



Savitribai Phule Pune University
(Formerly University of Pune)

Syllabus for
Post Graduate Course in Microbiology
M. Sc. Part II (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

Sr. no.	Title	Page No.
I.	About the Department	3
II.	Introduction to NEP (CBCS) and Scope	3
III.	Definitions	4
IV.	Program Objectives (POs)	4
V.	Program Specific Outcomes (PSOs)	4
VI.	Program Details- General Instructions	5
VII.	M. Sc. Microbiology Program Outline (Semester Wise)	8
VIII.	Course Wise Content Details for M.Sc. Microbiology Program	
	Semester III	12
	Semester IV	31

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.

M.Sc. Microbiology Part II Syllabus (NEP 2020) for University Dept. SPPU AY 2024 onwards

- 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- III

MB 631 MJ : Immunology

Total: 2 Credits; Workload: 15 h/credit

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

Course Objective:

This course aims to reintroduce the basics of immunology along with a comprehensive understanding of the components, organization, and functions of the immune system, the mechanisms of immune responses against various pathogens and an in-depth study of the molecular biology and biochemistry of the elements of the immune system.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Immune response anatomy: Skin immune system, mucosal immunity, lymphatic system, organization of lymphoid tissue, lymphocyte homing, immune system cells in the liver, immunologically privileged sites, handling the antigen.	04
2	T-cell and B-cell receptors: Structure and function, differentiation and maturation of T and B cells, molecular genetics of TCR and BCR diversity.	05
3	Immune system regulation: Immunogenetics, activation induced cell death, negative regulation of the immune system, immunoregulation by T cells, immunoendocrine networks.	05
4	Types and properties of immunoglobulins, Genetic basis of immunoglobulin formation, genetics of immunoglobulins, class-switching, hybridoma technology.	05
5	The complement system: Classical, lectin, and alternative pathway and their regulation.	05
6	Immunity against bacterial, fungal, and viral infections. Regulation of immune system.	03
7	Organ transplant and Immunosuppression.	03

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

- Understand and summarize the organization of the immune system.
- Define the process by which the elements of the immune system are triggered and mount a response against foreign bodies.
- Summarize the molecular mechanisms underlying recognition of pathogens by the immune system and signaling pathways.
- Analyze experimental results to identify patterns or trends in immune cell populations, cytokine production, or antibody responses.
- Develop problem-solving skills. Learn to interpret and analyse the data based on above modules.

References:

1. Abbas A. K. & Lichtman A. H. (2004). Basic immunology, functions and disorders of immune system, 2nd Ed., Elsevier Inc. United States of America.
2. Abbas, A. K., Lichtman, A. H. & Pillai, S. (2014). Basic immunology: Functions and disorders of the immune system. 5th Ed. Elsevier Health Sciences. Canada.
3. Delves, P. J., Martin, S. J., Burton, D. R. & Roitt, I. M. (2017). Essential immunology. Wiley, United Kingdom.
4. Garcia, C. K. & Adams, E. J. (2005). How the T cell receptor sees antigen - A structural view, Cell, Vol. 122: 333– 336, Cell Press.
5. Hafler, D. A. (2007), Cytokines and interventional immunology, Nature Reviews, Immunology, 7: 423.
6. Kindt, T. J., Goldsby, R. A., Osborne, B. A. & Kuby, J. (2007). Kuby immunology. Macmillan. London, United Kingdom.
7. Mccarty, C. (2018). Immunology: Essential and fundamental. EDTECH, United Kingdom.
8. Murphy, K. & Weaver, C. (2017). Janeway's immunobiology. 9th Ed. Garland Science, Taylor & Francis Group, New York & London.
9. Yoshimura, A., Naka, T. & Kubo, M. (2007). SOCS proteins, cytokine signaling and immune regulation, Nature Reviews, Immunology, 7:454-465.

MB 632 MJ : Molecular Biology - II

Total: 2 Credits; Workload: 15 h/credit

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

Course Objectives:

To provide a detailed understanding of the mechanisms of gene expression (transcription and translation) and regulation in both prokaryotic and eukaryotic systems, focusing on the initiation, elongation, and termination phases, and the regulatory factors that ensure accurate protein synthesis followed by its targeting- transport.

Sr. No.	Credit Title & Contents	No. of Lectures
1	a. Prokaryotic Transcription and Regulation: RNA polymerase, Transcription unit, Initiation promoter recognition, Elongation, intrinsic and rho-dependent termination, Concept of Operon (lactose, galactose, arabinose, tryptophan, histidine, phage lambda), positive and negative regulation, regulation by attenuation, phage strategies to regulate transcription, antitermination. b. Eukaryotic Transcription and Regulation: RNA Polymerases I, II and III, Transcription unit for each polymerase, transcription factors, processing of transcripts, promoters and enhancers. c. Post Transcriptional Modifications: Processing of hnRNA, tRNA, rRNA, 5'-Cap formation, 3'-end processing and polyadenylation, Splicing, RNA editing, nuclear export of mRNA, mRNA stability, catalytic RNA. Transcriptional and posttranscriptional gene silencing.	12
2	Prokaryotic and Eukaryotic Translation and its regulation:	10

Sr. No.	Credit Title & Contents	No. of Lectures
	Prokaryotic and Eukaryotic Translation: Activation of tRNA, Initiation – role of initiation factors, Shine Dalgarno sequences, elongation – Role of elongation factors, translocation of ribosomes, termination – termination codons, role of release factors, GTP as an important source of energy for translation, fidelity of translation. Co and post-translational modifications and regulation.	
3	Protein Targeting-Transport: Transport of proteins to various cell compartments, molecular chaperones, protein stability, protein turnover and degradation.	8

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

- Understand the difference between mechanism of transcription in prokaryotes and eukaryotes (structure of polymerases, promoter sequences, transcription factors, and regulation).
- Relate the need for post transcriptional modifications required to process the RNAs before being taken up for translation; including factors involved in stabilizing and degradation of RNA.
- Differentiate between the components required for translation of RNA to proteins in prokaryotes and eukaryotes.
- Correlate the prokaryotic control mechanisms for regulation of genes involved in sugar metabolism and amino acid synthesis.
- Understand the co translational and post translational modifications involved during protein synthesis and targeting.
- Thus, understand and investigate the intricate processes of gene expression and regulation, equipping them with the skills to apply this knowledge in research and practical applications in the field of molecular biology.

References:

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. & Walter, P. (2015). Molecular biology of the cell. 6th Ed. ISBN: 9781317563754. Garland Science, Taylor & Francis Group, New York, United States of America.
2. Craig, N. L., Green, R., Greider, C. C., Greider, C. W., Storz, G., Wolberger, C. & Cohen-Fix, O. (2021). Molecular biology: Principles of genome function. Oxford University Press, United Kingdom.
3. Krebs, J. E., Lewin, B., Goldstein, E. S. & Kilpatrick, S. T. (2014). Lewin's genes XI, Jones & Bartlett Publishers. Massachusetts, United States of America.
4. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Martin, K. C., Yaffe M. & Amon, A. (2021). Molecular cell biology. 9th Ed. ISBN: 9781319208523. Macmillan learning, United States of America.
5. Snyder, L. & Snyder, L. A. (2024). Bacterial genetics and genomics. CRC Press, United Kingdom.
6. Twyman, R. (2018). Advanced molecular biology: A concise reference. CRC Press, United Kingdom.
7. Watson, J. D. (2014). Molecular biology of the gene. Pearson, United Kingdom.
8. Wilson, J., Hunt, T. (2014). Molecular biology of the cell - The Problems Book. W.W. Norton. United States of America.

MB 633 MJ : Biophysical Techniques - 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 conceptual knowledge about the principle and operation of various types of centrifugation techniques. The course will also cover the understanding of advanced microscopy techniques tailored for various biological applications.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Basic concepts, principles and applications of centrifugation methods: a. Differential centrifugation b. Ultra-centrifugation c. Isopycnic and Rate zonal centrifugation	05
2	Microscopy: Principle and working of different contrast enhancing technique: a. Confocal microscopy b. Concepts of digital microscopy and image analysis c. Atomic force Microscopy d. Electron and cryo-electron microscopy e. Fluorescence microscopy <ul style="list-style-type: none">• Multiphoton microscopy, Image deconvolution and quantification• Foerster resonance energy transfer (FRET) microscopy• Fluorescence lifetime imaging microscopy (FLIM)• Fluorescence correlation spectroscopy (FCS)• Total internal reflection fluorescence (TIRF) microscopy Breaking the diffraction barrier: Concept of optical super resolution, stimulation emission depletion (STED) microscopy, single molecule localization microscopy: Stochastic optical reconstruction microscopy (STORM) and photoactivation localization microscopy (PALM).	25

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

- Correlate the relevance of centrifugation & microscopic techniques in life sciences.
- Design a method to fractionate, purify and characterize different cell types (subcellular organelles and macromolecules) based on their physical properties for varied applications.
- Integrate the advanced imaging techniques and software for automated image analysis.
- Implement and apply the principles of super resolution microscopy for studying molecular interaction, membrane dynamics and protein interaction.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Goldman, R. D. & 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.
2. Graham, J. (2020). Biological centrifugation. Garland Science, United Kingdom.

- Graham, J. M. & Rickwood, D. (1997). Subcellular fractionation: A practical approach (No. 173). Oxford University Press, United Kingdom.
- Nelson, D. L. & Cox, M. M. (2017). Lehninger principles of biochemistry. India: W. H. Freeman.
- Pattabhi, V. & Gautham, N. (2002). Biophysics. Springer, India.
- Serdyuk, I. N., Zaccai, N. R. & Zaccai, J. (2007). Methods in molecular biophysics: structure, dynamics, function. Cambridge University Press, United Kingdom.
- Voet, D., Pratt, C. W. & Voet, J. G. (2013). Principles of biochemistry. Vol. 4. Wiley, New York, United States of America.
- Walker, J. M. & Wilson, K. (2010). Principles and techniques of biochemistry and molecular biology. Cambridge university press, United Kingdom.

MB 634 MJ : Animal and Plant Virology

Total: 2 Credits; Workload: 15 h/credit

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

Course Objective:

The aim of this course is to understand the foundational principles that govern viruses, their diverse replication strategies, the classification systems, the life cycles of DNA and RNA viruses, to identify and understand viruses that affect animals and plants, and to understand the principles of antiviral drug action, vaccine design, and immunization strategies against viral diseases.

Sr. No.	Credit Title & Contents	No. of Lectures
1	History and principles of virology.	01
2	a. Introduction to replication strategies of viruses. b. Classification and nomenclature of viruses: ICTV recommendations, Baltimore classification system. c. Morphology and ultra-structure of viruses and bacteriophages: Capsids (icosahedral/ helical), envelope, glycoprotein proteins and lipids.	04
3	Growth of viruses: a. In embryonated egg, experimental animals and cell cultures-primary and secondary cell lines, suspension cell cultures and monolayer cell cultures. b. Assay of viruses: Physical and chemical methods of assay, (protein, nucleic acid, radioactivity tracers, electron microscopy, infectivity assay of animal viruses (plaque method, pock counting, end point method) and infectivity assay of plant viruses.	06
4	a. Viruses of veterinary importance and zoonotic viruses. b. Life cycles: DNA viruses with special reference to herpes, pox, adeno, SV40; RNA viruses with special reference to measles, rabies, polio, influenza, retroviruses; oncoviruses and lentiviruses (HIV). c. Slow and persistent viruses. Mechanism of persistence, genetic stability, Influence on host cell growth control, Immune response against viruses. d. Antiviral drugs and virus vaccines.	09
5	a. Effects of viruses on plants:	09

Sr. No.	Credit Title & Contents	No. of Lectures
	Appearance of plants, histology, physiology and cytology of plants. b. Diagnostic techniques to detect viruses: In seeds, seed stocks, diseased plants. c. Behaviour of viruses in plants: Early stages of infection, biochemistry of virus replication, cellular sites of virus replication, assembly and accumulation of virus particles. d. Transmission of plant viruses: Vectors (insects, nematodes, fungi) without vectors (contact, seed, pollens). e. Prevention of crop losses due to virus infection: Virus-free planting material, vector control, disease forecasting. f. Life cycle: Tobacco mosaic virus (TMV), Cauliflower mosaic virus (CaMV).	
6	Virus related agents - prions, virions, viroids.	01

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

- Identify the major classes of viruses infecting animals and plants, and summarize their basic replication strategies.
- Comprehend about the life cycles of specific animal viruses and plant viruses.
- Discuss basic concepts of virus cultivation and purification.
- Diagnose viral infections in plants using various techniques.
- Learn about virus transmission methods and strategies for prevention.
- Gain knowledge about managing and mitigating virus-induced crop losses.
- Develop problem-solving skills and learn to interpret and analyse the data based on above modules.

References:

1. Bowman, C. (2019). Plant virology. ED-Tech Press, United Kingdom.
2. Erik Lycke & Erling Norrby (2014). Textbook of Medical Virology. United Kingdom: Elsevier Science.
3. Flint, S. J., Racaniello, V. R., Rall, G. F., Skalka, A. M. (2015). Principles of Virology. Wiley, United States of America.
4. Hull, R. (2013). Plant virology. ISBN: 9780123848727, 0123848725. Elsevier Science, United States of America.
5. Knipe, D. M., Howley, P. (2013). Fields Virology. Wolters Kluwer Health, United States of America.
6. Matthews, R. C. (2012). Fundamentals of plant virology. ISBN: 0-12-361160-1. Academic Press, London, United Kingdom.
7. Matthews, R. E. F. & Hull, R. (2002). Matthews' Plant virology. 4th Ed. Elsevier Academic Press, United Kingdom.
8. Uyeda, I. & Masuta, C. (2015). Plant virology protocols: new approaches to detect viruses and host responses. 3rd Ed, ISBN: 9781493917440, Springer, New York, United States of America.
9. Walkey, D. G. (1991). Plant virology: An Introduction. In applied plant virology (1-23). Dordrecht: Springer, Netherlands.
10. Wilson, C. R. (2014). Applied plant virology. ISBN: 978-1-84593-991-5. CABI, United Kingdom.

MB 631 MJP : Lab Exercises in Immunology and Virology

Total: 2 Credits; Workload: 30 h/credit

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

Course Objective:

This course aims to give the student practice in basic immunological techniques that can be used to identify, isolate, and examine the cells and molecules of the immune system. Students will also gain hands-on experience in sampling techniques of viruses.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Separation and identification of antigens by immunoelectrophoresis	04
2	Immunodetection of proteins using antibodies by western blotting.	12
3	Detection of antibodies for a specific antigen and to determine its titer by immunoprecipitation.	12
4	Visualization of protein of interest in an animal cell using immunofluorescence.	08
5	Purification of Immunoglobulins.	12
6	Field work: Sampling of virus infected plants, identification virus symptoms on infected plants, and examination of cytopathic effects of plant viruses.	12
7	Mechanical transmission of plant viruses through the sap of an infected plant material and observation of disease development.	08
8	Industrial visit for demonstration of egg inoculation.	06

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

- Detect the presence of antibody/antigen in the given clinical sample by several methods.
- Purify immunoglobulins for further experimentation.
- Identify viral antigens in infected plants and apply proper sampling methods for effective virus detection in plants.
- Identify and document common and uncommon virus symptoms in plants and differentiate between viral symptoms in plants and those caused by other pathogens or abiotic factors.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Dijkstra, J. & de Jager, C. (2012). Practical plant virology: protocols and exercises. Springer Science & Business Media, Germany.
2. Hull, R. (2014). Plant virology. 4th Ed. Elsevier Academic press, London, United Kingdom.
3. Hull, R. (2004). Matthews' Plant virology. 4th Ed. Elsevier Academic press, London, United Kingdom.

4. Matthews, R. E. F. (1992), Fundamentals of plant virology, Academic press Inc. London, United Kingdom.
5. Rose, N. R. (1997). Manual of clinical laboratory immunology; 5th Ed, ASM Press. Washington, DC.
6. Rubio, L., Galipienso, L. & Ferriol, I. (2020). Detection of plant viruses and disease management: relevance of genetic diversity and evolution. *Frontiers in Plant Science*, 11, 539737.
7. Trigiano, R. N., Windham, M. T. & Windham, A. S. (2003). Plant pathology: Concepts and laboratory exercises. CRC Press, United States of America.
8. Venbrux, M., Crauwels, S. & Rediers, H. (2023). Current and emerging trends in techniques for plant pathogen detection. *Frontiers in Plant Science*, 14, 1120968.

MB 632 MJP : Lab Exercises in Recombinant DNA technology

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. Students would learn and apply molecular biology techniques and microbiological methods required for basic research.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Restriction enzyme digestion of plasmid DNA and construction of plasmid map.	08
2	Vector and insert ligation.	08
3	Preparation of competent cells, transformation of <i>E. coli</i> with standard plasmids, calculation of transformation efficiency.	16
4	Confirmation of the insert by Colony PCR and restriction mapping.	12
5	Lactose induction of Beta-galactosidase; glucose repression; diauxic growth curve of <i>E. coli</i> .	12
6	Real-time quantitative and reverse transcriptase PCR.	08

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

- Illustrating the map of an unknown segment of DNA through usage of different restriction enzymes to cut or digest the DNA molecules at different restriction sites.
- Acquire skill in transferring the gene of interest and selection of transformants.
- Perform and analyse data obtained by running various types of PCR.
- Develop problem-solving skills and learn to interpret and analyse the data.

References:

1. Brown, T. A. (2020). Gene cloning and DNA analysis: An introduction. John Wiley & Sons, Germany.
2. Glick, B. R. & Pasternak, J. J. (1998). Principles & applications of recombinant DNA. ASM, Washington DC.

- Glick, B. R. & Patten, C. L. (2022). Molecular biotechnology: principles and applications of recombinant DNA. John Wiley & Sons, Germany.
- Greene, J. (1998). Recombinant DNA principles and methodologies. CRC Press, United States of America.
- Karp, G. (2009). Cell and molecular biology: concepts and experiments. John Wiley & Sons, United States of America.
- Primrose, S. B. & Twyman, R. (2006). Principles of gene manipulation and genomics. John Wiley & Sons, United States of America.
- Rapley, R. (2021). Basic molecular biology techniques. Molecular biology and biotechnology. 978-1-78801-786-2. 7th Ed. CPI Group, United Kingdom.
- Rastogi, S. & Pathak, N. (2009). Genetic engineering. Oxford University Press, England.
- Walker, J. M. & Wilson, K. (2010). Principles and techniques of biochemistry and molecular biology. Cambridge University Press. United Kingdom.
- Wu, R., Grossman, L. & Moldave, K. (2014). Recombinant DNA methodology. Academic Press, United States of America.

MB 633 MJP : Lab Exercises in Biophysical 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 to provide hand-on experience of various biophysical techniques like microscopy, centrifugation, tensiometer and image analysis software to understand their applications in separating, characterizing, localizing and quantifying the biomolecules and subcellular organelles.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Fluorescence microscopy analysis of live cells.	08
2	Cell segmentation and image quantification using FIJI - an Image software.	08
3	Determination of surface and interfacial tension of liquids using Tensiometer.	08
4	Determination of wetting properties and critical micelle concentration (CMC) of surfactants.	08
5	Fluorescence lifetime measurement and determination of quantum yield.	08
6	Flow cytometric analysis of blood/microbial sample using fluorescence activated cell sorting (FACS).	16
7	Separation of subcellular organelles and biomolecules using Density gradient centrifugation – Sucrose gradient, CsCl gradient.	16

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

- Learn the handling and operation of fluorescent microscopy, optimize the image quality using various inputs parameters as per the requirement.
- Gain proficiency in handling the image software for cell segmentation and quantitative analysis to extract valuable information from microscopy images for various biological applications.
- Design and execute experiments to measure surface and interfacial tension of different liquids.
- Understand the implications of surface and interfacial tension in areas such as emulsification, wetting behavior, and surface coating processes.
- Design and execute FACS experiments to separate and isolate specific cell populations based on their fluorescence characteristics.

References:

1. Chopra, A., Bobate, S., Rahi, P., Banpurkar, A., Mazumder, P. B. & Satpute, S. (2020). *Pseudomonas aeruginosa* RTE4: a tea rhizobacterium with potential for plant growth promotion and biosurfactant production. *Frontiers in Bioengineering and Biotechnology*, 8, 861.
2. Flow cytometry - Basic guide by Bio-Rad. <https://biotech.ufl.edu/wp-content/uploads/2021/04/flow-cytometry-basics-guide.pdf>.
3. Heit, B. Fluorescent microscopy. 2 023. *Methods in Molecular Biology (fluorescent microscopy)*, ISBN: 978-1-0716-2051-9, Humana New York, United States of America.
4. Satpute, S. K., Banpurkar, A. G., Dhakephalkar, P. K., Banat, I. M. & Chopade, B. A. (2010). Methods for investigating biosurfactants and bioemulsifiers: a review. *Critical Reviews in Biotechnology*, 30(2), 127-144.
5. Satpute, S. K., Mone, N. S., Das, P., Banat, I. M. & Banpurkar, A. G. (2019). Inhibition of pathogenic bacterial biofilms on PDMS based implants by *Lactobacillus acidophilus* derived biosurfactant. *BMC Microbiology*, 19, 1-15.
6. Walker, J. M. & Wilson, K. (2010). *Principles and techniques of biochemistry and molecular biology*. Cambridge University Press. United Kingdom.

MB 635 MJ : Pharmaceutical 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 introduce to the student about basics of the drug discovery and development process, including its sources, extraction procedure, characterization, toxicity, and pre-clinical/clinical steps. It is also meant to familiarize the student with Quality Assurance, Validation, Rules, and Regulations in the Pharmaceutical Industry.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Study of major groups of pharmacologically active molecules of plant, animal and microbial origins, Physical and chemical properties, metabolic pathways, extraction, purification and characterization of active molecules by conventional methods.	08
2	Hit, lead optimization, candidate drug selection, new investigational drug Rational drug design:	08

Sr. No.	Credit Title & Contents	No. of Lectures
	Principle (Structure-activity relationship - SAR) and Tools (applications of high throughput screening, combinatorial synthesis, pharmaco-genomics). Preclinical drug development, identification of drug target and validation, elucidation of the mechanism of drug action. Steps towards commercialization of drug – Clinical development: Phase I, II and III clinical trials. Regulations on drug development, FDA.	
3	Safety profiling of drugs: Drug interactions, toxicity and adverse reactions, toxicity testing, assays for mutagenicity, carcinogenicity, pyrogenicity and allergy testing. Basic concepts - ADME, Dose-Response relationship, bioavailability, therapeutic ratio, therapeutic index, selective toxicity.	09
4	Quality assurance and validation in Industries: The concept of ISO Certification, preparation of standard operating procedure (SOP), Validation protocols for methods in - quality control, process validation-discuss above data within World Health Organization (WHO) norms, exercises on preparation of SOPs, operation and validation for analytical methods.	05

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

- Articulate basic concepts of pharmaceutical microbiology.
- Define and summarize the steps involved in drug discovery and development.
- Learn about the techniques involved in drug toxicity testing and standardization.
- Describe the methods to determine the safety of drugs, and the process and rules of their commercialization.

References:

1. Blass, B. E. (2021). Basic principles of drug discovery and development. Elsevier. 2nd Ed. ISBN: 978-0-12-817214-8. Academic Press, Elsevier.
2. Ecker, D. J. & Crooke, S. T. (1995). Combinatorial drug discovery: which methods will produce the greatest value?. *Bio/Technology*, 13(4), 351-360.
3. Franklin, T. J. & Snow, G. A. (2005). Biochemistry and molecular biology of antimicrobial drug action. Springer Science & Business Media. United States of America.
4. Hughes, J. P., Rees, S., Kalindjian, S. B. & Philpott, K. L. (2011). Principles of early drug discovery. *British Journal of Pharmacology*, 162(6), 1239-1249.
5. Kokate, C. K., Purohit, A. P. & Gokhale, S. B. (2005). Pharmacognosy, Nirali Prakashan. India.
6. Lorian, V. (2005). Antibiotics in laboratory medicine. Lippincott Williams & Wilkins. United Kingdom.
7. Lüllmann, H., Mohr k., Hein L. & Bieger D. (2005). Color atlas of pharmacology. 3rd Ed. Thieme.
8. Mavromoustakos, T. & Kellici, T. F. (2018). Rational drug design. Springer, New York, ISBN: 978-1-0716-2051-9
9. Mayers, D. L., Sobel, D., Ouellette, M., Kaye, K. S. (2009). Antimicrobial drug resistance. 803-824. Humana press, New York.
10. Michels, P. C., Khmelnitsky, Y. L., Dordick, J. S. & Clark, D. S. (1998). Combinatorial biocatalysis: a natural approach to drug discovery. *Trends in Biotechnology*, 16(5), 210-215.

11. Poduri, R. (2021). Drug discovery and development. From targets and molecules to medicines, Springer, Singapore
12. Roberts, S. A. (2001). High-throughput screening approaches for investigating drug metabolism and pharmacokinetics. *Xenobiotica*, 31(8-9), 557-589.
13. Rogge, M. & Taft, D. R. (2016). Preclinical drug development. 2nd Ed. CRC Press.
14. Truhlar, D. G., Howe, W. J., Hopfinger, A. J., Blaney, J. & Dammkoehler, R. E. (2012). Rational drug design. Vol 108. Springer Science & Business Media.
15. Walsh, G. (2013). Biopharmaceuticals: Biochemistry and biotechnology. 2nd Ed. ISBN: 978-1-118-68738-3, John Wiley & Sons, England.

MB 636 MJ : Food Technology

Total: 2 Credits; Workload: 15 h/credit

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

Course Objective:

The aim of the course is to teach the students with different groups of microorganisms associated with food, their role in food production, destruction and detection in food. It also includes food preservation strategies and microbiology of the fermented food.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Basic concepts: Food as substrate for microorganism, Factors influencing microbial growth, survival, and destruction; Pathogenic and beneficial microorganisms, detection, isolation and enumeration methods of microorganisms.	05
2	Food spoilage: Intrinsic and extrinsic factors of foods involved in food spoilage i.e. water activity, pH, preservatives, heating, gaseous environment, food sanitation, foodborne diseases/illness, major pathogenic foodborne bacteria, viruses, parasites and fungi, inspection and analysis techniques.	07
3	Food preservation: Physical and chemical methods of food preservation, Food additives, commercial preservatives, food adulterations.	05
4	Microbiology of fermented foods: Importance of fermentative microorganisms (bacteria, yeasts and molds), microbiology of fermented foods for fermented milks, cheese, koji, sauerkraut, kimchi, soya sauce, wine, single cell protein.	08
5	Concept of probiotics and prebiotics: a. Definitions and History. b. Classification and physiology of Lactic acid bacteria (LAB), <i>Bifidobacterium</i> and <i>Propionibacterium</i> . c. Nutraceuticals and high value metabolites produced by LABs. d. FAO/WHO Guidelines on probiotics. e. Safety considerations on probiotics.	05

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

- Learn about factors affecting the food spoilage, food preservations, and different methods of food testing.
- Acquire knowledge about the process of traditional fermented food preparation, their indigenous microbial flora and their importance.
- Comprehend the concept, history, and different types of probiotic and prebiotics.
- Develop problem-solving skills and learn to interpret and analyse the data.

References:

1. Adams, M. R., Moss, M. O. & McClure, P. (2016). Food microbiology. 4th Ed. Royal Society of Chemistry.
2. Banwart, G. J. (1989). Basic food microbiology. 2nd Ed. CBS publishers & Distributors, Pvt. Ltd. India.
3. Casida, L. E. (2016). Industrial microbiology. 2nd Ed. ISBN: 978-8122438024. New Age International Publishers, India.
4. Early, R. (2012). Guide to quality management systems for the food industry. Blackie Academic & Professional, England.
5. Frazier, W. C. & Westhoff, D. C. (2008). Food microbiology. 4th Ed. Tata McGraw-Hill Publishing Company Limited, United States of America.
6. Garbutt, J. (1997). Essentials of food microbiology. 2nd Ed. Arnold Heinemann, India.
7. Heinz, H. J. (1991). Principles and practices for the safe processing of foods. 1st Ed. ISBN: 9781483165349. Butterworth-Heinemann, United Kingdom.
8. Jay, J. M., Loessner, M. J. & Golden, D. A. (2005). Modern food microbiology. 7th Ed. Springer. United States of America.

MB 637 MJ : Bioremediation

Total: 2 Credits; Workload: 15 h/credit

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

Course Objective:

The major objective of this course is to impart a basic understanding of the microbial interactions with pollutants in the soil and environment. Provide an overview of organic wastes and information bioremediation, in-depth information bio-mining.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Treatment of solid waste by saccharification: Solid waste characterization, pretreatment of solid waste, saccharification definition, types of enzymes involved, mechanism behind the process, applications.	04
2	Gasification: Basics, five processes of gasification (drying, pyrolysis, combustion, cracking, reduction), gasifier types, applications of gasification.	03

Sr. No.	Credit Title & Contents	No. of Lectures
3	a. Composting: Stages of composting (mesophilic, thermophilic, curing phase), Types of microbes involved, Factors influencing the process (C:N ratio, moisture, temperature, pH), advantages & disadvantages of composting, applications. b. Vermicomposting: Definition, vermiculite, types of earthworms, various substrates required for earthworms, methods of vermicomposting (Pit method, Windows method), Steps involved in vermicomposting, Effect of vermicompost on soil fertility & quality, applications of vermicompost.	05
4	Microbial degradation of pesticides, xenobiotics: Introduction (types of various pesticides & xenobiotics, their ill effects on living things and environment), types of microorganisms used for degradation and mechanisms involved.	05
5	Advantages and limitations of bioremediation.	01
6	Microbial enhanced oil recovery (MEOR): Processes of crude oil recovery, drawbacks of existing methods, Role of microorganisms in oil recovery and mechanisms involved in MEOR, applications of biosurfactants and/or bioemulsifiers in MEOR.	05
7	Microbes in metal extraction, mineral leaching and mining: Various methods for microbial metal extraction (bioleaching, biooxidation, etc.), microorganisms involved in microbial metal extraction, mechanisms involved in microbial metal extraction, methods of microbial metal extraction (Heap bioleaching, dump bioleaching, in-situ bioleaching, etc.).	07

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

- To study the biodegradation of lignocellulosic biomass.
- To study the use of cellulases in saccharification of cellulosic material.
- To demonstrate composting process.
- Gain in depth knowledge of different types of solid waste, liquid waste and their management.
- Get familiar with problems of pollution and applications of clear up technologies for the pollutants.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Bisen, P. S. (2014). Microbes in practice. I. K. International Publication House Pvt Ltd. Press. United States of America.
2. Bisen, P. S., Debnath, M., Prasad G. B. K. S. (2012). Microbes-concepts and applications Willey BlackWell Pub. - A John Wiley & Sons, Inc., Publication. United States of America.
3. Chandra, R. & Yadav, S. (2014). Distillery wastewater pollution and Bioremediation, CBS Publishers & Distributors Pvt. Ltd., New Delhi, India

M.Sc. Microbiology Part II Syllabus (NEP 2020) for University Dept. SPPU AY 2024 onwards

4. Christon, J. H., Crawford, R. L., Garland, J. L., Lipson, D. A., Mills, A. L., Stetzenbach, L. D. (2007). A manual of environmental microbiology. American Society for Microbiology Press. Washington, DC.
5. Cummings, S. P. (2012). Bioremediation: Methods and protocols, ISBN: a3 978-1617796609, Humana Press, Totowa,
6. Das, S. (2014). Microbial Biodegradation and Bioremediation, Elsevier Ltd.
7. Forster, C. F. & John, D. A. (2000). Environmental Biotechnology. Ellis Horwood Ltd. Publication.
8. Maier, R. M., Pepper, I. L. & Gerba, C. P. (2000). Environmental microbiology. Academic Press, United States of America.
9. Michel, R. (.1974). Introduction of environmental microbiology. Prentice Hall. United States of America.
10. Pepper, I. L., Gerba, C. P. & Brusseau, M. L. (2006). Environmental and pollution science. ISBN: 9780128147207. Academic Press, United States of America.
11. Rajendran, P. & Gunasekaran, P. (2007). Microbial bioremediation, MJP Publishers, Chennai, India.
12. Sharma, P.D. (2016). Environmental microbiology, Rastogi Publications. India.
13. Sharma, S. K. (2020). Bioremediation: A sustainable approach to preserving Earth's water, CRC Press, Taylor & Francis Group, New York, United States of America.
14. Talley, J. (2016). Bioremediation of recalcitrant compounds, CRC Press, Taylor & Francis Group, London.
15. Thangadurai, D. & Sangeetha, J. (2014). Biotechnology and bioinformatics: Advances and applications for bioenergy, bioremediation and biopharmaceutical research. Apple Academic Press, Canada.
16. Tomasini, A. & León-Santiesteban, H. H. (2019). Fungal bioremediation. Fundamentals and applications, CRC Press, Taylor & Francis Group, London.

MB 635 MJP : Lab Exercises in Pharmaceutical 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 give the student hands-on experience bioactive compound extraction, and assessment of its pharmacodynamics studies. Students will also study the estimation and importance of pathological biomarkers and toxicity testing.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Extraction of bioactive principles from different sources using different methods.	16
2	Determination of bioactivity of the extracted compound.	08
3	Interpretation of UV and IR spectra of bioactive compounds or drugs (Any two).	12
4	Determination of partition coefficient of two drugs.	12
5	Testing antibiotic combinations as new intervention by checkerboard assay.	12

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
6	Pyrogenicity testing of drug by Limulus amoebocyte lysate (LAL) test.	08
7	Mutagenicity testing of drug by Ames test.	12
8	Toxicity testing using invertebrate animal model.	16
9	Assessment of efficacy of a drug in formulations or dressings.	16

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

- Perform extraction techniques for bioactive compound from different sources
- Determine the antimicrobial efficacy of the extracts
- Test the antimicrobial efficacy of new interventions
- Analyze the toxicity of compounds
- Study the testing for pathologically important biomarkers.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Abubakar, A. R. & Haque, M. (2020). Preparation of medicinal plants: Basic extraction and fractionation procedures for experimental purposes. *Journal of Pharmacy and Bioallied Sciences*, 12(1), 1-10.
2. Bellio, P., Fagnani, L., Nazzicone, L. & Celenza, G. (2021). New and simplified method for drug combination studies by checkerboard assay. *MethodsX*, 8, 101543. doi: 10.1016/j.mex.2021.101543. PMID: 34754811; PMCID: PMC8563647.
3. Franklin, T. J. & Snow, G. A. (2005). *Biochemistry and molecular biology of antimicrobial drug action*. Springer Science & Business Media. United States of America.
4. Garcia, L. (2014). Synergism Testing: Broth microdilution checkerboard and broth macrodilution methods, in: *Clinical microbiology procedures handbook*, 3rd Ed. American Society of Microbiology, 2014: pp. 140–162.
5. Ignasiak, K. & Maxwell, A. (2017). *Galleria mellonella* (greater wax moth) larvae as a model for antibiotic susceptibility testing and acute toxicity trials. *BMC Research Notes*, 10, 1-8. doi: 10.1186/s13104-017-2757-8. PMID: 28851426; PMCID: PMC5576310.
6. Lorian, V. (2005). *Antibiotics in laboratory medicine*. Lippincott Williams & Wilkins. United Kingdom.
7. *Performance standards for antimicrobial susceptibility testing (CLSI guidelines)*, 34th Ed.
8. Rao, B. S. & Alagarsamy, A. (2019). *Practical pharmaceutical in-organic chemistry*. BSP Books Pvt. Ltd. India.
9. Redfern, J., Kinninmonth, M., Burdass, D. & Verran, J. (2014). Using soxhlet ethanol extraction to produce and test plant material (essential oils) for their antimicrobial properties. *Journal of Microbiology & Biology Education*. 1;15(1):45-6. doi: 10.1128/jmbe.v15i1.656. PMID: 24839520; PMCID: PMC4004744.
10. Silverstein, R. M., Webster, F. X., Kiemle, D. J. & Bryce, D. L. (2015). *Spectrometric Identification of Organic Compounds*. Wiley, United Kingdom.
11. Watson, J. D., Baker Tania A., Bell Stephen, P., Alexander, G., Michael, L. & Richard, L (2017). *Molecular Biology of the Gene*, 7th Ed. ISBN: 978-9332585478. Pearson Education. London, United Kingdom.

MB 636 MJP : Lab Exercises in Food Technology

Total: 2 Credits; Workload: 30 h/credit

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

Course Objective:

This laboratory course aims to train students in the laboratory methods used in the microbiological analysis of foods, probiotic culture isolation, and production of fermented food products. It also includes the microbial technology experiments such as solid and submerged state fermentation processes for various microbial product productions.

Sr. No.	Credit Title & Contents (Experiments equivalent to 60 h to be completed)	No. of Hours
1	Enumeration of microbial load in various food samples products (Meat, milk, fruits, vegetables and canned foods).	12
2	Determination of thermal death point (TDP) and thermal death time (TDT) of microbes.	16
3	Detection of contaminants and adulterants in milk or other food products by qualitative and quantitative tests.	12
4	Characterization of probiotic cultures obtained from various sources. (Adhesion, bile tolerance, antimicrobial activity and antibiotic susceptibility etc.).	12
5	Production of fermented food and characterization of acidity, alkalinity and its microbial profile: curd, wine.	08
6	Estimation of vitamins: Ascorbic acid.	08
7	Aflatoxin production and detection.	12
8	a. Fungal spore/Yeast cells count. b. Isolation, screening and optimization of conditions for production: <ul style="list-style-type: none">● Solid state fermentation: Enzymes or alcohol or organic acids.● Submerged fermentation: Enzymes or exopolysaccharide or alcohol or organic acids or antibiotics or fungal chitosan.	20

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

- Understand the importance of microbes in food preparation, preservation.
- Acquire skill sets to evaluate the microbial quality of food samples.
- Screen microbial cultures suitable for designing probiotic formulations and other food products.
- Operate various levels of fermentation process and determine suitable parameters for large scale production of microbial products.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Adams, M. R., Moss, M. O. & McClure, P. (2016). Food microbiology. 4th Ed. Royal Society of Chemistry.
2. Banwart, G. J. (1989). Basic food microbiology. 2nd Ed. CBS Publishers & Distributors, Ltd. India.
3. Casida, L. E. (2016). Industrial microbiology. 2nd Ed. ISBN: 978-8122438024. New Age International Publishers, India.

4. Early, R. (2012). Guide to quality management systems for the food industry. Blackie Academic & Professional, England.
5. Frazier, W. C. & Westhoff, D. C. (2008). Food microbiology. 4th Ed. Tata McGraw-Hill Publishing Company Limited, United States of America.
6. Garbutt, J. (1997). Essentials of food microbiology. 2nd Ed. Arnold Heinemann, India.
7. Heinz, H. J. (1991). Principles and practices for the safe processing of foods. 1st Ed. ISBN: 9781483165349. Butterworth-Heinemann, United Kingdom.
8. Jay, J. M., Loessner, M. J. & Golden, D. A. (2005). Modern food microbiology. 7th Ed. Springer, United States of America.
9. 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.

MB 637 MJP : Lab Exercises in Bioremediation and Waste Management

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 knowledge on bioremediation concepts by using microorganisms to degrade organic contaminants/pollutants present in soil, sludge, groundwater, solid samples. Understand the role of various microorganisms in break-down of contaminants/pollutants where they are used as energy source. Understand the principles of surface active/emulsifying agents and their applications in various fields.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Biodegradation of agricultural waste to obtain value added products – alcohol or biomethane.	12
2	Saccharification of cellulosic material using enzymatic method.	12
3	Demonstration of composting process.	12
4	Screening of biosurfactant or bioemulsifiers producers using qualitative assays.	16
5	Microbial enhanced oil recovery.	12
6	Biodegradation of recalcitrant compounds – insecticides or pesticides or industrial dyes and effluents etc.	16

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

- Learn the role of microorganisms in conversion of agricultural waste to value added products.
- Acquire the skills to handle the enzymes involved saccharification process.
- Understand the fundamentals composting process and identify the potential microorganisms that can degrade crude oil/hydrocarbons.

M.Sc. Microbiology Part II Syllabus (NEP 2020) for University Dept. SPPU AY 2024 onwards

- Acquire skills and knowledge to identify and evaluate biosurfactant and bioemulsifier producing microorganisms.
- Understand the fundamentals of microbial enhanced oil recovery and design MEOR Strategies and evaluate the efficiency of the process.

References:

1. Bushnell, L. D. & Haas, H. F. (1941). The utilization of certain hydrocarbons by microorganisms. *J. Bacteriology*. 41:653-673
2. Hanson, K. G. & A. J. Desai. (1996). Intergeneric protoplast fusion between *Acinetobacter* sp. A3 and *Pseudomonas putida* DP99 for enhance hydrocarbon degradation. *Biotechnology Letters*. (UK). 18:1369-1374.
3. Morikawa, M., Ito, M. & Imanaka, T. (1992). Isolation of a new surfactin producer *Bacillus pumilus* A-1, and cloning and nucleotide sequence of the regulator gene, *psf-1*. *Journal of Fermentation and Bioengineering*, 74(5), 255-261.
4. Satpute, S. K., Banpurkar, A. G., Dhakephalkar, P. K., Banat, I. M. & Chopade, B. A. (2010). Methods for investigating biosurfactants and bioemulsifiers: a review. *Critical Reviews in Biotechnology*, 30(2), 127-144.
5. Satpute, S. K., Bhawsar, B. D., Dhakephalkar, P. K. & Chopade, B. A. (2008). Assessment of different screening methods for selecting biosurfactant producing marine bacteria. *Indian Journal of Marine Science*. 37, 243–250.

MB 630 RP : Dissertation - Plan of Work and Literature Review

Total: 4 Credits; Workload: 30 h/credit

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

Course Objective:

The objective of this course is to introduce the students to the concepts of literature review, to identify gaps in research, develop a rationale, and propose a hypothesis for study along with a detailed plan to execute the research project.

Content:

Students will begin the preliminary work on their dissertation. They will be given topics by their respective dissertation guide. They will write a literature review based on the given topic by doing referencing. They will also formulate a plan that will consist of the work they intend to do as part of the dissertation project.

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

- Read and understand literature related to a specific topic. Use various referencing tools and databases.
- Critically analyze data available in literature.
- Present their perspective by writing review articles.
- Propose hypothesis, objectives, and methodologies to answer scientific questions.
- Independently plan a design of experiments to be performed to achieve the given set of objectives.

Sr. No.	Credit Title & Contents	No. of Lectures
	(Quantum dots, magnetic nanoparticles, plasmonic nanoparticles, carbon nanotubes, graphene) in drug delivery, disease diagnosis, catalysis, energy harvesting, etc., nanotechnology in agriculture – Fertilizer and pesticides. c. Biomimetics and nanotechnology.	05 03

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

- Comprehend the principle of various spectroscopic techniques and select the spectroscopic methods best suited to address the biological problem in hand.
- Interpret the spectroscopic data to govern the structural and dynamic properties of a molecule.
- Interpret flow behavior (viscosity), surface and interfacial tension values of fluids and apply the obtained results in the field of food science, colloidal and material science etc.
- Apply the knowledge of mechanical properties of biomolecules, such as elasticity, stiffness, and binding interactions for mechanobiological studies.
- Comprehend the unique properties of nanomaterials, various methods to synthesize nanomaterials and characterize the synthesized nanomaterials using various biophysical techniques for their possible biological applications.

References:

1. Banwell, C. N. (1972). Fundamentals of molecular spectroscopy. United Kingdom.
2. De vlaminc, Iwijn & Dekker, Cees. (2012). Recent advances in magnetic tweezers. Annual Review of Biophysics. 41. 453-72. 10.1146/annurev-biophys-122311-100544.
3. Deb, P. K., Kokaz, S. F., Abed, S. N., Paradkar, A. & Tekade, R. K. (2019). In : Rakesh K. Tekade, Pharmaceutical and biomedical applications of polymers. In Basic fundamentals of drug delivery. 203-267. ISBN: 978-0-12-817909-3. Academic Press. United States of America.
4. Fazal, F. M. & Block, S. M. (2011). Optical tweezers study life under tension. Nat Photonics. May 31;5:318-321. doi: 10.1038/nphoton.2011.100. PMID: 22145010; PMCID: PMC3229214.
5. Ghosh, S. & Webster T. J. (2021). Nanobiotechnology, Elsevier, ISBN 9780128228784, <https://doi.org/10.1016/B978-0-12-822878-4.00026-2>.
6. Igor, N. S, Zaccai, N. & J Zaccai. (2007). Methods in molecular biophysics. University Press. Cambridge, United Kingdom.
7. Kulkarni, S. K. (2014). Nanotechnology: Principles and Practices. Springer International Publishing. Germany.
8. Mallick, P. K. (2023). Fundamentals of molecular spectroscopy. Springer Nature, Germany.
9. Pattabhi, V., Gautham, N. (2002). Biophysics. Springer, India.
10. Sarkar, R., Rybenkov Valentin V. (2016). A Guide to magnetic tweezers and their applications. Frontiers in Physics. Vol 4. doi: 10.3389/fphy.2016.00048.
11. Satpute, S. K., Banpurkar, A. G., Dhakephalkar, P. K., Banat, I. M. & Chopade, B. A. (2010). Methods for investigating biosurfactants and bioemulsifiers: a review. *Critical Reviews in Biotechnology*, 30(2), 127-144.
12. Subbiah Balaji. Nanobiotechnology. (2019). MJ Publisher. India.
13. Voet, D., Pratt, C. W. & Voet, J. G. (2013). Principles of biochemistry. Wiley, Philippines.

MB 642 MJ : Omics Concepts, Techniques, and Applications

Total: 4 Credits; Workload: 15 h/credit

(Total Workload: 4 credits x 15 h = 60 h in semester)

Course Objective:

The objective of microbial genomics is to provide an overview of the complete set of microbial genetic instructions provided by the DNA and insights into gene expression patterns. Proteomics aims to deliver thorough knowledge about dynamic protein products and their interactions whereas metabolomics will provide understanding of an organism's entire metabolism.

Sr. No.	Credit Title & Contents	No. of Lectures
1	<p>Introduction to Genomics:</p> <p>a. Pre and post genomic era, major advancements in genomic approaches, epigenetics and metagenomics, next generation sequencing (NGS)-illumina (Solexa), Roche 454, sequencing by oligonucleotide ligation and detection (SOLiD), ion torrent technology etc. parallel sequencing, nanopore sequencing, sequence analysis and their applications: Genome projects, genomic insights into evolution, advantages of comparative genomic analysis, analysis of microarray data.</p> <p>b. Functional genomics, model organisms used for functional genomics, forward versus reverse genomics, methods used for forward and reverse genetic screens, genome analysis - Genome editing approaches and their applications (Zinc Finger Nucleases, TALENS, and CRISPR Cas9), Gene expression approaches and their applications.</p>	25
2	<p>Proteomics:</p> <p>a. Introduction, types of proteomics investigation and importance of proteomics Tools of proteomics-separation technology (SDS PAGE, 2D PAGE), Liquid chromatography.</p> <p>b. Applications of MS-protein identification by peptide mass fingerprinting, Protein molecular weight determinations, primary sequence determination of peptides, post-translational modification analysis of proteins, quantitative proteomics, peptide microarray-based technology, structural proteomics, Host-pathogen interaction, protein-protein interaction, drug discovery. Databases to identify Proteins.</p>	20
3	<p>Metabolomics:</p> <p>a. Basic concepts, metabolic fingerprinting and metabolic profiling,</p> <p>b. Tools of metabolomics: Capillary electrophoresis, gas chromatography (GC), electrochemical detectors, and applications of metabolomics in biology. MS-based metabolite measurements-electrospray ionization (ESI) and electron impact (EI) ionization.</p>	15

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

- Apply omics approaches in genome analysis.
- Compare various next-generation sequencing (NGS) platforms.
- Decide NGS platform as per the requirement.
- Understand the revolutions in microbial genomics and genetic research.
- Integrate omics approaches for genomics, proteomics, and metabolomics and gain a holistic understanding of biological systems.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Ahmadian, A., Ehn, M. & Hober, S. (2006). Pyrosequencing: history, biochemistry and future. *Clinica Chimica Acta*, 363(1-2), 83-94.
2. Bentley, D. R., Balasubramanian, S., Swerdlow, H. P., Smith, G. P., Milton, J., Brown, C. G. & Roe, P. M. (2008). Accurate whole human genome sequencing using reversible terminator chemistry. *Nature*, 456(7218), 53-59.
3. Chai, C. (2019). Principle of emulsion PCR and its applications in biotechnology. *Journal of Animal Reproduction and Biotechnology*, 34(4), 259-266.
4. Doudna J. A. (2020). The promise and challenge of therapeutic genome editing. *Nature*, 578(7794), 229–236. <https://doi.org/10.1038/s41586-020-1978-5>
5. Eid, A. & Mahfouz, M. M. (2016). Genome editing: the road of CRISPR/Cas9 from bench to clinic. *Experimental & Molecular Medicine*, 48(10), e265. <https://doi.org/10.1038/emm.2016.111>
6. Fakruddin, M., Chowdhury, A., Hossain, N., Mahajan, S. & Islam, S. (2013). Pyrosequencing: A next generation sequencing technology. *World Applied Sciences*, 24(12), 1558-1571.
7. Fraser, C. M., Read, T. D. & Nelson, K. E. (2004). *Microbial genomes*. Humana Press, New Jersey.
8. Gaj, T., Sirk, S. J., Shui, S. L. & Liu, J. (2016). Genome-editing technologies: Principles and Applications. *Cold spring harbor perspectives in biology*, 8(12), a023754. <https://doi.org/10.1101/cshperspect.a023754>.
9. Lesk, A. M. (2017). *Introduction to genomics*. Oxford University Press, United Kingdom.
10. Mayers, D. L., Sobel, D., Ouellette, M. & Kaye, K. S. (2009). *Antimicrobial drug resistance*. 803-824. Humana press, New York.
11. Pevsner, J. (2015). *Bioinformatics and functional genomics*. Wiley, United Kingdom.
12. Saraswathy, N. & Ramalingam, P. (2011). *Concepts and techniques in genomics and proteomics*. Elsevier Science, United Kingdom.
13. Seshasayee, A. S. N. (2015). *Bacterial Genomics: Genome organization and gene expression tools*. India: Cambridge University Press, United Kingdom.
14. Sethuraman A. (2022). Teaching computational genomics and bioinformatics on a high performance computing cluster-a primer. *Biology methods & protocols*, 7(1), bpac032. <https://doi.org/10.1093/biomethods/bpac032>
15. Shao, K., Ding, W., Wang, F., Li, H., Ma, D. & Wang, H. (2011). Emulsion PCR: A high efficient way of PCR amplification of random DNA libraries in aptamer selection. *PloS One*, 6(9), e24910.
16. Siu, R. H., Liu, Y., Chan, K. H., Ridzewski, C., Slaughter, L. S. & Wu, A. R. (2021). Optimization of on-bead emulsion polymerase chain reaction based on single particle analysis. *Talanta*, 221, 121593.

17. Snyder, L. & Snyder, L. A. (2024). Bacterial genetics and genomics. CRC Press. New York, United States of America.
18. Zhou, J. (2004). Microbial functional genomics. Wiley, United Kingdom.

MB 643 MJ : Microbial Ecology and Evolution

Total: 4 Credits; Workload: 15 h/credit
(Total Workload: 4 credits x 15 h = 60 h in semester)

Course Objective:

This course aims to provide thorough knowledge about the origin of life on earth, understand the differences in ancient and contemporary conditions of life on earth, and in evolution of life one form from another for a better chance of survival.

Sr. No.	Credit Title & Contents	No. of Lectures
1	a. Ecology: The Environment - Biotic and abiotic factors and interactions. b. Habitat and Niche: Theory of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; tropical niche conservatism.	05
2	a. Types of Ecology: Population ecology, Community Ecology, Ecosystem Ecology. Concept of metapopulation – demes and dispersal, interdemec extinctions, age structured populations.	06
	b. Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.	06
	c. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.	03
3	Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.	03
4	a. Ecosystem structure; ecosystem function; energy flow and mineral cycling (C, N, P); primary production and decomposition. b. Structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine).	07
5	History and development of evolutionary theory, Neo Darwinism: Spontaneous mutation controversy, evolution of rates of mutation, types of selection, levels of selection, group selection and selfish gene.	10
6	a. Sociobiology, kin selection, evolutionary stability of cooperation, sociality and multicellularity in microorganisms, game theory. b. Co-evolutionary strategies, host parasite coevolution, neutral evolution and molecular clocks, phylogeny and molecular distances.	10
7	Molecular evolution: Origin of life, the origin of new genes and proteins. Evolution of life histories,	10

Sr. No.	Credit Title & Contents	No. of Lectures
	aging, evolutionary trade-offs, r and k selection, evolutionary origin of biochemical disorders: The case of insulin resistance.	

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

- Provide a basic idea of biological evolution how populations and species of organisms change over time.
- Understand different theories proposed by several evolutionary biologists for biological evolution. How each species possesses its unique set of heritable (genetic) differences from the common ancestor, which have accumulated gradually over very long period.
- Understand mechanism for evolution: natural selection, where heritable traits that help organisms survive and reproduce become more common in a population over time.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Carlile, M. J. & Moseley, B.E.B. (1981). Molecular & cellular aspects of microbial evolution, Cambridge University Press, Cambridge, England.
2. Cooper, G. M. (1990). Oncogenes, Jones & Bartlett Publishers, Sudbury. United States of America.
3. Hall, B. K. (2011). Evolution: Principles and processes, Jones & Bartlett Publishers, Sudbury. United States of America.
4. Hall, B. K. (2008). Strickberger's evolution: Integration of genes, organisms and populations 4th Ed. Jones & Bartlett Publishers, Sudbury.
5. Hall, B. K. & Benedikt, H. (2008). Strickberger's evolution: the integration of genes, organisms and populations. Jones & Bartelette Publications. United States of America.
6. Mark, R. (2003). Evolution. 3rd Ed. ISBN: 978-1-405-10345-9. Wiley-Blackwell Science Ltd. Publishing, United States of America.
7. Mayr, E. (2001). What evolution is? Science masters series. Weidenfeld & Nicolson, United Kingdom.
8. McArthur, J. V. (2006). Microbial ecology: An evolutionary approach, Academic Press, London.
9. Natrang, K. (1995). Encylopaedic dictionary of genetics and organic evolution Vol (A-F), Anmol Publications Pvt. Ltd., New Delhi, India.
10. Sanders-Lorenz, E. & Miller, J. H. (2010). Microbiologist: A Discovery-Based Course in Microbial Ecology and Molecular Evolution, American Society for Microbiology, Washington.

MB 644 MJ : Bioinformatics and Structural Biology

Total: 4 Credits; Workload: 15 h/credit

(Total Workload: 4 credits x 15 h = 60 h in semester)

Course Objective:

To train the students about basics of bioinformatics and its tools/techniques to analyse the macromolecules with innovative approaches and its applications in multi-disciplinary research field.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Introduction and biological databases: Nucleic acids, proteins, Genomes-structure databases, Search engines, sequence data forms and submission tools, scoring matrices for sequence alignments, algorithms-pairwise sequence alignments, database similarity searches-BLAST, FASTA phylogenetic analysis and tree building methods, motif searches, epitope prediction, data mining tools and applications, promoter and gene prediction, comparative analysis. Hands-on sessions.	20
2	Protein modeling and structure-based approaches: Force field methods, energy, buried and exposed residues, side chains and neighbors, fixed regions, hydrogen bonds, mapping properties onto surfaces, fitting monomers, RMS fit of conformers, assigning secondary structures, Sequence alignment methods, Evaluation, scoring, protein structure prediction, alignment algorithms, sequence based methods of structure prediction, prediction using inverse folding, fold prediction, significance analysis, scoring techniques, sequence-sequence scoring, protein function prediction. Hands-on sessions.	20
3	Computational biology: Introduction to mathematical modeling in biology, basic concepts (ordinary differential equation), modeling population growth, logistic, stochastic and deterministic models, modeling molecular processes in the cells-Ligand-receptor binding, enzymatic reaction, transcription and translation. Hands-on sessions.	15
4	Introduction to AI and data science for applications in life sciences.	05

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

- Understand the basic principles/concepts of bioinformatics, tools/techniques and application.
- Learn about the basic analysis of genomic, proteomic, and transcriptomic data using bioinformatics softwares.
- Use bioinformatics methods to analyse the structure and function relationship of molecules.
- Develop problem-solving skills, new algorithms and analysis methods to address a range of biological questions.
- Use and describe bioinformatics data, information resource and also to use the software effectively from large databases.
- Learn about the basics of AI techniques and application.

- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Baxevanis, A. D. & Francis Ouellette, B. F. (2004). Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd Ed. John Wiley & Sons, In. United States of America.
2. Choudhuri, S. (2014). Bioinformatics for beginners: Genes, genomes, molecular evolution, databases and analytical tools. 1st Ed. eBook ISBN: 9780124105102. Academic Press, London, United Kingdom.
3. Liljas, A., Liljas, L., Lindblom, G., Nissen, P., Kjeldgaard, M. & Ash, M. R. (2016). Textbook of structural biology. Vol 8. 2nd Ed. ISBN: 9813142499. World Scientific Publisher, Singapore.
4. Mount, D. W. (2004). Bioinformatics sequence and genome analysis. 2nd Ed. ISBN: 0-87969-597-8. Cold Spring Harbor Laboratory Press, United States of America.
5. Rastogi, S. C. & Mendiratta, N. (2006). Bioinformatics: Concept, skill and applications. 2nd Ed. ISBN: 978-8123908854. CBS Publishers & Distributors, India.
6. Xiong, J. (2007). Essential bioinformatics, 1st Ed. ISBN: 978-0521706100. Cambridge University Press, Cambridge, United Kingdom.

MB 645 MJ : Clinical Immunology and Cancer biology

Total: 4 Credits; Workload: 15 h/credit

(Total Workload: 4 credits x 30 h = 60 h in semester)

Course Objective:

This course aims to advance the student's knowledge about the immune system by detailing its regulation and disorders. This course is also meant to introduce the student to the biochemistry and molecular biology of cancer.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Regulation of Immune response: a. Negative regulation - Immunological tolerance, Mechanisms of tolerance induction (related experimentation using transgenic animals), T cell mediated suppression of immune response. b. Regulation of immune responses by: antigen, antigen-antibody complexes, Network theory and its experimental evidence. c. Cytokine mediated cross regulation of TH subsets (TH1-TH2). d. Regulation of complement system: Classical and alternative pathway. e. Immunomodulation: BRMs for therapy.	15
2	Immunological Disorders: Pathophysiology, diagnosis, prognosis and therapeutic approaches to a. Immunodeficiency disorders – Phagocytic deficiencies, humoral deficiencies, Cell mediated deficiencies, combined deficiencies and complement	15

Sr. No.	Credit Title & Contents	No. of Lectures
	deficiencies. b. Autoimmune disorders (Immunopathological mechanisms and theories of autoimmunity) - Rheumatoid arthritis, Systemic Lupus Erythematosus (SLE), Multiple myeloma, Myasthenia gravis.	
3	Molecular and Cell Biology of Cancer: a. Cellular transformations during neoplastic growth, Classification of tumors based on histological, physiological, biochemical and immunological properties, Tumors of lymphoid system (lymphoma, myeloma, Hodgkin's disease). Metabolism in cancer cells. b. Cell cycle control by CDKs and cyclins, loss of cell cycle control. c. Hallmarks of cancer, Tumor suppressor genes and oncogenes, Tumor microenvironment and cancer cell heterogeneity, Physical and biological factors associated with tumorigenesis, cancer stem cells, Molecular mechanism of metastasis, Epithelial to mesenchymal transition, mitogenic cell signaling (Ras-Raf-MAPK, erbB, c-myc, signaling pathways), Different mechanisms of cancer cell adaptations. d. Concept of tumor associated and tumor specific antigens, role of immune system in cancer, Immunosurveillance and immunoediting, tumor evasion of immune system.	20
4	Cancer Diagnostics and Therapy: a. Conventional and molecular methods, Clinical grading of tumors. b. Cancer therapy: basic principles of chemotherapy and radiation. c. Emerging concepts in cancer therapy: Cancer immunotherapy, Passive and adoptive cancer immunotherapy, hyperthermia.	10

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

- Understand how the immune system is regulated in the presence or absence of various pathological factors.
- Define the disorders that occur due to a dysfunctional immune system.
- Analyze the pathogenesis, clinical features, and treatment options for autoimmune diseases
- Gain a comprehensive understanding of the molecular and cellular basis of cancer development
- Outline the mechanisms of tumorigenesis, tumors and cancer.
- Investigate various diagnostic techniques and treatment modalities for cancer.

References:

1. Basu, S. K., Panda, C. K. & Goswami, S. (2022). Cancer diagnostics and therapeutics: Current trends, challenges, and future perspectives. Springer Verlag, Singapore.
2. Fior, R. & Zilhao, R. (2019). Cancer-when cells break the rules and hijack their own planet. Molecular and cell biology of cancer. Springer Charm. Switzerland.

M.Sc. Microbiology Part II Syllabus (NEP 2020) for University Dept. SPPU AY 2024 onwards

3. Kindt, T. J., Goldsby, R. A., Osborne, B. A. & Kuby, J. (2007). Kuby immunology. Macmillan. London, United Kingdom
4. Pecorino, L. (2021). Molecular biology of cancer: Mechanisms, targets, and therapeutics. 3rd Ed. Oxford University Press.
5. Pezzella, F., Tavassoli, M. & Kerr, D. J. (2019). Oxford textbook of cancer biology. Oxford University Press. United Kingdom.

MB 646 MJ : Bio-entrepreneurship and IPR

Total: 4 Credits; Workload: 15 h/credit

(Total Workload: 4 credits x 15 h = 60 h in semester)

Course Objective:

The objective of this course is to equip students with the entrepreneurial skills necessary to establish and manage sustainable, eco-friendly bio-enterprises. The course aims to foster an understanding of how to create, protect, and monetize intellectual property (IP) rights, thereby enabling students to innovate and thrive in the biotechnology sector.

Sr. No.	Credit Title & Contents	No. of Lectures
1	<p>a. Bioentrepreneurship : Introduction, definition, scope. Characteristics of successful bioentrepreneurs, overview of the biotechnology industry.</p> <p>b. Problem Identification: Defining a problem, identifying a problem, techniques to characterize the problem, defining a precise problem statement.</p> <p>c. Creative thinking/ business solution: Ideation, techniques to derive solutions (Design thinking/TRIZ), innovation methodology, business potential of solution.</p> <p>d. Building a biotech business, business models:</p> <p>e. Advantages and disadvantages of each model. Selecting the right business model for your venture.</p>	05
2	<p>a. Writing a business plan: Key components, executive summary, company description, market analysis, organization and management, product line or services, marketing and sales, funding request, financial projections and business type profiling- B2B, B2C or B2B2C.</p> <p>b. Tips for writing a compelling business plan.</p> <p>c. Product development, commercialization: Concept, design, testing, and validation, scope of intellectual property building - Patent, copyright, publications etc.</p> <p>d. Regulatory considerations, approvals. Strategies to bring a product to market.</p>	08
3	<p>a. Financial aspects, types of funding: Grants, venture capital, angel investors, crowdfunding. Preparing for investor</p>	07

Sr. No.	Credit Title & Contents	No. of Lectures
	presentations and pitches. b. Understanding term sheets and investment agreements. Financial management and projections. Marketing strategies for biotech products - scaling up strategies and challenges. c. Legal, ethical, and regulatory considerations-Overview of regulatory bodies (e.g., FDA, EMA).	
4	a. Concept of property and intellectual property (IP) b. Forms of IPR: Patents, trademarks, copyrights, designs, other forms - Biological diversity, data protection, domain names, geographical indications, semiconductor integrated circuit layouts, trade secrets, traditional knowledge.	08
5	International treaties for the protection of IPRs, world trade organization (WTO), trade related aspects of intellectual property rights (TRIPS), Bern convention, Paris convention, patent cooperation treaty (PCT), Budapest treaty, Madrid protocol.	05
6	Protection of new Invention through patents, invention disclosure form requirement, patentability criteria, novelty, inventive step, industrial utility, non-patentable invention section (3) of the Indian patent act, patent prior art search, types of patent applications, patent filing process and requirements, freedom to operate (FTO), patent Infringements, strategies to file Patents in other countries.	07
7	Experiential learning: Designing a business plan using the right business model for a venture. OR Preparing a patent landscape or drafting a pre-patent application.	20

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

- Recognize that protecting and profiting from new inventions.
- Comprehend the importance of invention disclosures and the prerequisites for preparing the draft of a patent application and conducting a prior art search.
- Gain knowledge and abilities to initiate start-ups or run a biotech company.
- Recognize the nuances of the biotechnology sector and be ready to handle the challenges in implementing cutting-edge biotechnology.
- Recognize the importance of invention disclosures and the prerequisites for preparing the draft of a patent application and conducting a prior art search.
- Understand the techniques for submitting patent applications in India and other nations with the intention of making money off of patented innovations.
- Draft and file patent applications by comprehending the legal and treaty provisions.
- Operate free databases which are utilized independently in patent searches.

References:

1. Arora, M. (2007). Universal's guide to patents law. 4th Ed. ISBN: 9788175345836, 8175345837. Universal Law Publishing Company. India.

M.Sc. Microbiology Part II Syllabus (NEP 2020) for University Dept. SPPU AY 2024 onwards

2. Kankanala K. C. (2012). Fundamentals of intellectual property. 1st Ed. ISBN: 9789381849514, 938184951X. Asia Law House, India.
3. Kankanala K. C. (2012). Indian patent law. ISBN 9780198089605, 0198089600. Oxford University Press, New Delhi, India.
4. Narayan, P. (2020). Intellectual property law : Revised and updated. Eastern Law House, India,
5. Paul, M. (2018). Intellectual property law. 7th Ed. ISBN: 9788189530556, 8189530550, Allahabad Law Agency Myneni, S.R. Intellectual property law. Asia Law House, India.
6. Reddy, G.B. (2020). Intellectual property law. 11th Ed. Gogia Law Agency, India.
7. Sharma, B. & Kalia, A. (2012). Dictionary on Indian patent law. 1st Ed. ISBN: 9789381849477, 9381849471. Asia Law House, India.
8. Shimasaki, C. (2014). Biotechnology entrepreneurship: Starting, managing, and leading biotech companies. Academic Press, London, United Kingdom.
9. Singh, P. M. (2024). Singh on Patent Law Volume 1 & 2. Thomson Reuters, Canada.
10. The Indian Patent Act 1970.
11. Wadhera, B. L. (2016). Law relating to intellectual property, Universal Law Publishing Co. India.

MB 647 MJ : Waste Management

Total: 4 Credits; Workload: 15 h/credit

(Total Workload: 4 credits x 15 h = 60 h in semester)

Course Objective:

The major objective of this course is to impart a basic understanding of the waste management techniques and possible resource recovery.

Sr. No.	Credit Title & Contents	No. of Lectures
1	Solid waste management:	
	a. Biomass waste management of plant residues: Lignocellulolytic microorganisms.	02
	b. Enzymes and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles (iv) biofuels, (v) animal feed production.	12
	c. Resource recovery from waste: Biofuels (ethanol, methane, hydrogen, biodiesel) - Microbial groups involved in biogas production and interaction among them, factors affecting biogas production, design of digester, feed stocks, uses of spent slurry.	15
	d. Valorization of agricultural waste for value added products - biomass production and applications (Fungal biomass- baker's yeast and single cell oil, Mushroom cultivation, use of algal biomass).	06
2	Liquid waste management: a. Wastewater treatment system (unit process): Physical screening, flow equalization, mixing, flocculation, flotation, granular medium filtration, adsorption, chemical precipitation, disinfection, dechlorination, biological: (aerobic and anaerobic, suspended and attached growth processes).	10

Sr. No.	Credit Title & Contents	No. of Lectures
	b. Treatment systems and their analysis: reactions and kinetics, mass balance analysis, reactor types, hydraulic character of reactors, selection of reactor type, critical operating parameters like DO, hydraulic retention time, mean cell residence time, F/M ratio etc.	05
	c. Water pollution control, regulation and limit for disposals in the lakes, rivers, oceans, and land.	02
	d. Direct and indirect reuse of treated effluents and solid wastes.	02
	e. Current industrial wastewater treatment and disposal processes (Textile, food and dairy, paper and pulp manufacturing industries).	06

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

- Gain in depth knowledge of different types of solid waste, liquid waste and their management.
- Get familiar with problems of pollution and applications of clear up technologies for the pollutants.
- Gain in depth knowledge of different types of techniques for conversion of waste to wealth.
- Develop problem-solving skills and learn to interpret and analyse the data based on the above modules.

References:

1. Alexander, M. (2011). Soil microbiology 2nd Ed. ISBN 978-0060546465. Krieger Pub Co. Germany.
2. Atlas, R. M. & Barta, R. (1998). Microbial ecology: Fundamentals and applications. ISBN: 0805306552, 9780805306552. Pearson Education, India.
3. Burlage, R. S., Atlas, R., Stahl, D., Geesey, G. & Sayler G. (1998). Techniques in microbial ecology. ISBN: 0-19-509223-6. OUP, United States of America.
4. Colwd, D. (1999). Microbial diversity, Academic Press. United States of America.
5. Eweis, J. (1998). Bioremediation principles. McGraw-Hill Education, United States of America.
6. Grant, W. P. & Long, P. E. (2013). Environmental microbiology. Springer Science & Business Media, Germany.
7. Hurst, C. J. (2002). Manual of environmental microbiology, 2nd Ed. ASM Press. Washington, DC.
8. Johri, B. N. (2000). Extremophiles, Springer Verlag, New York, United States of America.
9. Mitchell, R. & Gu Ji-Dong. (2010). Environmental microbiology. ISBN: 978-0-470-17790-7. Wiley-Blackwell. A John Wiley & Sons, Inc. United States of America.
10. Subba Rao, N. S. (1995). Soil microbiology and plant growth. ISBN ý 978-1886106185. Science Publishers, United States of America.
11. Tilak, S. T. (1997). Aerobiology. ISBN: 978-9352551613. New Central Book Agency Private Limited. India.

MB 640 RP : Dissertation - Lab Work and Data Compilation

Total: 6 Credits; Workload: 30 h/credit

(Total Workload: 6 credits x 30 h = 180 h in semester)

Course Objective:

Providing a unique opportunity for the students to investigate biological question/s of their interest under the guidance of a teacher/mentor.

Course content:

The student will perform experiments as per the plan designed in the previous semester. The generated data will be interpreted and analyzed. These data will then be presented in the form of a dissertation report and a viva-voce.

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

- Investigate a scientific question.
- Measure various parameters by performing experiments.
- Analyze and interpret the data generated from experiments.
- Present the data.