total credits of two semesters of the first year of M.Sc. (Microbiology).

11. Completion of the Degree Program:

a) In order to qualify for the award of M.Sc. (Microbiology) Degree, a student has to earn minimum 88 credits and also need to complete the compulsory audit courses as prescribed by the University from time to time.

b) Only those courses in which the student has passed will be considered for calculating the CGPA and overall grade.

c) The applicable policies and procedures laid down by SPPU will be followed for the conduct of examinations, evaluations and declaration of the results.

The above circular supersedes all previous circulars on the credit system being operated at Department of Microbiology, SPPU.

VII M. Sc. Microbiology Program Outline (Semester Wise)

Semester I		
Core Courses		
Theory Courses		
Subject Code	**Subject Title**	**Number of Credits**
MB 531 MJ	General Microbiology	02
MB 532 MJ	Microbial Diversity and Systematics	02
MB 533 MJ	Molecular Biology and Biochemical Techniques	02
MB 534 MJ	Biochemistry and Metabolism - I	02
Practical Courses		
MB 531 MJP	Lab Exercises in General Microbiology	02
MB 532 MJP	Lab Exercises in Microbial Diversity	02
MB 533 MJP	Lab Exercises in Biochemical and Molecular Biology Techniques	02
Elective Courses: Opt any one elective theory course with corresponding practical course		
Subject Code	**Subject Title**	**Number of Credits**
MB 535 MJ	Microbial Pathogenesis and Epidemiology	02
MB 536 MJ	Fundamentals of Bioprocess Engineering & Technology	02
MB 537 MJ	Environmental and Applied Microbiology	02
MB 535 MJP	Lab Exercises in Microbial Pathogenesis	02
MB 536 MJP	Lab Exercises in Fermenter Design and Applications	02
MB 537 MJP	Lab Exercises in Environmental and Applied Microbiology	02
Research Methodology		
Subject Code	**Subject Title**	**Number of Credits**
MB 530 RM	Research Methodology- Scientific Writing and Communication	02
MB 530 RMP	Practical Based on Scientific Writing and Communication	02

Semester II		
Core Courses		
Theory Courses		
Subject Code	**Subject Title**	**Number of Credits**
MB 541 MJ	Biochemistry and Metabolism - II	02
MB 542 MJ	Microbial Genetics	02
MB 543 MJ	Molecular Biology - I	02
MB 544 MJ	Biostatistics and Mathematics for Biologists	02
Practical Courses		
MB 541 MJP	Lab Exercises in Enzymology	02
MB 542 MJP	Lab Exercises in Microbial Genetics	02
MB 543 MJP	Lab Exercises in Molecular Biology	02
Elective Courses: Opt any one elective theory course with corresponding practical course		
Subject Code	**Subject Title**	**Number of Credits**
MB 545 MJ	Clinical Microbiology- Diagnosis and Therapies	02
MB 546 MJ	Bioengineering and Downstream Processing	02
MB 547 MJ	Agricultural Microbiology	02
MB 545 MJP	Lab Exercises in Clinical Microbiology	02
MB 546 MJP	Lab Exercises in Bioengineering and Downstream Processing	02
MB 547 MJP	Lab Exercises in Agricultural Microbiology	02
On Job Training / Field Project		
Subject Code	**Subject Title**	**Number of Credits**
MB 540 OJT	On Job Training / Internship / Field work	04

Semester III		
Core Courses		
Theory Courses		
Subject Code	**Subject Title**	**Number of Credits**
MB 631 MJ	Immunology	02
MB 632 MJ	Molecular Biology - II	02
MB 633 MJ	Biophysical Techniques - I	02
MB 634 MJ	Animal and Plant Virology	02
Practical Courses		
MB 631 MJP	Lab Exercises in Immunology and Virology	02
MB 632 MJP	Lab Exercises in Recombinant DNA Technology	02
MB 633 MJP	Lab Exercises in Biophysical Techniques	02
Elective Courses: Opt any one elective theory course with corresponding practical course		
Subject Code	**Subject Title**	**Number of Credits**
MB 635 MJ	Pharmaceutical Microbiology	02
MB 636 MJ	Food Technology	02
MB 637 MJ	Bioremediation	02
MB 635 MJP	Lab Exercises in Pharmaceutical Microbiology	02
MB 636 MJP	Lab Exercises in Microbial and Food Technology	02
MB 637 MJP	Lab Exercises in Bioremediation and Waste Management	02
Research Project		
Subject Code	**Subject Title**	**Number of Credits**
MB 630 RP	Dissertation- Plan of Work and Literature Review	04

Semester IV		
Core Courses		
Theory Courses		
Subject Code	**Subject Title**	**Number of Credits**
MB 641 MJ	Biophysical Techniques - II	04
MB 642 MJ	Omics Concepts, Techniques, and Applications	04
MB 643 MJ	Microbial Ecology and Evolution	04
Elective Courses: Opt any one elective theory course		
Subject Code	**Subject Title**	**Number of Credits**
MB 644 MJ	Bioinformatics and Structural Biology	04
MB 645 MJ	Clinical Immunology and Cancer Biology	04
MB 646 MJ	Bio-entrepreneurship and IPR	04
MB 647 MJ	Waste Management	04
Research Project		
Subject Code	**Subject Title**	**Number of Credits**
MB 640 RP	Dissertation- Lab work and Data Compilation	06

VIII. Course Wise Content Details for M.Sc. Microbiology Program: Attached below.

SEMESTER-1

MB 531 MJ : General Microbiology

Total: 2 Credits; Workload: 15 h/credit
(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objective:
The objective of this course is to learn about the basic principles of bacteriology, cell structure and organization, biosafety and bioethics in laboratory.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Biosafety and bioethics in laboratory: a. Introduction, historical background, introduction to biological safety cabinets, primary containment for biohazards. b. Recommended biosafety level for infectious agents and infected animals, biosafety levels of specific microorganisms. c. Biosafety guidelines: Government of India, definition of genetically modified organisms (GMOs), roles of institutional biosafety committee, review committee on genetic modification (RCGM), India, genetic engineering appraisal committee (GEAC) India etc. for GMO applications in food and agriculture, environmental release of GMOs, risk analysis, risk assessment, risk management and communication. d. Introduction to bioethics and its importance, ethical guidelines, policy and supplementary guidance related to various types of biomedical research conducted in India. e. Overview of national regulations and relevant international agreements including Cartagena protocol.	05
2	Principle and applications of microscopes: Light microscope, phase-contrast microscope, florescence microscope, confocal microscope, electron microscope.	05
3	Eubacterial and archaebacterial cell structure and growth: a. Cell membrane, cell wall (monoderm and diderm), s-layer, cytoskeleton, spores, flagella, capsule. b. Mechanism of bacterial cell division. c. Microbial growth under aerobic and anaerobic conditions. d. Chemotaxis, biofilm and quorum sensing. e. Transportation and secretory mechanism.	09
4	Virus structure: Viral morphology, life cycle, virus cultivation.	02
5	Eukaryotic cell organization: a. Cell membrane, nucleus, endoplasmic reticulum, mitochondrion, golgi complex, lysosomes and peroxisomes, cytoskeleton. b. Mechanism of cell division: Mitosis and meiosis, programmed cell death.	07
6	Maintenance and preservation of microbial cultures; Animal cell culturing techniques.	02

Course Outcomes: The student at the completion of the course will be able to:

- Understand the basic biosafety and bioethical rules to be followed while practicing microbiology experiments.
- Get acquainted with the prokaryotic and eukaryotic cell structure and its organization.
- Understand the working of different microscopic techniques for studying the cells structure and related processes.
- Comprehend the bacterial growth pattern and behavior under aerobic and anaerobic conditions.
- Learn different methods to maintain and preserve the microbial cultures.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Alberts, B., Hopkin, K., Johnson, A. D., Morgan, D., Raff, M., Roberts, K. & Walter, P. (2018). Essential cell biology. 5th Ed. WW Norton & Company. United States of America.
2. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. United Kingdom: CRC Press.
3. Cavicchioli, R. (2007) Archaea: Molecular and cellular biology. John Wiley & Sons. United States of America.
4. Fields, B. N. (2007). Fields virology. Wolters Kluwer Health/Lippincott Williams & Wilkins, United States of America.
5. Flint, S. J., Racaniello, V. R., Rall, G. F. & Skalka, A. M. (2015). Principles of virology. Wiley, United States of America.
6. Guidelines and handbook for institutional biosafety committees. (2011). Department of Biotechnology, Ministry of Science & Technology & Biotech Consortium India Limited, New Delhi, India.
7. Lodish, H. F., Berk, A. & Kaiser, C. (2007). Molecular cell biology. W.H. Freeman, India.
8. Mahone, C. R. & Goley, E. D. (2020). Bacterial cell division at a glance. Journal of cell science, 133(7), jcs237057. https://doi.org/10.1242/jcs.237057
9. Mathur, R. (2017). National ethical guidelines for biomedical and health research involving human participants. Indian Council of Medical Research. ISBN: 978-81-910091-94. India.
10. Wang, J. D. & Levin, P. A. (2009). Metabolism, cell growth and the bacterial cell cycle. Nature Reviews. Microbiology, 7(11), 822–827. https://doi.org/10.1038/nrmicro2202.
11. Watson, D. (2022). Microbiology: Theories and applied principles. 978-1647400941. Syrawood Publishing House, United States of America.

MB 532 MJ : Microbial Diversity and Systematics

Total: 2 Credits; Workload: 15 h/credit

(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objective:

The objective of this course is to learn about molecular techniques used in microbial systematics. Expose students to research with the help of various tools and technologies used by the scientific community.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Microbial classification systems and approaches: a. Species concept and species evolution. b. 5-Kingdom classification system, 3-Domain classification system. c. Polyphasic approach. d. Bergey's manual (Determinative and Systematic) for microbial identification. e. Molecular clocks, phylogeny and molecular distances.	04
2	Phenetic methods/chemotaxonomy: a. Cell wall composition, whole-cell protein, lipid, Isoprenoid quinone, cytochrome, amino acids sequences of various proteins, protein, enzyme profiling, fermentation product profiles, secondary metabolites. b. Automated systems typing method for identification and classification of microbes.	05
3	Genotypic methods: a. Determination of the DNA base ratio (moles percent), nucleic acid hybridization, DNA-based typing methods. b. Importance of rRNA in molecular taxonomy: rRNA homology studies, 16S rRNA, 18s rRNA/rDNA fingerprinting.	04
4	Exploration of uncultured microbial diversity: a. Concept of 'unculturable' bacterial diversity. b. Strategies for culture of 'unculturable' bacteria. c. Culture independent molecular methods: PCR dependent approaches versus PCR independent approaches (RFLP, RAPD, ARDRA, DGGE, TGGE, Microarray, FISH, RISA). d. Metagenomics: Concepts, work flow, collection and processing of samples, metagenomic DNA isolation.	07
5	Fungal taxonomy: Different groups, phenotypic characterization: Physiological properties, chemotaxonomic methods, description of new species, genotypic methods, databases.	06
6	Microbial diversity: The expanse of microbial diversity: Morphological, structural, metabolic, ecological, behavioral and evolutionary, Estimates of total number of species, species divergence and measurement of microbial diversity, measures and indices of diversity.	04

Course Outcomes: The student at the completion of the course will be able to:

- Get accustomed with different microbial classification systems.
- Comprehend different phenotypic and genotypic methods used in microbial systematics.
- Attain knowledge about the different molecular tools used in microbial classification systems.
- Acquire in depth knowledge and importance of chemotaxonomic tools in microbial taxonomy.
- Exploring the metagenome concepts, isolation and processing of DNA from various habitats.
- Get acquainted with the methods involved in assessing the diversity of uncultivable microbes.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Bergey, D. H. & Holt, J. G. (2000). Bergey's manual of determinative bacteriology. 9th Ed. Lippincott Williams & Wilkins, Philadelphia.
2. Brenner, D. J., Krieg, N. R. & Staley, J. T. (2005). Bergey's Manual® of Systematic bacteriology: Vol. 2: The proteobacteria (Part C). Springer, Unites States.
3. Brown, J. W. (2014). Principles of microbial diversity. ISBN: 978-1-683-67341-5. John Wiley & Sons, Germany.
4. Daniel, R. (2005). The metagenomics of soil. Nature Reviews Microbiology, 3(6), 470-478.
5. Das, S., Dash, H. R., Mangwani, N., Chakraborty, J. & Kumari, S. (2014). Understanding molecular identification and polyphasic taxonomic approaches for genetic relatedness and phylogenetic relationships of microorganisms. Journal of Microbiological Methods, 103, 80-100.
6. Gannibal, P. B. (2022). Polyphasic approach to fungal taxonomy. Biology Bulletin Reviews, 12(1), 18-28.
7. Garrity G., Boone D. R. & Castenholz R. W. (2001). Bergey's Manual of Systematic Bacteriology. Vol 1. The archaea and the deeply branching and phototrophic bacteria. 2nd Ed. Springer-Verlag, New York, United States of America.
8. Garrity G., Brenner D. J., Krieg N. R. & Staley J. R. (2005). Bergey's manual of systematic bacteriology. Vol. 2. The Proteobacteria, Part A: The Gamma proteobacteria. 2nd Ed. Springer-Verlag, United States of America.
9. Garrity G., Brenner D. J., Krieg N. R. & Staley J. R. (2005). Bergey's manual of systematic bacteriology. Vol 2. The proteobacteria. Part B: Alphaproteobacteria. 2nd Ed. Springer-Verlag, United States of America.
10. Garrity G., Brenner D. J., Krieg N. R. & Staley J. R. (2005). Bergey's Manual of Systematic Bacteriology. Vol 2. Part C. The combination of the Beta-, Delta- and Epsilon proteobacteria. 2nd Ed. Springer-Verlag, United States of America.
11. Goodfellow, M., Sutcliffe, I. & Chun, J. (2014). New approaches to prokaryotic systematics. Academic Press. London; San Diego; Waltham; Oxford.
12. Goodfellow, M., Kämpfer, P. Busse, H.J., Martha, E., Ken-ichiro Suzuki, T., Ludwig, W. & Whitman, W. B. (2012). Bergey's manual of systematic bacteriology: Vol 5. The Actinobacteria. Springer, New York, United States of America.
13. Keller, M. & Zengler K. (2004). Tapping in to microbial diversity. Nature Reviews. 2(2): 141-150.
14. Madigan, M.T., Martinko, J.M. & Parker, J. (1997). Brock biology of microorganisms. Vol. 11. Upper Saddle River, Prentice hHall, New Jersey, United States of America.

15. Priest, F. & Goodfellow, M. (2000). Applied microbial systematics. Springer Dordrecht, Berlin, Germany.
16. Riesenfeld, C. S., Schloss, P. D. & Handelsman, J. (2004). Metagenomics: Genomic analysis of microbial communities. Annual Reviews Genetics. 38, 525-552.
17. Staley, J.T. & Reysenbach, A. L. (2002). Biodiversity of microbial life. John Wiley & Sons, Germany.
18. Vandamme, P., Pot, B., Gillis, M., De Vos, P., Kersters, K. & Swings, J. (1996). Polyphasic taxonomy, a consensus approach to bacterial systematics. Microbiological Reviews, 60(2), pp.407-438.

MB 533 MJ : Molecular Biology and Biochemical Techniques

Total: 2 Credits; Workload: 15 h/credit
(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objectives:
The objective of this course is to provide in depth knowledge of techniques used for understanding the molecular and biochemical processes in various microbial system.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Separation of biomolecules: Centrifugation, filtration, salting out (dialysis and ultra-membrane filtration).	03
2	UV-Vis spectroscopy: Principle and applications.	01
3	Radiolabel detection: Detection and quantitation of radiolabeled proteins and DNA in gels and blots.	01
4	Chromatography: Theory of partition chromatography, principles and applications of gel filtration, Ion exchange, affinity, HPLC, FPLC, and Gas chromatography.	06
5	Gel electrophoresis: Principle, types, applications – Agarose gel electrophoresis, polyacrylamide gel electrophoresis.	03
6	Polymerase chain reaction: Principle, types, applications of PCR and its variations (hot-start, multiplex, nested, gradient, RT-PCR, qRT-PCR etc.).	04
7	Fluorescence in situ hybridization (FISH) and microarray technology.	03
8	Blotting techniques: Principle, methodology and applications: Northern, southern and western blotting.	01
9	Sequencing methods: a. Principle, methodology and applications of protein and nucleic acids sequencing (Classical approaches). b. Overview of next generation sequencing methods.	05
10	Methods to study gene function: Gene silencing and gene knockout.	03

Course Outcomes: The student at the completion of the course will be able to:

- Learn the principle and application of UV-Visible spectroscopy for detection of biomolecules.
- Understand the use of radiolabel in quantification of biomolecules.
- Design a multi-step purification and characterization protocols for target biomolecules.
- Learn the principle of PCR, FISH, microarray and sequencing techniques and their applications.
- Analyse the data and solve the problems based on the above techniques.

References:

1. Chatwal, G. R. (2011). Biophysics. Himalaya Publishing, India.
2. Hofmann, A. & Clokie, S. (2018). Wilson and Walker's Principles and techniques of biochemistry and molecular biology. 8th Ed. doi:10.1017/9781316677056. Cambridge University Press, Cambridge, England.
3. Pattabhi, V. & Gautham, N. (2003). Biophysics, Narosa Publishing House, India.
4. Sadasivam, S. & Manickam, A. (2007). Biochemical methods. New Age International Limited, India.
5. Scheena, M. (2007). DNA microarrays. ISBN: 9781904842156. Scion Pub, Netherlands.

MB 534 MJ : Biochemistry and Metabolism - I

Total: 2 Credits; Workload: 15 h/credit
(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objective:

The objective of this course is to provide the basic understanding of structure and function of biomolecules and vital processes that occur in living organisms.

Sr. No.	Credit Title & Contents	No. of Lectures
1	The nature of the chemical bond, Ionic, covalent, coordinate bonds, dipole-dipole interactions, electrostatic interactions, van der waal's forces, hydrogen bond, structure of water, ionization and concept of pH, buffer, mole concept.	03
2	Carbohydrate chemistry and metabolism: Carbohydrates chemistry, Glycolysis and gluconeogenesis and its regulation; Pentose phosphate pathway; Glycogen synthesis and breakdown and its regulation; TCA cycle and its regulation, and its role in energy generation; glyoxylate cycle; Entner-Doudoroff Pathway.	06
3	Nucleic acid chemistry and metabolism: Nucleic acid chemistry, purine and pyrimidine biosynthesis and degradation, deoxyribonucleotide synthesis, regulation of purine and pyrimidine biosynthesis.	05
4	Proteins chemistry and metabolism: Structure and function of amino acids, N_2 fixation, amino acid synthesis and breakdown, urea cycle and biological amines.	06
5	Bioenergetics: Laws of thermodynamics; Concept of entropy, enthalpy, free energy, free energy	10

Sr. No.	Credit Title & Contents	No. of Lectures
	and equilibrium constant, Gibbs free energy equation; determination of free energy of hydrolytic and biological oxidation reduction reactions under standard and non-standard conditions, high energy compounds, coupled reactions; determination of feasibility of reactions.	

Course outcome: The student at the completion of the course will be able to:

- Understand the concept of molecular interactions, pH and buffer, and mole concept.
- Describe the carbohydrates and nucleic acids structures, their synthesis, breakdown and regulation in prokaryotes and eukaryotes.
- Describe the amino acids and proteins structures, their synthesis, breakdown and regulation in prokaryotes and eukaryotes.
- Get familiar with some key concepts of the biochemical reactions.
- Learn the problem-solving approach in biochemistry and bioenergetics.

References:

1. Gottschalk. G. (1985). Bacterial metabolism. 2nd Ed. Springer, New York, United States of America.
2. Lundblad, R. L. & Macdonald, F. (Eds.). (2018). Handbook of Biochemistry and Molecular Biology 5th Ed. CRC Press, Boca Raton, United States of America.
3. Morrison, R.T. & Boyd, R. N. (2016). Organic chemistry. 6th Ed. ISBN: 978-8177581690. Pearson, India.
4. Nelson, D. L. & Cox, M. M. (2017). Lehninger principles of biochemistry. 7th Ed. W.H. Freeman. Macmillan Learning, London, United Kingdom.
5. Segel, I. (2004). Biochemical calculations. 2nd Ed. ISBN: 978-81-265-2643-7. John Wiley & Sons, India.
6. Stryer, L. (1995). Biochemistry. 4th Ed. W. H. Freeman & Company, New York.
7. Voet, D., Voet, J. G. & Pratt, C. W. (2016). Fundamentals of biochemisty. 5th Ed. ISBN: 978-1-118-91840-1. John Wiley & Sons, Germany.
8. Wood, W. B., Wilson, J. H., Benbow, R. M. & Hood, L. E. (1974). Biochemistry: A problems approach, ISBN: 978-0805398403. Menlo Park, CA: W.A. Benjamin-Cummings Pub Co, United States of America.

MB 531 MJP : Lab exercises in General Microbiology

Total: 2 Credits; Workload: 30 h/credit

(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The objective of this course is to give training in basic laboratory practices used in microbiology.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	a. Training of standard operating procedure (SOPs) for media preparation and sterilization. b. Understanding SOPs for handling equipment in laboratory.	04
2	a. Biosafety and bioethics protocols. b. Biowaste segregation and disposal.	04
3	Phosphate, Tris-HCl and acetate buffer preparation, p*Ka* value determination using titration curve method.	08
4	Maintenance and preservation of the bacteria and bacteriophages: Freeze drying (lyophilization) method, overlay with mineral oil method and glycerol stock preparation.	08
5	Enumeration of bacteria from the environmental sample using Neubauer chamber method and TVC method.	08
6	Growth curve determination by serial dilution method (Bacteria) and biomass measurement (Fungi).	10
7	Bacterial biofilm formation detection by crystal violet staining assay.	08
8	Bioassay for determination of quorum sensing signals produced by bacteria.	08
9	Determination of chemo-taxis responses shown by bacteria using agar plate or capillary tube method.	08
10	Microscopic techniques: a. Sample preparation for SEM/TEM and observation. b. Analysis of microscopic images using Image J software.	12

Course outcome: The student at the completion of the course will be able to:

- Learn handling and operation of basic laboratory equipment as per the standard guidelines.
- Prepare buffers for various biological experiments.
- Learn different methods for microbial culture preservation.
- Enumerate the bacteria from different environmental samples and study their growth curve.
- Check the biofilm forming capability and cell viability of microorganisms.
- Prepare samples for electron microscopy and analyse the data obtained.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Atlas, R. M. (1997). Handbook of microbiological media. CRC-Press, United Kingdom.

2. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. Taylor & Francis, United Kingdom.
3. Caudle, C. & Ohair, J. (2022). Principle Laboratory practices for microbiology. Kendall Hunt Publishing Company, Iowa, United States of America.
4. Goldman, E. & Green, L. H. (2015). Practical handbook of microbiology. 3rd Ed. CRC Press. https://doi.org/10.1201/b17871
5. Mahone, C. R. & Goley, E. D. (2020). Bacterial cell division at a glance. Journal of Cell Science. 8;133(7).
6. Segel, I. H. (2010). Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry. Italy: Wiley.
7. Spector, D. L. (2006). Basic methods in microscopy: Protocols and concepts from cells: A laboratory manual. Cold Spring Harbor Laboratory Press, United States of America.
8. Tortora, G. J., Funke, B. R. & Christine, L. (2007). Microbiology, Case, Pearson Benjamin Cummings, United States of America.
9. Wang, J. D. & Levin P. A. (20090). Metabolism, cell growth and the bacterial cell cycle. Nature Reviews Microbiology. 7(11):822-7.

MB 532 MJP : Lab Exercises in Microbial Diversity

Total: 2 Credits; Workload: 30 h/credit

(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The objective of this course is to give training in isolating and characterizing the bacterial and fungal isolates from the environmental samples to understand their diversity.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Enrichment and isolation of halophiles, thermophiles, acidophiles, alkalophiles, actinomycetes (any two), Determination of diversity index.	15
2	Identification and characterization of bacterial isolates using biotyping (classical approach and VITEK system).	15
3	Demonstration of identification of microbes using genotypic methods.	10
4	Isolation of fungi, molds and yeasts, Determination of diversity index.	15
5	Identification of fungi by classical methods: Slide culture plate technique, Lactophenol cotton blue staining: Mycelium and spore morphology.	15
6	Understanding the interface of NCBI or other available data for sequence analysis.	10

Course outcome: The student at the completion of the course will be able to:

- Acquaint the biosafety rules to be followed while handling the environmental samples.
- Learn the sampling and enrichment techniques for isolation of bacteria and fungi.
- Calculate the microbial diversity indices and interpret the distribution of microbial species.

- Get acquainted with analysis o and submission of sequences data on NCBI or other available databases.
- Learn the problem-solving approach based on above modules.

References:

1. Atlas, R. M. (1997). Handbook of microbiological media. CRC-Press, United Kingdom.
2. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. 1st Ed. CRC Press., United Kingdom.
3. Horikhoshi, K. & Grant, W. D. (1998). Extremophiles- Microbial life in extreme environment. ISBN: 978-0-471-02618-1. John Wiley & Sons, Inc. Germany.
4. Parkinson, D. & Williams, S. T. (1961). A method for isolating fungi from soil microhabitats. Plant and soil. Vol. 13(4):347–55.
5. Warcup, J. H. (1950). The soil-plate method for isolation of fungi from soil. Nature 166, 117–118.

MB 533 MJP : Lab Exercises in Biochemical and Molecular Biology Techniques

Total: 2 Credits; Workload: 30 h/credit
(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The objective of this course is to provide laboratory training on use of various molecular biology and biochemical techniques for biomolecules.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Spectrophotometry: a. Extraction of protein (from bacteria/fungi) and its estimation using a standard graph of BSA prepared using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law. b. Extraction of polysaccharide (from bacteria/fungi) and its estimation using a standard graph of total sugar prepared using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law. c. Microvolume quantitation of nucleic acids/protein.	12 12 03
2	Chromatography: a. Separation of amino acids and sugars using paper and thin layer chromatography (TLC). b. Separation of biomolecules using molecular sieve chromatography.	12 06
3	Electrophoresis: a. Separation of DNA using agarose gel electrophoresis. b. Separation of proteins using SDS PAGE. c. Blotting of the protein on nitrocellulose membrane.	06 06 03
4	Dialysis and Ultrafiltration.	06

Course outcome: The student at the completion of the course will be able to:

- Learn the isolation of proteins and polysaccharides from microbial system and their quantification using spectrophotometer.
- Gets experience of quantification of proteins using micro volume spectrophotometer.
- Learn the separation of mixtures of amino acids, sugars using paper chromatography and TLC.
- Separate the DNA and proteins using electrophoresis techniques.
- Separate and concentrate the samples using ultrafilter membrane.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. 1st Ed. CRC Press, United Kingdom.
2. Cooper, A. (2004). Biophysical chemistry. Royal Society of Chemistry, United Kingdom.
3. Lasseter, B. F. (2019). Biochemistry in the lab: A manual for undergraduates. CRC Press, United States of America.
4. Lundblad, R.L. & Macdonald, F. (2018). Handbook of biochemistry and molecular biology. 5th Ed. CRC Press, Boca Raton, United States of America.
5. Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw Hill Publishing Company, India.
6. Sadasivam, S. & Manickam, A. (2007). Biochemical methods. New Age International Limited, India.
7. Wood, W. B. (1974). Biochemistry: A problems approach. W. A. Benjamin, Netherlands.

MB 535 MJ : Microbial Pathogenesis and Epidemiology

Total: 2 Credits; Workload: 15 h/credit
(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objectives:

Provide knowledge on mechanisms by which microbes cause infectious disease in humans, understand the host pathogen interactions. Define key terms and concepts related to microbial pathogenesis and epidemiology. Explain the mechanisms of microbial pathogenesis and how pathogens cause diseases, epidemiological measures and range of epidemiologic study designs.

Sr. No.	Course Title and Contents	No of Lectures
1	Host pathogen interactions: a. Overview of host defences: Skin and mucosal secretions, non-specific local responses, non-specific inflammatory responses, specific immune responses. b. Pathogen Defenses: Mechanism of adhesion, colonization and evasion of host tissues by bacterial pathogens, mechanisms of bacterial resistance to host cellular and humoral defenses.	03
2	Mechanisms of pathogenesis: Transmission, adherence, invasion and colonisation of host cells.	02

Sr. No.	Course Title and Contents	No of Lectures
3	Virulence factors: Adherence and colonization factors, invasion factors, capsules and other surface components, biofilms, microbial toxins (exotoxin and endotoxin), Siderophores (To be taught with reference to their role and mechanism of action with examples).	05
4	Molecular basis of bacterial pathogenicity: Cytoskeletal modulation of host cell, virulence genes and pathogenicity islands.	03
5	Medical mycology: Pathogenesis of fungi, structural dimorphism and role of extra cellular products in fungal infection.	03
6	Epidemiology: a. Basic principles of epidemiology, principles of measurement. b. Study designs: Cross-sectional studies, ecologic studies, cohort studies, case-control studies, randomized trials. c. Molecular Epidemiology.	06
7	Epidemiological and investigational approaches for: a. Persistent and Latent Infections with reference to *Mycobacterium tuberculosis,* Hepatitis B, C and D viruses, *Toxoplasma gondii*. b. Health Care Associated Infections: Nosocomial infections caused by ESKAPE pathogens, surgical site infections (SSI) and three other types of infections commonly seen in ICU patients—central-line associated bloodstream infections (CLABSI), catheter-associated urinary tract infections (CAUTI), and ventilator-associated pneumonia (VAP).	05
8	Infection control practices: a. Standard precautions – Hand hygiene, donning doffing of. Personal Protective Equipment (PPE) kit. b. Transmission based precautions: Contact precautions, droplet precautions, airborne precautions. c. Disinfection policy. d. Waste management. e. Emergency plan while working in clinical settings.	03

Course outcome: The student at the completion of the course will be able to:

- Describe the mechanisms of bacterial invasion of hosts and virulence factors.
- Define various portals of entry and the routes of transmission of the infection.
- Compare and contrast the variety of disease-causing mechanisms associated with viral, bacteria, fungal and oomycete pathogens.
- Critically evaluate the attempts and strategies to control disease.
- Illustrate the basic concepts of epidemiology, application of research and concepts of prevalence and incidence in epidemiology.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Aschengrau, A. & Seage, G. R. (2013). Essentials of epidemiology in public health. Jones & Bartlett Learning, United States of America.
2. Barton, A. W. (2010). Host-pathogen interactions: Genetics, immunology, and physiology. Nova Biomedical Press, United States of America.
3. Casadevall, A. & Pirofski, L. A. (2001). Host-pathogen interactions: The attributes of virulence. The Journal of Infectious Diseases, 184(3), 337-344.
4. Cole, M. F. (2019). Unifying microbial mechanisms: Shared strategies of pathogenesis. CRC Press, United States of America.
5. Johnson, D. I. (2017). Bacterial pathogens and their virulence factors. Springer International Publishing, Germany.
6. Oxford textbook of medical mycology. (2017). Oxford University Press, United Kingdom.
7. Peterson, J. W. (1960). Chapter 7 - Bacterial pathogenesis. In: Baron S. (Ed.) Medical Microbiology. 4th Ed. https://www.ncbi.nlm.nih.gov/books/NBK8526/. University of Texas, Medical Branch, Galveston.
8. Sastry, A. S. & Deepashree, R. (2019). Essentials of hospital infection control. Jaypee Brothers Medical Publishers Pvt. Limited, India.
9. Wilson, J. (2018). Infection control in clinical practice. Elsevier Health Sciences, Netherlands.

MB 536 MJ : Fundamentals of Bioprocess Engineering & Technology

Total: 2 Credits; Workload: 15 h/credit
(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objective:

The objective of this course is to learn the strain improvement techniques and acquire knowledge of bioreactors and optimization strategies for the development of microbial products production processes.

Sr. No	Credit Title & Contents	No. of Lectures
1	Introduction to bioprocess engineering.	01
2	Microbial systems for bioprocessing: a. Strain improvement techniques and culture preservation. b. Inoculum development. c. Primary and secondary metabolites.	04
3	Bioreactors (Types, principle, applications and limitations): a. Lab scale fermenters: Benchtop, micro-fluidics-based device. b. Pilot scale and industrial scale bioreactors (Principle, types, applications and limitations): for microbial/algae/fungi fermentations and cells cultivations. c. Scale-up of optimized media.	09
4	Fermentation Media: a. Media composition; media components and parameter screening and optimization.	04

Sr. No	Credit Title & Contents	No. of Lectures
	b. Media sterilization and contamination.	02
5	Aeration and agitation of fermentation broth: Aeration -Theory of oxygen transfer in bubble aeration, oxygen transfer kinetics, determination of K_{La}, Agitation-Design of impellers and their hydrodynamics, Fermentation broth rheology and power requirements for agitation-Concept of Newtonian and non-Newtonian fluids, effect of broth rheology on heat, nutrient and oxygen transfer, Reynolds number, power number, aeration number.	06
6	Stoichiometry of bioprocesses and models of microbial growth.	04

Course outcome: The student at the completion of the course will be able to:

- Learn about design and principle of lab scale, pilot scale and industrial scale bioreactors and their applications in industrial processes.
- Propose the strategies for achieving media compositions for microbial fermentations.
- Understand and illustrate various optimized physical conditions for operating a typical fermentation process.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Doran, P. M. (1995). Bioprocess engineering principles. Elsevier Science, United Kingdom.
2. Goldman, E. & Green, L.H. (2015). Practical handbook of microbiology. 3rd Ed. CRC Press. https://doi.org/10.1201/b17871.
3. Karamchandani, B. M., Maurya, P. A., Awale, M., Dalvi, S. G., Banat, I. M. & Satpute, S. K. (2024). Optimization of fungal chitosan production from *Cunninghamella echinulata* using statistical designs. 3 Biotech, 14(3), 1-15.
4. Reed, G. (2004). Prescott and Dunn's industrial microbiology. CBS Publishers & Distributors, India.
5. Stanbury, P. F., Whitaker, A. & Hall, S. J. (2016). Principles of fermentation technology. Elsevier Science, United Kingdom.

MB 537 MJ : Environmental and Applied Microbiology

Total: 2 Credits; Workload: 15 h/credit
(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objective:
The objective of this course is to aim to provide students with a comprehensive understanding of the role of microorganisms in the environment, as well as the practical applications in addressing environmental challenges and advancing sustainable practices.

Sr. No	Credit Title & Contents	No. of Lectures
1	Introduction to environmental microbiology: Scope, research areas, natural resources; Interdependence of man and environment; biogeochemical cycles: role of microbiota in carbon, nitrogen, phosphorus cycles.	05
2	Aeromicrobiology: a. Biological material in air: Microorganisms, spores and toxins; bioaerosol.	02
3	Aquatic microbiology: a. Fresh and marine ecosystems (estuaries, mangroves, deep sea, hydrothermal vents, salt pans, coral reefs); b. Water pollution: eutrophication, plastic pollution, ground water pollution and their measurements; drinking water microbiology and quality control.	05
4	Soil microbiology: Soil ecosystem, agricultural soil, desert soil, polar region, Soil pollution.	05
5	Space microbiology: a. Historical development of space microbiology. b. Life detection methods: Evidence of metabolism (Gulliver), evidence of photosynthesis (autotrophic and heterotrophic).	04
6	Microbiology of extreme environment: Study of methanotrophs, oligotrophs, thermophiles, psychrophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles with respect to Occurrence, diversity, adaptations and potential applications.	05
7	Basic aspects of bioengineering: Strain improvement, principle and applications of bioreactors for large scale production (bacterial/fungal/algal).	04

Course Outcomes: The student at the completion of the course will be able to:

- Know about the diverse microbial populations in various natural habitats like soil, air, water.
- Get the proficiency in aquatic microbiology (freshwater, marine ecosystems, water pollution.
- Evaluate the importance of soil microbiota in ecosystem functioning and nutrient cycling.
- Become aware of the important role microbes play in bio-geochemical cycling of essential elements occurring within an ecosystem and its significance.

- Understand the principles of strain improvement and the operation of bioreactors for large-scale microbial production, including bacterial, fungal, and algal cultures.

References:

1. Bijlani, S., Stephens, E., Singh, N. K., Venkateswaran, K. & Wang, C. C. (2021). Advances in space microbiology. Science, 24(5).
2. Goldman, E. & Green, L. H. (2015). Practical handbook of microbiology. 3rd Ed. CRC Press, Boca Raton, United States of America.
3. Horikoshi, K. (2010). Extremophiles handbook. ISBN: 978-4-431-53897-4. Springer, Tokyo.
4. Horneck, G., Klaus, D. M. & Mancinelli, R. L. (2010). Space microbiology. Microbiology and Molecular Biology Reviews: MMBR, 74(1), 121–156. https://doi.org/10.1128/MMBR.00016-09
5. Munn, C. B. (2020). Marine microbiology: Ecology & applications. CRC Press, United Kingdom.
6. Pepper, I. L. & Gerba, C. P. (2015). Aeromicrobiology. Environmental Microbiology, 89–110.
7. Stanbury, P. F., Whitaker, A. & Hall, S. J. (2016). Principles of Fermentation Technology. Elsevier Science, United Kingdom.
8. Subba, R. (2017). Soil microbiology. CBS Publishers & Distributors, India.

MB 535 MJP : Lab Exercises in Microbial Pathogenesis

Total: 2 Credits; Workload: 30 h/credit
(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The student at the completion of the course will be able to: The objective of this course is to learn about handling, isolation and characterization of pathogens from clinical sources.

Sr. No.	Course Title and Contents (Experiments equivalent to 60 h to be completed)	No of Hours
1	a. Donning and doffing of personal protective equipment (PPE) kit and gloves. b. Hand hygiene - steps for sanitization. c. Spillage management. d. Biomedical waste handling and disposal and visit to plant.	06
2	Microbiology air surveillance in microbiology lab - different methods.	08
3	Protocols for collection and transport of clinical specimens.	02
4	Isolation and identification of pathogens using classical and automated systems.	12
5	Identification of Methicillin-resistant *Staphylococcus aureu*s (MRSA) - Different methods.	08
6	Identification of extended-spectrum beta-lactamase producers (ESBLs) - Screening tests and confirmatory tests.	08
7	a. Determination/ detection of virulence factors: b. Biofilm formation. c. Hemolysis. d. Siderophores etc.	12
8	ELISA based methods for detection of bacterial toxins.	06
9	Rapid diagnostic serological tests pathogen typing.	06

Course Outcome: The student at the completion of the course will be able to:

- Learn the basics of handling and management of pathogenic samples in clinical a laboratory.
- Gain skills to isolate, characterize and identify the isolated clinical samples.
- Acquire skills to characterize and identify multidrug resistant pathogens.
- Identify various pathogenic determinants causing infections through diagnostic tools.

References:

1. Aschengrau, A. & Seage, G. R. (2013). Essentials of epidemiology in public health. Jones & Bartlett Learning, United States of America.
2. Casadevall, A. & Pirofski, L. A. (2001). Host-pathogen interactions: the attributes of virulence. The Journal of Infectious Diseases, 184(3), 337-344.
3. Cole, M. F. (2019). Unifying microbial mechanisms: Shared strategies of pathogenesis. CRC Press, United States of America.
4. Johnson, D. I. (2017). Bacterial pathogens and their virulence factors. Springer International Publishing, Germany.
5. Palavecino, E. L. (2014). Rapid methods for detection of MRSA in clinical specimens. Methicillin-resistant *Staphylococcus aureus* (MRSA) protocols, 71-83.
6. Peterson, J. W. (1996). Bacterial pathogenesis. In: Baron S. (Ed.) Medical Microbiology. 4th Ed. University of Texas, Medical Branch, Galveston; Chapter 7. https://www.ncbi.nlm.nih.gov/books/NBK8526/.
7. Wadekar, M. D., Anuradha, K. & Venkatesha, D. (2013). Phenotypic detection of ESBL and MBL in clinical isolates of Enterobacteriaceae. International Journal of Current Research and Academic Review. 1(3), 89-95.

MB 536 MJP : Lab Exercises Fermenter Designs and Applications

Total: 2 Credits; Workload: 30 h/credit

(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The objective of this course is to learn the microbial screening and strain improvement for the application in food and fermentation industries.

Sr. No	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Screening of bacteria for enzyme/antibiotic/organic acid/vitamin/biosurfactant production (Any Two).	12
2	Strain improvement by mutation: UV mutation/chemical mutation.	16
3	Optimization of media components and parameters for biomass/metabolites using one-factor-at-a-time (OFAT) approach.	24
4	Demonstration of Design-Expert® software for media optimization and interpretation of the data.	08
5	Pilot-scale production of microbial products (enzyme/antibiotic/organic acid/vitamin/biosurfactant) (Any One).	20
6	Immobilization of the enzyme using entrapment method.	08

Course Outcome: The student at the completion of the course will be able to:

- Learn the strategy for screening the potential microbes for production of primary and secondary metabolites.
- Get familiar with the methods for improvement of strain for their desired characters.
- Formulate the optimized medium and other parameters for important microbial products.
- Handle and operate pilot-scale bioreactors.
- Develop problem-solving skills and learn to interpret and analyse the data.

References:

1. Bisen, P. S. (2014). Laboratory Protocols in Applied Life Sciences. CRC Press, United Kingdom.
2. Choi, G. H., Lee, N. K. & Paik, H. D. (2021). Optimization of medium composition for biomass production of *Lactobacillus plantarum* 200655 using response surface methodology. Journal of Microbiology and Biotechnology, 31(5), 717.
3. Design-Expert® software for media optimization.
4. Doran, P. M. (1995). Bioprocess Engineering Principles. Elsevier Science, United Kingdom.
5. Karamchandani, B. M., Maurya, P. A., Awale, M., Dalvi, S. G., Banat, I. M. & Satpute, S. K. (2024). Optimization of fungal chitosan production from *Cunninghamella echinulata* using statistical designs. *3 Biotech*, *14*(3), 1-15.
6. Latha, S., Sivaranjani, G. & Dhanasekaran, D. (2017). Response surface methodology: A non-conventional statistical tool to maximize the throughput of Streptomyces species biomass and their bioactive metabolites. Critical Reviews in Microbiology, 43(5), 567-582.
7. Singh, V., Haque, S., Niwas, R., Srivastava, A., Pasupuleti, M. & Tripathi, C. K. M. (2016). Strategies for fermentation medium optimization: an in-depth review. Frontiers in Microbiology. 7: 2087.

MB 537 MJP : Lab Exercises in Environmental and Applied Microbiology

Total: 2 Credits; Workload: 30 h/credit
(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The objective of this course is to understand the interaction and reaction of microbial impacts and role of microorganisms in the environment.

Sr. No	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Sample preparation for heavy metal detection. Determination of heavy metals (Fe/Cu) by spectrophotometric methods.	08
2	Use of Fenton reaction for degradation of pollutants.	08
3	Waste water analysis: a. pH, conductivity. b. Total dissolved solids (TDS). c. Dissolved oxygen (DO), Chemical oxygen demand (COD), Biochemical oxygen demand (BOD).	20

Sr. No	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
	d. Alkalinity, chloride and hardness measurements.	
4	Decolourization or adsorption of dye present in industrial effluents.	08
5	Bioleaching of metals from waste.	10
6	Production of fungal biopolymers (chitin and chitosan): Production, isolation and yield determination.	16
7	Effect of gravitational force on microbial growth.	12

Course Outcomes: The student at the completion of the course will be able to:

- Get familiar with various techniques for water analysis, analyte detection methods and applications of pollutant removal technologies.
- Design methods for estimating heavy metals and detection of contaminants in natural resources.
- Learn the approach to recover the valuable metals from waste material.
- Develop problem-solving skills and learn to interpret and analyse the data.

References:

1. Atlas, R. M. & Batha, R. (2000). Microbial ecology: Fundamentals & applications. 4th Ed. Benjamin & Cummings Science Publishing, Unite States of America.
2. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. CRC Press, United Kingdom.
3. Goldman, E. & Green, L. H. (Eds.). (2015). Practical handbook of microbiology. 3rd Ed. CRC Press. https://doi.org/10.1201/b17871.
4. Huang, B., Li, D. G., Huang, Y. & Liu, C. T. (2018). Effects of spaceflight and simulated microgravity on microbial growth & secondary metabolism. Military Medical Research, 5, 1-14.
5. Maier, R. M., Pepper, I. L. & Gerba, C. P. (2009). Environmental microbiology. 2nd Ed. Academic Press. China.

MB 530 RM : Research Methodology - Scientific Writing and Communication

Total: 2 Credits; Workload: 15 h/credit

(Total Workload: - 2 credits x 15 h = 30 h in semester)

Course Objective:

The objectives of this course are to understand the importance of research in life sciences, to learn the different research methodologies and their application in Microbiology, to cultivate critical thinking and analytical skills necessary for identifying research problems and formulating research questions, to proficiently analyse the results, and to provide skill to write research proposals and research paper.

Sr. No.	Course Title and Contents	No of Lectures
1	History of research: Research concept: Definition, characteristics, objectives, utility, types of	03

Sr. No.	Course Title and Contents	No of Lectures
	research: descriptive vs. analytical research; applied vs. fundamental research; quantitative vs. qualitative research; conceptual vs. empirical research.	
2	Problem identification and formulation: a. Formulating the research problem, defining the research problem, Origin of the research problem. b. Literature review: Purpose of the literature review, Types of information and sources, primary and secondary sources. c. Research objectives.	04
3	Research design: Types of research design (descriptive research design, correlational research design, experimental research design, and explanatory research design).	04
4	Research methods: a. Quantitative research, qualitative research, experimental research, and mixed methods approaches, data analysis and interpretation. b. Sample collection and processing techniques (Water, soil, air and medical).	04
5	Research report writing: a. Purpose of the writing, types and formats of scientific reports, scientific writing skills, significance of communicating science, ethical issues, copy rights and plagiarism of a research paper. b. Preparation of project proposal – Time frame and work plan – Budget and Justification.	05
6	Citation: Methods, bibliography, citation rules.	03
7	Data presentation: Presentation skills, formal scientific presentation skills; Preparing power point presentation, Presenting the work, Scientific poster preparation.	04
8	Current trends in research: a. Mono-disciplinary research, trans-disciplinary research, inter-disciplinary research. b. Threats and challenges to good research.	03

Course Outcomes: The student at the completion of the course will be able to:

- Understand research terminologies.
- Describe quantitative, qualitative and mixed methods approaches to research.
- Identify the components of a literature review process.
- Analyze and interpret the research.
- Apply ethical principles of research in preparation of scientific documents.
- Learn to interpret and analyse the data.

References:

1. Arora, R. (2004). Encyclopedia of research methodology in biological sciences. Anmol Publications Pvt. Limited, India.
2. Hofmann, A. (2022). Scientific writing and communication. ISBN: 978019761379Oxford University Press, USA
3. Hofmann, A. H. (2023). Scientific writing and communication: papers, proposals, and presentations. 5th Ed. ISBN: 978-0197613795. OU, United States of America.
4. Kumar, R. (2010). Research methodology: A Step-by-Step Guide for Beginners. SAGE Publications, United Kingdom.
5. Lang, T. A. (2017). Writing a better research article. Journal of Public Health and Emergency, 1(12).
6. Mishra, S. B. & Alok, S. (2017). Handbook of research methodology: A Compendium for Scholars & Researchers. Educreation Publishing, India.
7. Prathap, T. S., Ali, M. A. & Kamraju, M. (2019). How to write an academic research paper. Journal of Emerging Technologies and Innovative Research, 6(4), 488-493.
8. Thelle, D. & Laake, P. (2015). Research in medical and biological sciences. Planning and preparation to grant application and publication, 275-320. Elsevier Science, Netherlands.

MB 530 RMP : Research Methodology – Practical Based on Scientific Writing and Communication

Total: 2 Credits; Workload: 30 h/credit

(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The objectives of this course are to apply scientific writing and communication skills learned as a part of theory course preparing and presenting scientific articles, blogs, graphical abstracts, etc.

Title and Contents	No. of Hours
Seminar presentations, group activities, and scientific writing sessions based on above theory course. These will include but not limited to- a. Use of search engines for scientific data mining. b. Use of reference management tools. c. Preparing power point presentation. d. Presenting a research article. e. Writing an abstract for a research paper. f. Preparing a graphical abstract using software. g. Writing a concept note for research project. h. Scientific poster preparation and presentation. i. Writing a scientific news article or a science blog. j. Preparing scientoon. k. Participating in group discussions, conferences, symposia etc.	60

Course Outcomes: The student at the completion of the course will be able to:

- Review and summarize scientific literature, identify strengths and weaknesses in research studies and assessing the credibility of sources.
- Write clear, concise, and well-organized scientific documents, including research papers, reports, and proposals.
- Learn techniques for presenting scientific data visually, including graphs, charts, and diagrams, in a clear and informative manner.
- Communicate scientific concepts orally through presentations, seminars, and discussions, employing effective speaking techniques and visual aids.

References:

1. Arora, R. (2004). Encyclopedia of research methodology in biological sciences. Anmol Publications Pvt. Limited, India.
2. Day, R. A. (1998). How to write and publish a scientific paper. 5th Ed. Oryx Press, United States of America.
3. Day, R. A. & Gastel, B. (2011). How to Write and Publish a Scientific Paper 7th Ed. ISSBN: 0313391971. Greenwood, United States of America.
4. Hofmann, A. (2022). Scientific writing and communication. ISBN: 978019761379Oxford University Press, USA
5. Hofmann, A. H. (2023). Scientific writing and communication: Papers, proposals, and presentations. 5th Ed. ISBN: 978-0197613795. OU, United States of America.
6. Kumar, R. (2010). Research methodology: A Step-by-Step Guide for Beginners. SAGE Publications, United Kingdom.
7. Lang, T. A. (2017). Writing a better research article. Journal of Public Health and Emergency, 1(12).
8. Mishra, S. B. & Alok, S. (2017). Handbook of research methodology: A Compendium for Scholars & Researchers. Educreation Publishing, India.
9. Prathap, T. S., Ali, M. A. & Kamraju, M. (2019). How to write an academic research paper. Journal of Emerging Technologies and Innovative Research, 6(4), 488-493.
10. Thelle, D. & Laake, P. (2015). Research in medical and biological sciences. Planning and preparation to grant application and publication, 275-320. Elsevier Science, Netherlands.

SEMESTER-2

MB 541 MJ : Biochemistry and Metabolism - II

Total: 2 Credits; Workload: 15 h/credit

(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objectives:

The objective for this course is to gain the fundamental knowledge of enzymes and their role in biological reactions, role of catabolic and anabolic pathways in cellular metabolism.

Sr. No	Credit Title & Contents	No. of lecture
1	Enzymology: Enzyme purification, Kinetics of single substrate enzyme catalyzed Reaction; Kinetics of reversible inhibitions enzyme catalyzed reactions, King and Altman approach to derive two substrate enzyme catalyzed reactions, types of two substrate enzyme catalyzed reactions, concept of allosterism, positive and negative co-operativity, models of allosteric enzymes (Monad, Wyamann and Changuax and Koshland, Nemethy and Filmer model), kinetics of allosteric enzyme, Hill plot, examples of allosteric enzymes and their significance in regulation.	10
2	Bacterial photosynthesis: Photosynthetic microorganisms, photosynthetic pigments and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain (ETC) in photosynthetic bacteria, carbon dioxide fixation pathways.	06
3	Respiration: Aerobic and anaerobic 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 n potential and its significance, 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 methanogens.	08
4	Lipids: Building blocks of lipids: Biosynthesis and degradation of lipids and its regulation.	04
5	Vitamins: Water and fat soluble vitamins: structure and function.	02

Course Outcomes: The student at the completion of the course will be able to:

- Understand the steps involved in enzyme purification.
- Describe the structure and function of enzymes, mechanism of enzymes-catalyzed reaction.
- Understand the fundamental bioenergetics of biochemical processes, chemical logic of metabolic pathways.
- Knowing in detail about concepts to illustrate how enzymes and redox carriers works and the oxidative phosphorylation machinery occur.

- Understand the concept and significance of proton motive force to drive the formation of high energy bonds and high energy compounds.
- Understand the Interrelations, regulation & malfunction of electron transport chain and its consequences.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Almeida, P. (2016). Proteins: Concepts in Biochemistry. CRC Press, United Kingdom.
2. Gottschalk. G. (1985). Bacterial metabolism. 2nd Ed. Springer, New York, United States of America.
3. Lundblad, R. L. & Macdonald, F. (Eds.). (2018). Handbook of Biochemistry and Molecular Biology. 5th Ed. CRC Press, Boca Raton, United States of America.
4. Morrison, R. T. & Boyd, R. N. (2016). Organic chemistry. 6th Ed. ISBN: 978-8177581690. Pearson, London, England.
5. Nelson, D. L. & Cox, M. M. (2017). Lehninger principles of biochemistry. 7th Ed. W.H. Freeman. Macmillan Learning, London, United Kingdom.
6. Segel, I. (2004). Biochemical calculations. 2nd Ed. ISBN: 978-81-265-2643-7. John Wiley & Sons, India.
7. Stryer, L. (1995). Biochemistry. 4th Ed. W. H. Freeman and Company, New York.
8. Voet, D., Voet, J. G. & Pratt, C. W. (2016). Fundamentals of biochemisty. 5th Ed. ISBN: 978-1-118-91840-1. John Wiley & Sons, Germany.
9. Wood, W. B., Wilson, J. H., Benbow, R. M. & Hood, L.E. (1974). Biochemistry: A Problems Approach, ISBN: 978-0805398403. Menlo Park, CA: W. A. Benjamin-Cummings Pub Co, United States of America.

MB 542 MJ : Microbial Genetics

Total: 2 Credits; Workload: 15 h/credit
(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objective:

The objective of this course is to develop basic and deeper knowledge about molecular genetics in prokaryotes and eukaryotes. Expose students to understand the flow of genetic information in cells.

Sr. No.	Credit Title & Contents	No of Lecture
1	Mutation and genetic analysis: a. Spontaneous mutation theory-fluctuation test. b. Types of mutation, mutation rate, reversion mutants, suppressor mutants, mutagenic agents. c. Isolation and genetic analysis of mutants: Methods for selection, screening, enrichment of mutants, site-directed mutagenesis.	08
2	DNA repair mechanisms: Excision repair, recombination repair, SOS repair and mismatch repair.	06

Sr. No.	Credit Title & Contents	No of Lecture
3	Bacteriophage genetics a. Development cycle and phage DNA replication (T odd and T even phages, M13 phage, Phage Lambda). b. Regulation of Lytic and lysogenic cycles in Phage Lambda. c. Applications of phages.	06
4	Mobile genetic elements: a. Plasmids: types, structure and replication, application/ importance in various fields. b. Transposons: Types, structure, replication, transposon mutagenesis.	06
5	Gene transfer mechanisms – Transformation (natural and artificial), transduction, conjugation.	04

Course Outcomes: The student at the completion of the course will be able to:

- Get acquainted with inheritance mechanism in bacteria and bacteriophage.
- Understand the mechanisms of mutations and recombination in prokaryotic and eukaryotic systems.
- Get acquainted with the mechanism of horizontal gene transfer and their consequences.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Clark, D., Pazdernik, N., McGehee, M. (2018). Molecular biology, 3rd Ed. ISBN: 9780128132883 Elsevier, Academic Cell, United State.
2. Craig, N., Green, R., Greider, C., Storz, G., Cohen-Fix, O. & Wolberger, C. (2014). Molecular biology: principles of genome function, OUP Oxford, Oxford, England.
3. Freifelder, D. (1997) Essentials of molecular biology. Narosa Publishing House, New Delhi.
4. Glazer, A. N. & Nikaido, H. (1995). Microbial biotechnology – Fundamentals of Applied Microbiology, W.H. Freeman and company, New York.
5. Hughes, K. T. (2007). Advanced bacterial genetics: Use of transposons and phage for genomic engineering, Elsevier, Vol. 421.
6. Klug, W. S. & Cummings, M. R. (2003). Concepts of genetics. 7th Ed. Pearson Education, Inc, London, United Kingdom.
7. Krebs, J. E., Lewin, B., Goldstein, E. S. & Kilpatrick, S. T. (2014). Lewin's genes XI, Jones & Bartlett Publishers, Massachusetts, United States of America.
8. Meneely, P., Hoang, R. D., Okeke, I. N. & Heston, K. (2017). Genetics: genes, genomes, and evolution, Oxford University Press, New York, United States of America.
9. Nelson, D. L. & Cox, M. M. (2017). Lehninger principles of biochemistry. 7th Ed. W.H. Freeman. Macmillan Learning, London, United Kingdom.
10. Thomas, C. M. (2003). Horizontal gene pool: Bacterial plasmids and gene spread, ISBN: 9780429152900. CRC Press, London.
11. Wilson, K. & Walker, J. (2010). Principles and techniques of biochemistry and molecular biology. 7th Ed. Cambridge University Press, England.

MB 543 MJ : Molecular Biology - I

Total: 2 Credits; Workload: 15 h/credit

(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objective:

The objective of this course is to develop basic and deeper knowledge about molecular genetics in prokaryotes and eukaryotes. Expose students to understand the flow of genetic information in cells.

Sr. No.	Credit Title & Contents	No. of Lecture
1	Genomic organization of the cell: a. Genome size and C value paradox. b. Concept of gene: interrupted gene, non-coding genes, pseudogene, multiple gene families. c. Non-repetitive DNA sequences, Repetitive DNA sequences - satellite, tandem and interspersed repeats. d. Genome organization in viruses, prokaryotes and eukaryotes: Organization of nuclear and organellar genomes. e. Chromosomal banding, chromosomal territories, Giant chromosomes (lampbrush and polytene). f. Chromosomal domains (matrix, loop domains) and their functional significance. Heterochromatin and euchromatin, structure of chromatin, chromosome, centromere, telomere, nucleosome, nucleosome positioning g. Types of histones, histone modifications- methylation, acetylation, phosphorylation and its effect on structure and function of chromatin. h. Chromatin remodeling and genomic imprinting.	10
2	DNA replication in prokaryotes and eukaryotes: a. Mode of replication: semi-conservative mode of replication, rolling circle. b. Machinery involved in replication and its regulation. c. Steps in replication: initiation, events at the replication fork, elongation (continuous and dis - continuous), termination.	08
3	Recombinant DNA technology (RDT): a. Introduction, general strategies, gene cloning: genomic libraries, cDNA libraries, single gene cloning. b. Enzymes: DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase. c. Vectors: Plasmids, cosmids, lambda phage, shuttle vectors, YACs, BACs, Baculovirus and Pichia vectors system, Plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors. d. Cohesive and blunt end ligation, linkers, adaptors, homopolymeric tailing. e. Screening, characterization of transformants: Hybridization techniques, probe preparation (radioactive, nonradioactive ligands), hybrid detection. f. Genetic manipulation of animals, transgenic plants. g. Purification of recombinant proteins: His-tag, GST-tag, MBP-tag.	12

Course Outcomes: The student at the completion of the course will be able to:

- Account structure and function gene organization of the prokaryotic and eukaryotic cell and its organelles.
- Get illustrated with the central dogma of life - The flow of genetic information in cells.
- Recognize the importance of RDT and gene cloning strategies used by the scientific fraternity.
- Selection of appropriate enzymes to perform Recombinant DNA molecules of interest.
- Understand the strategies required for improving health conditions by developing new pharmaceutical products, vaccines etc.
- Describe the steps involved in the production of biopharmaceuticals in microbial and mammalian cell systems.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Brown, T. A. (2020). Gene cloning and DNA analysis: An introduction. John Wiley & Sons, Germany.
2. Brown, T. A. (2023). Genomes 5. ISBN: 978-0367674076. CRC Press, London.
3. Buchanan, B. B., Gruissem, W. & Jones, R. L. (2015). Biochemistry & Molecular Biology of Plants. Chichester, West Sussex: John Wiley & Sons, United Kingdom.
4. Clark, D., Pazdernik, N. & McGehee, M. (2018). Molecular biology, 3rd Ed. ISBN: 9780128132883. Elsevier, Academic Cell, United State.
5. Cohen, S. N., Chang, A. C. Y., Boyer, W. & Helling, B. Construction of biologically functional bacterial plasmids in vitro. Proc Natl Acad Sci U. S. A. 1973;70(11):3240–4.
6. Cotter, J. & Perls, D. (2019). Genetically engineered animals: from lab to factory farm. Friends of the earth, pp.09-01.
7. Craig, N., Green, R., Greider, C., Storz, G., Cohen-Fix, O. & Wolberger, C. (2014). Molecular biology: principles of genome function, OUP Oxford, Oxford, England.
8. Franklin, T. J. & Snow, G. A. (2005). Biochemistry and molecular biology of antimicrobial drug action. Springer Science & Business Media. United States of America.
9. Freifelder, D. (1997). Essentials of molecular biology. Narosa Publishing House, New Delhi, India.
10. Glick, B. R. & Pasternak, J. J. (1998). Principles & applications of recombinant DNA. ASM, Washington DC.
11. Glick, B. R. & Patten, C. L. (2022). Molecular biotechnology: principles and applications of recombinant DNA. John Wiley & Sons, Germany.
12. Klug, W. S. & Cummings, M. R. (2003). Concepts of genetics. 7th Ed. Pearson Education, Inc, London, United Kingdom.
13. Krebs, J. E., Lewin, B., Goldstein, E. S. & Kilpatrick, S. T. (2014). Lewin's genes XI, Jones & Bartlett Publishers, Massachusetts, United States of America.
14. Mayers, D. L., Sobel, D., Ouellette, M. & Kaye, K. S. (2009). Antimicrobial drug resistance. 803-824. Humana press, New York.
15. Primrose, S. B. & Twyman, R. (2006). Principles of gene manipulation and genomics. John Wiley & Sons, Germany.
16. Thomas, C. M. (2003). Horizontal gene pool: Bacterial plasmids and gene spread, ISBN: 9780429152900. CRC Press. London.

17. Wilson, K. & Walker, J. (2010). Principles and techniques of biochemistry and molecular biology. 7th Ed. Cambridge University Press, England.
18. Wu, R., Grossman, L. & Moldave, K. (2014). Recombinant DNA methodology. ISBN: 0-12-765560-3. Academic Press Ink, United Kingdom.

MB 544 MJ: Biostatistics and Mathematics for Biologists

Total: 2 Credits; Workload: 15 h/credit
(Total Workload: 2 credits x 15 h = 30 h in semester)

Course objective:
The objective of this course is to give basic concepts of mathematics and statistics to biology students.

Sr. No	Credit Title & Contents	No. of Lecture
1	Biostatistics/quantitative biology, descriptive statistics: Probability, binomial distribution and normal distribution.	03
2	Variable: Discrete and continuous random variables.	02
3	Population and sample: a. Measure of central tendency: Mean, mode, median. b. Concept of standard deviation and standard error. c. Confidence interval, parametric tests of statistical significance. d. Nonparametric hypothesis tests, analysis of variance. e. Linear regression and correlation, least square fit, Pearson's correlation coefficient, non-linear regression and data fitting. f. Displaying of data: Frequency plots, bar chart, histograms, scatter plots, box plots.	10
4	Mathematics: a. Mathematical functions and graph of a function: b. Linear function, quadratic function, exponential function, periodic function, logarithmic function. c. Slope of curves, limits and idea of derivative, derivative of simple and exponential function. d. Calculus, diffusion equation and mean square displacement.	15

Course Outcomes: The student at the completion of the course will be able to:

- Understand the concept of descriptive statistics; learn what sampling and probability distributions.
- Differentiate between sample and population.
- Calculate the central tendency of the biological data; understand the concept of dispersion of data from mean.

- Understand the difference between parametric and non-parametric tests and their applications.
- Understand the concept of correlation and regression.
- Apply the different graphical representation for biological data.
- Be familiar with some key ideas of mathematical functions.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Aitken, M., Broadhursts, B. & Haldky, S. (2009) Mathematics for biological scientists. Garland Science, New York, United States of America.
2. Arya, J. C. & Lardner, R. W. (1979). Mathematics for the biological sciences. Pearson, London, England.
3. Billingsley, P. (1986). Probability and measure. Wiley, New York, United States of America.
4. Chap, T. Le. & Lynn, E. E. (2016). 2nd Ed. Introductory biostatistics. Wiley, Hoboken, New Jersey, United States of America.
5. Daniel, W. W. (1987). Biostatistics, a foundation for analysis in the health sciences. Wiley, New York, United States of America.
6. Khan, Irfan, A. & Khanum, A. (1994). Fundamentals of biostatistics. 6th Ed. ISBN: 9788190044103. Ukaaz Publications, Hyderabad, India.
7. Rosner, B. (2000). Fundamentals of biostatistics. Duxbury Press. Boston, United States of America.
8. Stroud, K. A. & Booth, D. J. (2009). Foundation mathematics. Palgrave Macmillan, New York, United States of America.
9. Triola, M. M. (2020). Biostatistics for the biological and health sciences. 2nd Ed. ISBN: 9780137401512, Pearson, London, England.

MB 541 MJP : Lab Exercises in Enzymology

Total: 2 Credits; Workload: 30 h/credit
(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The objective of this course is to learn the purification of enzyme, its characterization, enzyme kinetics and determination the enzyme activity.

Sr. No	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Purification of enzymes (Amylase/Invertase): a. Saturated ammonium sulphate solution preparation. b. Dialysis method/ultra-membrane filtration for salting out. c. Size exclusion/ion exchange chromatography for enzyme purification. d. Polyacrylamide gel electrophoresis (SDS-PAGE) and activity staining of purified enzyme.	24

Sr. No	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
	e. Enzyme purification table for enzyme purification analysis.	
2	Determination of Km, Vmax and Kcat values of enzyme.	12
3	Optimization of parameters (pH and temperature) for enzyme activity and stability.	12
4	Determination of enzyme activity in presence of activators and inhibitors.	12

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

- Perform the enzyme purification from the given crude extract.
- Calculate and analyze the enzyme kinetics, rate of enzyme-catalyzed reaction for different enzyme-substrate reactions.
- To understand the different physical parameters governing optimal enzyme activity.
- Understand the role of activators and inhibitors in enzyme-catalyzed reaction and their role in different metabolic regulation.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. Taylor & Francis, United Kingdom.
2. Bisswanger, H. (2011). Practical Enzymology, Wiley-VCH Verlag GmbH & Co. KGaA, Germany.
3. Hofmann, A. & Clokie, S. (Eds.). (2018). Wilson and Walker's Principles and techniques of biochemistry and molecular biology. 8th Ed. Cambridge University Press, Cambridge, United Kingdom. doi:10.1017/9781316677056.

MB 542 MJP : Lab Exercises in Microbial Genetics

Total: 2 Credits; Workload: 30 h/credit
(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The objective of this course is to learn to perform genetic level study in prokaryotic model organism. Trained students to perform basic molecular level experiments to understand the gene transfer mechanisms, restriction mapping.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Observation of phenotypic verses genotypic variation in conjunction with the environment.	08
2	Replica plating method: Preparation of master and replica plates.	10
3	Fluctuation test: Luria Delbruck experiment.	12

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
4	Isolation of auxotrophic mutants using UV mutagenesis.	12
5	Isolation of antibiotic resistant mutants using chemical mutagens.	12
6	Isolation of phages and estimation of phage titre.	12
7	One step growth curve of isolated bacteriophage.	12

Course Outcomes: The student at the completion of the course will be able to:

- Understand the concept of operon or the group of genes involved in transport and metabolisms of molecules in prokaryotic system.
- Gain insights into the nature of mutations and the mechanisms of evolution.
- Understand how environmental conditions can modify gene expression and contribute to phenotypic diversity within populations.
- Gain skill sets to isolate and characterize mutants obtained using chemical and physical methods.
- Acquire skills to isolate and characterize bacteriophages.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Hughes, K. T. (2007). Advanced bacterial genetics: use of transposons and phage for genomic engineering, Vol. 421. ISBN: 9780080475103. Academic Press, United Kingdom.
2. Karp, G. (2009). Cell and molecular biology: concepts and experiments. John Wiley & Sons, United States of America.
3. Primrose, S. B. & Twyman, R. (2006). Principles of gene manipulation and genomics. John Wiley & Sons, United States of America.
4. Rapley, R. (2021). Molecular biology and biotechnology, ISBN: 978-1-78801-786-2. Royal Society of Chemistry, London, United Kingdom.
5. Thomas, C. M. (2003). Horizontal gene pool: Bacterial plasmids and gene spread, ISBN: 9780429152900. CRC Press, London.
6. Wilson, K. & Walker, J. (2010). Principles and techniques of biochemistry and molecular biology. 7th Ed. Cambridge University Press, England.
7. Wu, R., Grossman, L. & Moldave, K. (2014). Recombinant DNA methodology. ISBN: 0-12-765560-3. Academic Press Ink, United Kingdom.

MB 543 MJP : Lab Exercises in Molecular Biology

Total: 2 Credits; Workload: 30 h/credit

(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The objective of this study is to provide knowledge about the use of different microorganisms and their biomolecules for the research and development purpose at genetic level.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Isolation of genomic DNA from bacteria and plant samples.	12
2	Agarose gel electrophoresis of isolated DNA.	04
3	Estimation and quality analysis of DNA using colorimetric and spectrophotometric assay.	06
4	Isolation of plasmid DNA using alkaline lysis method and determining its molecular weight.	08
5	Extraction of bacterial/eukaryotic RNA and its estimation using colorimetric and spectrophotometric assay.	12
6	Polymerase Chain Reaction (PCR) and analysis by agarose gel electrophoresis.	06
7	Extraction of DNA from agarose gels.	06
8	Gene transfer methods: Conjugation of bacterial plasmid using membrane filter technique.	10
9	Curing of plasmid using chemical agents and confirmation using suitable assays.	12

Course Outcomes: The student at the completion of the course will be able to:

- Gain expertise in isolation, purification and quantitative estimation of biomolecules like DNA, RNA and proteins.
- Get aquatinted with gel electrophoresis technique to separate DNA, RNA fragments.
- Learn operating the PCR machine for amplification of nucleic acid.
- Acquire skill in isolation and characterization of plasmids.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Greene, J. (1998). Recombinant DNA principles and methodologies. CRC Press, United Kingdom.
2. Karp, G. (2009). Cell and molecular biology: concepts and experiments. John Wiley & Sons, United States of America.
3. Primrose, S. B. & Twyman, R. (2006). Principles of gene manipulation and genomics. John Wiley & Sons, United States of America.
4. Rapley, R. (2021). Molecular biology and biotechnology, ISBN: 978-1-78801-786-2. Royal Society of Chemistry, London, United Kingdom.
5. Rastogi, S. & Pathak, N. (2009). Genetic engineering. Oxford University Press, Oxford, United Kingdom.

6. Wilson, K. & Walker, J. (2010). Principles and techniques of biochemistry and molecular biology. 7th Ed. Cambridge University Press, England.
7. Wu, R., Grossman, L. & Moldave, K. (2014). Recombinant DNA methodology. ISBN: 0-12-765560-3. Academic Press Ink, United Kingdom.

MB 545 MJ : Clinical Microbiology- Diagnosis and Therapies

Total: 2 Credits; Workload: 15 h/credit
(Total Workload: 2 credits x 15 h = 30 h in semester)

Course objective:
The objective of this course is to learn the basic principles and application relevance of clinical disease, etiological agents responsible for global infectious disease. It will also provide a learning platform to develop diagnostic skills in microbiology, including the practical application and interpretation of laboratory tests for the diagnosis of infectious diseases. It will also give in-depth information about the biosensors and microfluidics.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Biosensors: Basic principles and operations, types of biosensors and applications of biosensors. Point of care medical diagnostic devices.	03
2	Medical diagnostic techniques: Biochemical analysis, DNA/RNA based analysis, etc., Necessity for rapid and in situ medical analysis, Miniaturization of medical diagnostic devices-microfabrication (Materials, processes, techniques for detection).	04
3	Microfluidics: Concept, procedure, applications and challenges, Integrated microfluidic devices: Lab-on-a-chip, system-on-a-chip, micro-total analysis system (µTAS), Present research scenario and future prospects.	02
4	Antimicrobial agents and chemotherapy: a. Principles of chemotherapy and selective toxicity; b. Drug targets and mechanisms of drug action: Antibacterial (cell wall, cell membrane, nucleic acids, proteins), antifungal, antiviral, antiprotozoal.	12
5	Antimicrobial resistance: Drug resistance and its mechanisms: Enzymatic modification of the drug, modification of the antimicrobial target, prevention of drug penetration or accumulation etc.	06
6	Techniques for antimicrobial susceptibility testing: Phenotypic, molecular and mass spectrometric.	03

Course Outcomes: The student at the completion of the course will be able to:

- Learn about the emerging technologies medical diagnostics.

- Gain in depth knowledge microfluidics and its scope in life sciences.
- Learn the importance of microorganisms in diagnosis, monitoring and treatment of infectious diseases.
- Explain the principles of chemotherapy, selective toxicity and rational drug design.
- Gain knowledge on the mechanisms of drug action and drug resistance.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Chakraborty, S. (2010). Microfluidics and microfabrication. Springer, United Kingdom.
2. Gajic, I., Kabic, J., Kekic, D., Jovicevic, M., Milenkovic, M., Mitic Culafic, D., Trudic, A., Ranin, L. & Opavski, N. (2022). Antimicrobial Susceptibility Testing: A Comprehensive Review of Currently Used Methods. Antibiotics (Basel, Switzerland), 11(4), 427. https://doi.org/10.3390/antibiotics11040427
3. Hamblin, M. R. & Karimi, M. (2020). Biomedical applications of microfluidic devices. Elsevier Science, Netherlands.
4. Lorian, V. (2005). Antibiotics in laboratory medicine. Lippincott Williams & Wilkins. United Kingdom:
5. Mayers, D. L., Sobel, D., Ouellette, M. & Kaye, K. S. (2009). Antimicrobial drug resistance. 803-824. Humana press, New York.
6. Murray, P. R. & Baron, E. J. (2007). Manual of clinical microbiology, 9th Ed., ASM Press, Washington, D.C.
7. Ross, P. W. (1979). Clinical bacteriology. Churchill Livingstone, Edinburgh.
8. Song, Y., Cheng, D. & Zhao, L. (2018). Microfluidics: Fundamentals, devices, and applications. John Wiley & Sons, Germany.

MB 546 MJ : Bioengineering and Downstream Processing

Total: 2 Credits; Workload: 15 h/credit

(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objectives:

The objective of this course is to understand the theoretical aspects of bioprocess engineering and downstream processing in industry.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Down-stream processing and product recovery: a. Recovery of particulates (cells and solid particles): Filtration, centrifugation, sedimentation, flocculation. b. Recovery of intracellular products: Cell disruption and extraction methods. c. Separation of soluble products: Solvent-solvent extraction, Precipitation.	03 01 02
2	Purification of product: Chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis.	04
3	Production, recovery, assay and applications of vitamin C, antibiotics	03

Sr. No.	Credit Title & Contents	No. of Lectures
	(Cycloheximide, Tetracyclins), microbial enzymes (Penicillin acylase, Chitinase, Lipase).	
4	Product drying; Crystallization; storage and packaging.	03
5	Biofuel production: Bioethanol (1G and 2G), biogas, biodiesel.	04
6	Microbial electrosynthesis: Concept, principle, and application.	02
7	Immobilization of enzymes and cells: Methods and application.	04
8	Biosensor: Basic principles and operation of biosensors, types of biosensors and applications of biosensors.	04

Course Outcomes: The student at the completion of the course will be able to:

- Acquire competency in applications of basic engineering principle in biological system to apply in industry and research.
- Illustrate the downstream processing and product recovery by various methods.
- Learn the use of alternative technology for biofuel production.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Dessì, P., Rovira-Alsina, L., Sánchez, C., Dinesh, G. K., Tong, W., Chatterjee, P. & Puig, S. (2021). Microbial electrosynthesis: Towards sustainable biorefineries for production of green chemicals from CO_2 emissions. Biotechnology Advances, 46, 107675.
2. Doran, P. M. (1995). Bioprocess engineering principles. Elsevier Science, United Kingdom.
3. Geethanjali, S. & Subash, A. (2013). Optimization and immobilization of purified labeo rohita visceral protease by entrapment method. Enzyme Research, 2013, 874050. https://doi.org/10.1155/2013/874050.
4. Nedovic, V. & Willaert, R. (2013). Fundamentals of cell immobilisation biotechnology. Vol. 8. Springer Science & Business Media, Netherlands.
5. Rabaey, K. & Rozendal, R. A. (2010). Microbial electrosynthesis - Revisiting the electrical route for microbial production. Nature Reviews Microbiology, 8(10), 706-716.
6. Reed, G. (2004). Prescott and Dunn's Industrial microbiology. CBS Publishers and Distributors, India.
7. Sezgintürk, M. K. (2020). Commercial biosensors and their applications*:* Clinical, food, and beyond. Elsevier Science, Netherland.
8. Srivastava, N., Srivastava, M., Mishra, P. K., Upadhyay, S. N., Ramteke, P. W. & Gupta, V. K. (2019). Sustainable approaches for biofuels production technologies. Biofuel and Biorefinery Technologies, 7, 121-146. ISBN: 978-3-319-94797-6. Springer International Publishing.
9. Stanbury, P. F., Whitaker, A. & Hall, S. J. (2016). Principles of fermentation technology. Elsevier Science, United Kingdom.

MB 547 MJ : Agricultural Microbiology

Total: 2 Credits; Workload: 15 h/credit

(Total Workload: 2 credits x 15 h = 30 h in semester)

Course Objective:

This course aims to provide an information about the role of microbes in and for agricultural applications, plant-microbe interactions, plant diseases caused by phytopathogenic. Additionally, the potential role of microbes as biofertilizers and biopesticides for sustainable agriculture.

Sr. No	Credit Title & Contents	No. of Lectures
1	Introduction: Importance of agricultural microbiology and its scope.	01
2	Plant-microbe interaction: a. Microbial antagonism: Bacterial and fungal pathogens. b. Plant-microbe symbiosis: Mycorrhizal fungi and Rhizobium. c. Evolution of pathogenesis in plant. d. Plant Immunity: Against bacteria, fungi and viruses.	10
3	Microbial bioinoculants: a. Definition, types and status of biofertilizers. b. Cultivation and mass production of microbial bioinoculants- Species of *Azotobacter, Rhizobium, Azospirillum*, Cyanobacteria (Anabaena) phosphate solubilizing microorganisms (VAM) and plant growth-promoting rhizobacteria (PGPR), quality control. c. Carrier-based inoculants-Production, methods of applications and quality control. d. Mechanisms of plant growth promotion.	07
4	Biocontrol agents: Definition, types of biopesticides: Bacterial (*Bacillus thuringiensis*, and *Pseudomonas syringae*), fungal (*Cephalosporium*, and *Trichoderma*) and viral (Nuclear polyhedrosis virus and baculovirus) and target pests; mode of action, Advantages and limitations of biopesticides.	06
5	a. Soil management and testing. b. Nutrient Management of soil.	03
6	Modern agricultural practices in: a. Agro-food safety and agromedicine. b. Use of agricultural residues for biochar production and application	03

Course Outcomes: The student at the completion of the course will be able to:

- Explain how microorganisms may be detected within various environments, including how they may be cultivated within the laboratory setting.
- Explain the various relationships microorganisms have with their environments, including pathogenic, symbiotic and commensal lifestyles.
- Understand the structural characteristics, the functionality and the integration of microorganisms in their natural environment.

- Comprehend the potential of microorganism applications in the food industry and in the agro-biotechnological sector.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Aneja, K. R. (2011). Experiments in microbiology, plant pathology and biotechnology, New Age International (P) Ltd. Publisher, New Delhi, India.
2. James, C. & Natile, S. (2014). 10th Ed. Microbiology - A laboratory manual: Pearson, India Education Services Pvt. Ltd., South Asia. India.
3. Madigan, M., Martinko, J. M. & Parker, J. (2015). 14th Ed. Brock biology of microorganisms. Prentice Hall of India Pvt. Ltd., New Delhi, India.
4. Pelczar, J. R., Chan, M. J. E. C. S. & Krieg, N. R. (2015). 5th Ed. Microbiology. McGraw Hill Publishers, New York, United States of America.
5. Subba Rao, N. S. (2014). 4th Ed. Soil microbiology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India.
6. Willey, J., Sherwood, L. & Woolverton, C. (2017). Prescott's microbiology. McGraw-Hill Education, Singapore.

MB 545 MJP : Lab Exercises in Clinical Microbiology

Total: 2 Credits; Workload: 30 h/credit
(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objectives:

The major objective of this course is to provide hands on experience on various diagnostic tests.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Studying the effect of bacteriostatic and bactericidal of agents on bacteria.	08
2	Determination of antibiogram of given bacterial culture by disc susceptibility method.	08
3	Determination of MIC, MBC by microdilution/agar dilution technique.	12
4	Determination of biofilm inhibitory concentration of the given agent.	12
5	Determination of biofilm disruption efficiency of the given agent.	12
6	Determination of anti-adhesion efficacy of the given agent on medical implants.	12
7	Lateral flow assay for diagnostic testing.	08
8	Bioassay using microfluidics/Lab–on-chip assay.	12
9	Estimation of blood glucose level using glucometer.	04

Course Outcomes: The student at the completion of the course will be able to:

- Understand various diagnostic methods and techniques for detection of pathogens in biological test samples.
- Demonstrate the anti-biofilm formation assay against multidrug resistance pathogens.
- Detect the presence of antibody/antigen in the given clinical sample.
- Evaluate the activity of potential antimicrobial agents in vitro.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Blair, J. E., Lennette, E. H. & Truant, J. P. (1970). Manual of clinical microbiology, 7th Ed. E. H. Lennette, University of Michigan and American Society for Microbiology, United States of America.
2. Franklin, T. J. & Snow, G. A. (2005). Biochemistry and molecular biology of antimicrobial drug action. Springer Science & Business Media. United States of America.
3. Huang, B., Li, D. G., Huang, Y. & Liu, C. T. (2018). Effects of spaceflight and simulated microgravity on microbial growth and secondary metabolism. Military Medical Research, 5(1), 18. https://doi.org/10.1186/s40779-018-0162-9.
4. Koneman, E. W. (2005). Color atlas and text book of diagnostic microbiology. 6th Ed. Lippinctt. United States of America.
5. Lorian, V. (2005). Antibiotics in laboratory medicine. Lippincott Williams & Wilkins. United Kingdom.
6. Magaldi, S., Mata-Essayag, S., De Capriles, C. H., Pérez, C., Colella, M. T., Olaizola, C. & Ontiveros, Y. (2004). Well diffusion for antifungal susceptibility testing. International Journal of Infectious Diseases, 8(1),39-45.
7. Paller, G. V. & Dalmacio, F. (2022). Antibiotic susceptibility and pathogenicity of *Streptococcus* spp. isolated from tilapia grow-out farms in Lubao, Pampanga, Philippines. AACL Bioflux, 15(3).
8. Tille, P. M. (2013). Bailey & Scott's Diagnostic microbiology. 13th Ed. Mosby, United States of America.

MB 546 MJP : Lab Exercises in Bioengineering and Downstream Processing

Total: 2 Credits; Workload: 30 h/credit

(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

The main objective of this course is to provide practical knowledge of isolation, extraction and purification of a fermented product using various physical and chemical methods

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No of Hours
1	Production and estimation of ethanol/antibiotics from fermentation broth.	12

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No of Hours
2	Cell disruption for intracellular enzymes by various physical and chemical methods.	16
3	Production and recovery of extracellular/intracellular product from fermentation broth (polysaccharides/organic acids).	16
4	Biohydrogen production using microbial electrolysis cell.	16
5	Mushroom production/algal production.	12

Course Outcomes: The student at the completion of the course will be able to:

- Learn the recovery of industrially important enzymes from the fermented product.
- Experience the purification of fermentation products (downstream processing).
- Use the microbes for the production of bioethanol and biohydrogen.
- Cultivate grow mushroom using agricultural wastes.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. Taylor & Francis, United Kingdom.
2. Doran, P. M. (1995). Bioprocess engineering principles. Elsevier Science, United Kingdom.
3. Stanbury, P. F., Whitaker, A. & Hall, S. J. (2016). Principles of fermentation technology, Elsevier Science. United Kingdom.

MB 547 MJP : Lab Exercises in Agricultural Microbiology

Total: 2 Credits; Workload: 30 h/credit

(Total Workload: - 2 credits x 30 h = 60 h in semester)

Course Objective:

This course aims to provide an information about the role of microbes in and for agricultural applications, plant-microbe interactions, plant diseases caused by phytopathogenic. Additionally, the potential role of microbes as biofertilizers and biopesticides for sustainable agriculture.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Lectures
1	Enumeration and isolation of rhizospheric bacteria.	12
2	Determination of plant growth promoting properties: a. Ammonia production. b. Phosphorus solubilization. c. Nitrogen fixation. d. Indole-3-acetic acid (IAA) production.	12
3	Effect of plant growth-promoting rhizobacteria (PGPR) on plant growth under	08

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Lectures
	abiotic stress.	
4	Seed inoculation with Rhizobia and observation of nodulation.	08
5	Soil quality testing.	04
6	Preparations of foliar formulations for best agricultural practices.	06
7	Calculation of percent disease index (PDI) to estimate the severity of diseases caused by phytopathogens.	04
8	Preparation of agricultural waste-based biochar for agronomic applications.	06

Course Outcomes: The student at the completion of the course will be able to:

- Propose and design the novel strategies for controlling plant diseases as well as phytopathogens.
- Understanding of pathogen interactions and plant defense systems would be helpful in proposing sustainable agriculture practices.
- Students will be skilled to use PGPR organisms and their products for designing innovative formulations in preventing resistance of pathogens and control contamination of the environment.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. Taylor & Francis, United Kingdom.
2. Mishra, C. S. K. (2016). Molecular methods in plant disease diagnostics. CABI. Biotechnology applications. IK International Pvt. Ltd., United Kingdom.
3. Patel, S., Sayyed, R. Z. & Saraf, M. (2016). Bacterial determinants and plant defense induction: Their role as biocontrol agents in sustainable agriculture. In Plant, Soil and Microbes. Vol. 2. Mechanisms and molecular interactions; In: Hakeem, K. R., Akhtar, M. S., Eds. 187–204. Springer, Cham, Switzerland.
4. Shaikh, S. S., Sayyed, R. Z. & Reddy, M. S. (2016). Plant growth promoting rhizobacteria: A sustainable approach to agro - plant growth-promoting rhizobacteria: An eco-friendly approach for sustainable agroecosystem. In plant, soil and microbes. Vol. Mechanisms and molecular interactions. In: Hakeem, K. R., Akhtar, M. S. (Eds), 181–201. Springer, Cham, Switzerland.
5. Sharma, P., Kumawat, K.C. & Kaur, S. (2016). Plant growth promoting rhizobacteria in nutrient enrichment: Current perspectives. In: Biofortification of food crops; Singh, U., Praharaj, C. S., Singh, S. S., Singh, N.P. (Eds). 263–289, Springer: New Delhi, India.

MB 540 OJT : On Job Training / Internship / Field work

Total: 4 Credits; Workload: 30 h/credit

(Total Workload: - 4 credits x 30 h = 120 h in semester)

Course Objective:

The objectives of this course are to foster the students through the development of professional and workplace ethics, skills in communication, problem-solving, teamwork, and adaptability. Hands-on learning experiences at research institutes/laboratories, Start-ups/entrepreneurs, venture centres will allow students to engage directly with tools, technologies, equipment, or processes relevant to their field of interest during winter or summer vacations.

Course Outcomes: The student at the completion of the course will be able to:

- Gain insights into potential career paths within their field of study, clarify their career goals and interest
- Develop strategies for pursuing future opportunities, such as employment, further education, or entrepreneurship.
- Establish and maintain professional relationships with colleagues, supervisors/mentors, and clients, demonstrating collaboration, teamwork, and interpersonal effectiveness.
- Demonstrate critical thinking skills by analyzing problems, evaluating alternative solutions, and making informed decisions based on evidence and rationale.