Veer Bahadur Singh Purvanchal University
Jaunpur

Ordinance and Syllabus for
M. Sc. in Microbiology
[Two-year (Four semesters) postgraduate degree program]

Faculty of Science
Under Choice Based Credit System (CBCS)
As per the guidelines of NEP-2020
w.e.f. 2022-23 (Session)

V.B.S. PURVANCHAL UNIVERSITY, JAUNPUR
Department of Microbiology
Faculty of Science

Vision

The Department is dedicated in providing the quality education, through both lectures and practical sessions, necessary to meet the needs of this growing field. The main objective and focus of the department are to guide and impart innovative education at par with national and international standards.

Mission:

- To be a world-class hub for interdisciplinary education and research programs in microbiology.
- To promote high-impact education and innovative research in a diverse and inclusive environment by exploring fundamental questions in microbiology.
- To provide outstanding education in microbiology to post-graduate and professional students.
- To expand interdisciplinary and multidisciplinary collaborations that are recognized nationally and internationally for their innovative impacts on microbiology.
- To contribute to the mission of the University by engagement in outreach to enhance community understanding of the importance of microbiology.
- To attract and retain a diverse, talented and dedicated group of faculty and staff to advance their careers through collaborative efforts in education, research, and service.

V.B.S. PURVANCHAL UNIVERSITY, JAUNPUR

Ordinance governing two-year (four semesters) postgraduate degree program

M. Sc. in Microbiology (Faculty of Sciences)

Under Choice Based Credit System (CBCS)

w.e.f. 2022-23 (Session)

The following ordinances have been framed governing the admission, course structure, examination and other allied matters relating to the two-year (four semesters) postgraduate degree programme (M.Sc.) in Microbiology being offered by V.B.S. Purvanchal University.

A. ADMISSION AND EXIT

1. All matters relating to admission to this course shall be dealt with by the Admission Committee constituted for the purpose by the University.
2. The M.Sc. Microbiology course is open to science graduates (with 3 year undergraduate degree of new or old system) with minimum of 50% of marks, from a recognized University (45% in case of SC/ST). Those who are appearing in final examination of B.Sc. (Biology/Life Sciences/BVSc & AH/MBBS/B. Pharm and related subjects of Life Science) degree can also apply for admission and shall be eligible to appear in the Entrance Test for admission but they will have to produce a proof of being a graduate at the time of admission. However, students of VBS Purvanchal University can be given provisional admission by the Admission Committee in case of delayed results.
3. Admission in M.Sc. Microbiology course will be based on the entrance test or merit as per the rules of the university.
4. The intake of students in this programme shall be fixed by V.B.S. Purvanchal University. The admission to M.Sc. courses shall be made through a merit based on Written Test conducted by VBS Purvanchal University Combined Admission Test (PUCAT). The reservation norms for admission shall be guided by State Government/ University notification issued from time to time.
5. On selection the candidates shall deposit the fees prescribed for the purpose to get his/her admission confirmed within the time period fixed by the Admission Committee of the Department. If a candidate fails to do so his/her admission shall be automatically cancelled and the seat falling vacant shall be offered to other candidates as per the merit/category. However, matter concerning fees of candidates under SC/ST category would be governed by Govt. Order; as such there is no provision of fee concession/exemption/refund.
6. Admission to M.Sc. course cannot be claimed by any candidate as a matter of right. The Admission Committee shall have power to refuse, reject or cancel any admission if it possesses sufficient reasons to do so.
7. **Student Mentor:** Every student will have a member of faculty of the Department as his/her student advisor. All teachers of the department shall function as Student Mentor (Advisors). The Student Advisor will advise the students in choosing Elective courses and offer all possible student support services

B. COURSES OF STUDY AND EXAMINATION

1. Postgraduate program (M. Sc. Microbiology) will be conducted in CBCS (Choice Based Credit System) and semester system
2. There will be 4(four) theory papers of main subject and 1 (one) practical paper (all four credits) in one semester, thus in a semester there will be 20 credits of papers of main subject. 40(forty) in 1(one) year that would be 80(eighty) credits in 2(two) years
3. All four theory papers are compulsory in the first semester.
4. In the second and third semester, the student can choose one paper based on the optional paper (specialization), according to his interest and on the basis of the resources available in the university /college.

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5. All the papers in the fourth semester are optional papers based on specialization from which the student can choose any four theory papers as per his/her interest.
6. In the first year of post-graduation, the student will have to take only 1 minor elective paper from any other faculty (a subject other than the main subject). This paper will be of 4 (four) credits
7. To conduct the M.Sc. (Microbiology) programme systematically and within a time bound frame, the concerned Department shall draw up an "Academic Calendar" in the beginning of academic session.
8. A candidate admitted to the M.Sc. course shall pursue a regular course of study in all the four semesters of the course and attend a minimum of 75% of the classes held to be eligible to appear in the semester examinations.
9. If a student fails to attend requisite classes in a semester due to illness, he/she may be given relaxation of 15% attendance (10% at the level of Vice-Chancellor and 5% at the level of Head of Department on production of medical certificate.
10. Semester examinations of the M.Sc. course shall be conducted by way of theory papers, practical and industrial training/surveys/research project. Each theory core and elective paper will be of 100 marks out of which 75 marks shall be allocated for semester examination and 25 marks for internal assessment. The pattern of question papers for theory examinations will be as per the University rules
11. Internal assessment is an integral part of the course and is compulsory for all students. Academic performance of students is evaluated by Continuous Internal Assessment (CIA) that includes day to day performance, attendance, home Assignment periodic tests, seminar presentation; subject's quizzes class discussion, etc.
12. The responsibility of evaluating the internal assessment is vested on the teacher(s) who teaches the course.
13. One practical (4 credits) examination shall be conducted which will be assessed jointly by the teachers of the department and the external examiner nominated by the university at the end of each semester out of 100 marks.
14. Ordinarily, the semester examinations shall be held in December and May.
15. Research Project in Post Graduate Program: In the first and second year of post-graduation, the student will have to do a major research project.
16. This research project can also be interdisciplinary / multi-disciplinary. This research project can also be in the form of industrial training / internship / survey work etc.
17. The research project will be done under the guidance of a teacher supervisor; co-supervisor can be taken from any industry/company/technical institute/research institute.
18. Undergraduate (including research) and postgraduate students will be required to undertake a research project of four credits (4 hours per week) in each semester.
19. Students will submit the final report (project report/dissertation) of the research project carried out in both the semesters at the end of the year, which will be assessed jointly by the supervisor and the external examiner nominated by the university at the end of the year out of 100* marks. Thus, there will be a total of 8 credits of this exam. The students have to submit a project report/dissertation/technical report in bound form duly certified by the supervisor. The evaluation of the project/dissertation/technical will be done through presentation and viva voce examination of the student.
20. If a student publishes any of his research papers in this research project in the UGC-CARE listed Journal and published during the program, then he can be given additional marks up to 25 in the evaluation of the research project (out of 100). The maximum received will be 100.
21. Most of the grades will be marked on the marks obtained in the research project and they will also be included in the calculation of CGPA.
22. It will be necessary to take the exam for credit validation. Credit will be incomplete without the examination.

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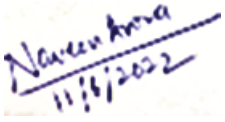
23. If a student qualifies for the examination on the basis of attendance in the class, but is not able to give the examination due to any reason, then he/she can appear for the qualifying examination in the next time, he/she will not need to take classes again.
24. Matters pertaining to the syllabi and conduct of examination shall be dealt with by the Board of Studies (BOS) constituted by the Vice-Chancellor.
25. The BOS shall recommend the panel of paper setters/examiners to the Vice-Chancellor. After getting approval from the Vice-Chancellor, the appointment letters shall be issued to the concerned paper setters/examiners by the Registrar/Controller of Examination of Purvanchal University.
26. Papers for theory examination in sealed covers shall be handed over/sent by registered post to the Registrar/Controller of Examination by the Examiners. Controller of Examinations/Technical Cell will ensure the printing of papers and fair conduct of the examinations.
27. The question papers shall be moderated before examination by a committee consisting of the Head and two senior most teachers of the department and the teacher of concerned paper. The Center Superintendent shall ensure implementation of this provision.
28. After the examinations, Controller of Examinations/Technical Cell for campus courses shall ensure the evaluation of the answer books and declaration of results of semester examinations within a reasonable time so as to enable the department to adhere to the Academic Calendar.
29. Practical examinations of semester I, II, III and IV shall be conducted by one internal and one external examiner. Similarly, in the Second and fourth semester project/dissertation/technical report and presentation carrying 100 marks shall also be evaluated jointly by external as well as internal examiner(s)..
17. For appearing in semester examinations each student shall have to deposit a prescribed examination fee along with a duly filled examination application form; separate fees will also be charged for back and improvement papers. For SC/ST candidate relaxation in examination fees applicable as per Govt. Order. He/she has been a student of good conduct.
18. The students of M.Sc. course shall be examined in the subjects in accordance with course curriculum given at the end of ordinance.

C. RESULTS, PROMOTION AND IMPROVEMENT

20. If a student wants to leave after passing the first year of post-graduation by earning a minimum of 52 credits, then he will be awarded a bachelor's (including research) degree. After earning a minimum of 52+48 credits in the first and second year of post-graduation, the student will be awarded a master's degree in that main subject of that faculty.
21. The results of M. Sc. 1st, 2nd and 3rd semester examination shall be declared as pass who scores at least 36% of marks in each paper separately and 40% in aggregate. About 50% of the paper setting would be internal.
22. If a student fails in more than 4 papers in an academic year he/she will not be promoted to the next year. Such student should be re-admitted as Ex. Student with coming batch and their seat will be additional.
23. Students, who failed in 4 or lower number of papers in the academic year will be awarded 'back' and given two chances to reappear and pass in respective paper(s) in next year and the following year with regular semester examination. There will not be any supplementary/special examination for back/improvement papers. However, all such papers must be cleared within two years ending fourth semester
24. In order to pass the 2-year M.Sc. (Microbiology) course, the students must pass both the year separately. The final result shall be declared on the basis of the combined marks secured by a candidate in all the four semesters in the following categories. If a student has secured pass marks in aggregate in a semester but has failed in a maximum of two papers a provision is made to grant him a maximum of 3 grace marks.



25. Student securing highest number of marks during the course in the first attempt will be awarded the University Gold Medal for the same.

Passed	**:**	**40% and above**
Second Division	**:**	**45% and above but less than 60%**
First Division	**:**	**60% and above**

26. Conversion of Marks into Grades: As per University rules
27. Grade Points: Grade points shall be determined as per the Grade point table as per University Examination rule.
28. CGPA Calculation: As per University Examination rule.

Note: Suggested Continuous Internal Evaluation (CIE) methods Continuous Internal Evaluation shall be based on Class test, presentation along with assignment and class interactions. Marks shall be as follows.

- Total marks: 25
- 10 marks for Test
- 10 marks for presentation along with assignment
- 05 marks for Class interactions

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V.B.S. PURVANCHAL UNIVERSITY, JAUNPUR 222003
Syllabus
Master of Science in Microbiology (M. Sc. Microbiology)
Designed as per Syllabus Development Guidelines of National Education Policy-2020 (NEP-2020)

Programme Structure:

The M.Sc. Microbiology programme is a two-year course divided into four-semesters. A studentis required to complete hundred credits for the completion of course and the award of degree. A student has to accumulate twenty-eight credits in first semester and twenty for credits in each of the remaining (second, third and fourth) semesters.

Part – I	First Year	Semester I	Semester II
Part – II	Second Year	Semester III	Semester IV

SEMESTER-WISE DETAILS OF M.Sc. MICROBIOLOGY COURSE

Semester I				
#	Course Code	Name of the course	Credits	Teaching Hours
Core Paper: Theory	B080701T	Bacteriology	4	60
	B080702T	Bacteriological Techniques	4	60
	B080703T	Cell Biology and Biochemistry	4	60
	B080704T	Molecular Biology & Microbial Genetics	4	60
Minor Elective: *Theory*	*To be offered by other faculty*	*Minor Elective (Any one out of all the available Minor Elective papers offered from other Faculties)*	4	60
Practical	B080705P	*Practical I*	4	120
Industrial Training/ Survey/ Research Project	B080706R	*Industrial Training/ Survey/ Research Project I*	4	
		Total Credits	**28**	

Semester II				
#	Course Code	Name of the course	Credits	Teaching Hours
Core Paper: Theory	B080801T	Immunology and Immunotechnology	4	60
	B080802T	rDNA Technology	4	60
	B080803T	Virology	4	60
Major Elective: *Theory (Any one of the two papers)*	B080804T	Instrumentation and Analytical Techniques	4	60
	B080805T	Extremophiles & their Application		
Practical	B080806P	*Practical II*	4	120

Industrial Training/ Survey/ Research Project	B080807R	*Industrial Training/ Survey/ Research Project II*	4	
		Total Credits	**24**	

Semester III				
#	Course Code	Name of the course	Credits	Teaching Hours
Core Paper: Theory	B080901T	Industrial Microbiology	4	60
	B080902T	Microbial Physiology & Metabolism	4	60
	B080903T	Environmental Microbiology	4	60
Major Elective: *Theory (Any one of the two papers)*	B080904T	Biostatistics & Bioinformatics	4	60
	B080905T	Microbial Biodiversity		
Practical	B080906P	*Practical III*	4	120
Industrial Training/ Survey/ Research Project	B080907R	*Industrial Training/ Survey/ Research Project III*	4	
		Total Credits	**24**	

Semester IV				
#	Course Code	Course	Credits	Teaching Hours
Major Elective: *Theory (Any four out of eight papers):*	B081001T	Food Microbiology	4	60
	B081002T	Agricultural Microbiology	4	60
	B081003T	Clinical Microbiology	4	60
	B081004T	Entrepreneurship, IPR & Biosafety	4	60
	B081005T	Microbial Pathogenicity	4	60
	B081006T	Plant Pathogen Interaction	4	60
	B081007T	Mycology & Phycology	4	60
	B081008T	Bioprocess Technology	4	60
Practical	B081009P	*Practical IV*	4	120
Industrial Training/ Survey/ Research Project	B081010R	*Industrial Training/ Survey/ Research Project IV*	4	
		Total Credits	**24**	

Note:

1. Up to first three semesters the marks allocated for continuous internal assessment (25 marks) will be

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evaluated on the basis of class attendance and a seminar. The seminar will be an integral part of the sessional and will be evaluated by all the faculty members of the Department.

2. The detailed syllabus is given in the following pages. The numbers given in front of each topic/group of topics represent the number of periods (60 minutes each) allocated for teaching that topic(s).

M. Sc. Microbiology
Programme Objectives (POs)

At the time of completion of the programme the student will have developed extensive knowledgein various areas of Microbiology. Through the stimulus of scholarly progression and intellectual development the programme aims to equip students with excellence in education and skills, thus enabling the student to pursue a career of his/her choice. By cultivating talents and promoting all round personality development through multi-dimensional education a spirit of self-confidence and self-reliance will be infused in the student. The student will be instilled with values of professional ethics and be made ready to contribute to society as responsible individuals.

M. Sc. Microbiology
Programme Specific Outcomes (PSOs)

After completing the two years degree course in M. Sc. Microbiology, the students will be:

PSO1: Able to understand and explain the technical aspects associated with existing microbiological challenges.

PSO2: Able to explain about various applications of Microbiology such as Environmental Microbiology, Industrial Microbiology, Food Microbiology, and Clinical Microbiology.

PSO3: Able to design and execute experiments related to Basic Microbiology, Immunology, Molecular Biology, Recombinant DNA Technology, and Microbial Genetics.

PSO4: Able to execute a short research project incorporating techniques of Basic and Advanced Microbiology

PSO5: Equipped to take up a suitable position in academia or industry.

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: First (I)**
Core Paper (Compulsory)	**Course Code: B080701T**	**BACTERIOLOGY**
Marks: 100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		

Course Objectives	The primary objective of the course is to build a strong foundation in the area of bacterial cell structure, division, survival and propagation
Course Learning Outcomes	Upon successful completion of the course, the student:
CO1	Will be able to describe the morphological features, cell arrangement and structural components of bacterial cell in detail; will be able to differentiate between Gram-positive and Gram-negative bacteria.
CO2	Will have gained knowledge about cell wall structure and extracellular appendages in different bacteria and is acquainted with current methodologies available for production of protoplasts, sphaeroplasts and L-forms.
CO3	Will have gathered detailed information regarding bacterial cell division and endospore formation. Can enlist the salient features of the genome organization of *E. coli.*
CO4	Can enlist the characteristics of archaea that differentiate it from eubacteria, and will have learnt key features of some model archaeal organisms.
CO5	Can understand the basic concept of bacterial systematics and prokaryotic species. Develop an understanding of phenetic and phylogenetic classification with polyphasic approach of taxonomy

Contents		Duration: 60 hours
UNIT I	Bacterial cell structure and appendages: Overview of eubacterial cell organization: nucleoid, ribosomes, intracytoplasmic membranes and cell inclusions. Detailed account of biogenesis and function of various cell structure appendages: flagella- structure, assembly and mechanism of movement; pili and fimbriae- types, structure and their role. External cell surface structures: capsule, glycocalyx, slime layer and S-layer.	12 Hours
UNIT II	Bacterial cell wall and cell membrane: Overview of gram negative and gram positive bacterial cell wall, outer membrane lipopolysaccharide (LPS). Detailed account of cell wall synthesis and its inhibitors including different antibiotics.	12 Hours
UNIT III	Bacterial cell division and reproduction: Genome organization of E.coli, Binary fission and other forms of reproduction in bacteria, bacterial cell cycle, assembly, maintenance and disassembly of Z ring, endospore structure and stages involved in endospore development in Bacillus subtilis.	12 Hours
UNIT IV	Archaebacteria and Extremophiles: Introduction to extremophiles like-hyperthermophiles, psychrophiles, halophiles, acidophiles, methnogenic extremophiles etc. Adaptation mechanisms of extremophiles, Importance of extremophilic microbial diversity in environment, pharmaceuticals & human health and industry, General characteristics of archaeal cell structure and comparison with eubacteria.	12 Hours
UNIT V	Bacterial Systematics: Identification and classification of bacteria based on classical and modern approach, Numerical Taxonomy; 16s rRNA	12 Hours

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	Analysis, Polyphasic Taxonomy, FAME Analysis, Prokaryotic Species Concept, Phylogenetic trees. General features of Archaea, Actinomycetes, Cyanobacteria, Mollicutes, *Rickettsia* and *Chalamydia*.	
Suggested Readings	1. Prescott's Microbiology by J. Willey, L. Sherwood, C. J. Woolverton. 10th edition. McGraw Hill Education. 2017. 2. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018. 3. Alcamo's Fundamentals of Microbiology by J. C. Pommerville. 10th Edition. Jones and Bartlett Learning. 2013. 4. Archaea Molecular and Cellular Biology by Ricardo Cavicchioli. American Society of Microbiology. 2007. 5. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond, C. Fuqua. 4th Edition. Oxford University Press. 2011.	

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: First (I)**
Core Paper (Compulsory)	**Course Code: B080702T**	**BACTERIOLOGICAL TECHNIQUES**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		

Course Objectives	The primary objective of the course is to build a basic foundation in the area of bacteriological techniques used for isolation and cultivation of bacteria.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will understand the basic concepts of various microbiological techniques and their applications.	
CO2	Will be able to understand the basic principles of sterilization. It will also develop an understanding about selection of suitable method for sterilization and disinfection	
CO3	Will learn the features of bacterial growth and phases of bacterial growth with various factors affecting growth.	
CO4	Will understand learn various conventional and non-conventional techniques of isolation and cultivation of bacteria. He/she will also be able to understand the techniques for isolation of unculturables.	
CO5	Will learn various techniques for short term and long term storage of microorganisms. Contents	
Contents		Duration: 60 hours
UNIT I	Microscopy: Basics of microscopy: image formation, magnification, resolution, Biological applications and instrumentation of various kinds of microscopy: Optical Microscopy, Fluorescence, Confocal and Electron Microscopy. Stains, dyes and staining techniques	12 Hours
UNIT II	Methods of Disinfection and Sterilization: Chemical Disinfection by Alcohols, Formaldehyde Phenolic Compounds, Quaternary Ammonium Compounds, Chlorine, Iodophors and Heavy Metals; Sterilization by Moist Heat, Dry Heat, Mathematical modeling of sterilization processes, Arrhenius equation, Del factor, effect of sterilization on media quality and yield coefficients, batch and continuous sterilization, Sterilization Gases (Ethylene Oxide, Formaldehyde, Hydrogen Peroxide, Chlorine Dioxide) and Filtration. filter and steam sterilization at industrial scale	12 Hours
UNIT III	Bacterial Growth: Definition of growth, mathematical expression of growth, growth curve, measurement of growth and growth yield, synchronous culture, Introduction of continuous culture; Factors affecting growth.	12 Hours
UNIT IV	Techniques for Isolation and Cultivation: Techniques for Isolation of Aerobic and Anaerobic Bacteria; Micromanipulation techniques and Laser micromanipulation systems (Optical tweezers and Laser microdissection); Cultivation of bacteria and fungi, Approaches for the cultivation of Unculturables, Types of media. Techniques for isolation and cultivation of Viruses and Fungi	12 Hours

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UNIT V	Preservation and Maintenance of Microorganisms: Short-Term Preservation Methods- Subculturing, Immersing in Oil, Ordinary Freezing, Deep Freezing, Drying; Long-Term Preservation Methods- Freeze-Drying (Lyophilization and Ultrafreezing; Preservation of Representative Genera And Specific Groups- Anaerobes, Cyanobacteria, Methanogens, Plasmid-Containing Bacteria and Spore formers. Culture Collections and their Functions.	12 Hours
Suggested Readings	1. Prescott's Microbiology by J. Willey, L. Sherwood, C. J. Woolverton. 10th edition.McGraw Hill Education. 2017. 2. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D.Stahl. 15th Edition. Pearson Education. 2018. 3. Alcamo's Fundamentals of Microbiology by J. C. Pommerville. 10th Edition. Jones andBartlett Learning. 2013. 4. Archaea Molecular and Cellular Biology by Ricardo Cavicchioli. American Society ofMicrobiology. 2007. 5. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond, C. Fuqua.4th Edition. Oxford University Press. 2011.	

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: First (I)**
Core Paper (Compulsory)	**Course Code: B080703T**	**BIOCHEMISTRY & CELL BIOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The primary objective of the course is to build a basic understanding about various biomolecules and Cell Biology. The course has been developed to understand the basic structure composition and functional aspects of the cell.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will learn about structure and functions of proteins and lipids. Develop a t basic concept of protein folding and sequencing	
CO2	Will learn about structure, functions and classification of carbohydrates and Nucleic acids.	
CO3	Will learn how individual proteins bind to specific substrates and other molecules to mediate catalysis.	
CO4	Will understand the basic structure composition and functional aspects of the cell.	
CO5	Will understand the basic concepts of cell to cell communication, cell cycle, programmed cell death and mechanisms of development of cancer.	
Contents		Duration: 60 hours
UNIT I	Structures of Proteins- Primary; secondary (Ramachandran plot); tertiary and quaternary structure; Protein folding and methods of protein sequencing. Lipids: Classification, structure, properties and function of fatty acids	12 Hours
UNIT II	Carbohydrates: Structure, Classification and general properties of Carbohydrates. Complex carbohydrates, mucopolysaccharides, amino sugars and glycoproteins. Nucleic Acids; Structure and function of nucleotides, RNA and 3D structure of tRNA, DNA topology; A, B and Z DNA. satellite DNA.	12 Hours
UNIT III	Classification, structure and function of Enzymes, coenzymes, cofactors and prosthetics groups. Enzyme kinetics: Mechanism of action- Competitive, Uncompetitive, Non-competitive and Mixed inhibition, Allosteric and Regulatory enzymes.	12 Hours
UNIT IV	Organization of Eukaryotic Cell: Structure and function of Nucleus, mitochondria, chloroplast, mechanism of Protein segregation, Cell interaction: Cell-cell adhesion, cytoskeleton.	12 Hours
UNIT V	Cell signalling and cell differentiation, Cell cycle and its control, Apoptosis, Characteristics of cancer cells, Mechanism of Carcinogenesis, Agents promoting carcinogenesis.	12 Hours
Suggested Readings:	1. Principles of Biochemistry (5th Edition) – Lehninger, Nelson and Cox. Pub Macmillan 2. Harper's Illustrated Biochemistry, (28th Edition) – R.K. Murray, D.K. Garner, P.A. Mayers and V.W. Rockwell, Pub: McGraw Hill International Edition. 3. Biochemistry (3rd Edition) – G. Zubay., Pub: Wm. C. Brown Pub. 4. Biochemistry (5th Edition) – Lubert Stryer. Pub: W.H. Freeman and Com., NY.	

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	5. Biochemistry – (2nd edition) D. Voet and J.G. VoetPub: John Willy and Son 6. Molecular biology of the cell, (4th Edition) – Bruce Albert, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter, Pub: G.S. Garland science Taylor and Francis Group New York – NY 10001- 7. Molecular Cell Biology, (5th Edition) H. Lodish, A. Berk P. Matsudaira Chris A.Kaiser, M.Krieger. M. P. Scott, L. Zipursky, J. Darnell. Pub: W.H. Freeman and Com., NY. 8. Cell and Molecular Biology: Concepts and Experiments:Gerald Karp, VIthEds

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: First (I)**
Core Paper (Compulsory)	**Course Code: B080704T**	**MOLECULAR BIOLOGY & MICROBIAL GENETICS**
Marks:100	**75 (UE) + 25 (CIE)**	Credits: 04

Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The primary objective of this course is to develop an understanding of structure of gene its multiplication, expression and regulation in prokaryotic and eukaryotic microbial systems	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will learn about mechanism of Conjugation and bacterial gene mapping	
CO2	Will learn about mechanism of transformation and transduction.	
CO3	Will learn how the DNA replicates in Prokaryotic and eukaryotic cell along with the mechanism of DNA repair. Will also learn about concepts of CRISPR-Cas systems	
CO4	Will understand the basic concepts of transformation and transduction along with the mechanisms of post transcriptional RNA processing.	
CO5	Will understand the mechanism of gene regulation and learn about transposable genetic elements	
Contents:		Duration: 60 hours
UNIT I	Mechanism of Conjugation, discovery, formation of Hfr and F' and their role in recombination, concept of transferosomes, bacterial gene mapping.	12 Hours
UNIT II	Transformation: discovery, mechanism of transformation in Gram positive and Gram-negative bacteria., Transduction- discovery, generalized and specialized recombination, regulation of lytic and lysogenic cycle	12 Hours
UNIT III	Replication of genetic material in prokaryotes and eukaryotes, DNA repair and recombination, DNA mismatch repair, Double Strand Break repair, recombination as a molecular biology tool, CRISPR-Cas systems for editing, regulating and targeting genomes.	12 Hours
UNIT IV	Mechanism of transcription in prokaryotes and eukaryotes, transcription factors. RNA polymerases., Translation: In Prokaryotes and Eukaryotes. Post transcriptional RNA processing (mRNA, tRNA and rRNA).	12 Hours
UNIT V	Regulation of gene expression, Positive and negative control, operon concepts – *lac*- and *trp*-operon, attenuation. An overview of regulation of gene expression in prokaryotes and eukaryotes, *cis* acting sites and *trans*acting molecules. Transposable genetic elements.	12 Hours
Suggested Readings	1. Genetics: Analysis and Principles by Robert J. Brooker, IIIrdEds 2. Principles of Genetics by Eldon J. Gardner, 12thEds 3. Modern Genetic Analysis: Integrating Genes and Genomes by Anthony J.F. Griffiths 7th 4. Gene by Benjamin Lewin, IXthEds,Oxford Univ. Press, U.K.. 5. Molecular Biology of gene by Watson, 12th Eds 6. Genetics Strickberger 13thEds Cell and Molecular Biology (8th Edition) – DeRobertis and DeRoberties, B.I. Pub.	

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	Publishers Pvt Ltd. N. Delhi

Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: First (I)**
Minor Elective (Optional)	Course Code: **to be provided by other faculty**	MINOR (OTHER FACULTY)
Marks:100	**75 (UE) + 25 (CIE)**	Credits: 04
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
		Duration: 60 hours

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: First (I)**
Core Paper (Compulsory)	**Course Code: B080705P**	**Practical I**
Marks:100 75 (UE) + 25 (CIE)	**Credits: 04**	**Duration: 120 hours**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 0-0-8		
Course Objectives	The major objective of the course is to impart hands-on training in basic microbiological and biochemical techniques. Students will be trained in basic bacterial culturing and identification methods, as well as working in biosafety cabinet. Student will become familiar with sterilization techniques when handling bacterial cells. Student will be trained in basic assays and be taught to present the results both, qualitatively and quantitatively.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1:	Will be able to use different sterilization procedures and learn handling of micropipette.	
CO2:	Will be able to work in Biosafety Cabinet.	
CO3:	Will be versed with identification and classification of given bacterial isolate by performing variety of cultural and biochemical tests.	
CO4:	Can determine pI of amino acids by titration method	
CO5:	Can determine concentration of sugar and protein in a given sample after drawing a standard curve.	

Contents:

1. To train students in handling, upkeep and calibration of micropipette for measuring small volumes
2. To give hands-on training in sterilization techniques and their application in microbiology lab
3. To train student in working with a biosafety cabinet in a BSL2 lab
4. To purify and identify the given bacterial sample by determining their:- Colony morphology, staining characteristics and biochemical characteristics
5. To analyze the given 16srRNA sequences by using BLAST and construct a phylogenetic tree based on the comparison results.
6. To draw the titration curve of amino acid and determine its pI.
7. To prepare standard curve of BSA and determine the concentration of unknown protein sample using Bradford / Lowry method using regression equation.
8. Quantitative estimation of carbohydrate (anthrone/phenol-H_2SO_4/Dinitrosalisylic acid method).
9. Quantitative estimation of proteins by biuret.
10. Saponification and acid value of fats
11. Estimation of DNA by diphenylamine method
12. Estimation of RNA by orcinol method
13. To prepare standard curve of ammonia and determine its uptake by bacterial cells with respect to time and temperature
14. To determine the specific growth rate of *E. coli* in different media.
15. Staining techniques for bacterial cells: simple, differential, negative, specialized
16. Measurement of growth and preparation of growth curve
17. To study glucose uptake by *E. coli*.
18. Effect of temperature, pH, salt concentration, antibiotics on growth.
19. Calculation of generation time and specific growth rate.
20. Microscopic measurements (micrometry)

Suggested Readings:	1. Microbiology: A laboratory manual by JG Cappucino, C.T. Welsh. 11th edition. Pearson. 2017. 2. Biochemistry Lab Manual by D.A. Thompson. 3rd edition. Create Space

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	Independent Publishing Platform. 2013. 3. Biochemical calculations: how to solve mathematical problems in general biochemistry by Irwin H. Segel, Wiley, 2nd Edition 2004 4. Practical Biochemistry (3rd Edition) – David Plummer. Pub: Tata McGraw Hill 5. Practical Biochemistry (5th Edition) – K. Wilson and J. Walker. Pub: Cambridge Univ. Press, (U.K.)

Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: First (I)**
Core Paper (Compulsory)	**Course Code: B080706R**	**Industrial Training /Surveys/Research Project I**
Marks:100	**Credits: 04**	
Course Details	This research project can be interdisciplinary / multi-disciplinary. This research project can also be in the form of industrial training / internship / survey work etc.	
	*** Students will submit the final report (project report/dissertation) of the research project carried out in both the semesters at the end of the year, which will be assessed jointly by the supervisor and the external examiner nominated by the university at the end of the year out of 100* marks**	

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: Second (II)**
Core Paper (Compulsory)	**Course Code: B080801T**	**VIROLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives:	The course will facilitate in understanding of molecular virology by examining common processes and principles in viruses to illustrate viral complexity, to understand viral reproduction. The course will teach the strategies by which viruses spread within a host, and are maintained within populations. It covers the molecular biology of viral reproduction and addresses the interplay between viruses and their host organisms	
Course Learning Outcomes:	Upon successful completion of the course, the student	
CO1	Is able to describe classification of viruses	
CO2	Is able to describe tools for studying virus structure, process of virus attachment and entry, virus assembly and release	
CO3	Is able to describe steps in replication of genome of RNA viruses, retroviruses, and DNA viruses	
CO4	Is able to describe steps in virus infection, transmission, patterns of infection, virus virulence, and host defense against virus infection	
CO5	Is able to describe methods of making virus vaccines and anti-viral drugs, drivers of virus evolution, and emerging viruses	
Contents:		Duration: 60 hours
UNIT I	Introduction to Virology: The big picture of all viruses using a common strategy, virus classification, the infectious cycle, studying virus infection. Koch's Postulates for viruses, virus genome types, double stranded DNA (dsDNA),gapped DNA genomes, single-stranded (ssDNA) genomes, double stranded RNA (dsRNA), single stranded RNA (ssRNA), (+) strand RNA, single stranded (+) sense RNA with DNA intermediate, single stranded RNA (-) sense, ambisense RNA genomes.	12 Hours
UNIT II	Virus Structure and Assembly: Metastability, the tools for viral structural biology. Helical symmetry, Icosahedal symmetry, Triangulation number, Quasi-equivalence. Virus attachment and entry, Initiation of infection, Cellular receptor for viruses. Getting into the nucleus, virus disassembly, metastable structures, concentrating components for assembly, getting things to the right place. How do viruses make sub-assemblies, sequential and concerted assembly. Packaging signals, packaging of segmented genome, acquisition of an envelope, budding strategies.	12 Hours
UNIT III	RNA directed RNA synthesis, Reverse Transcription and Integration, Translation, and genome replication of DNA viruses: Identification of RNA polymerase, how RNA synthesis occurs in viruses? Reverse transcriptase, retrovirus genome organization, steps of DNA	12 Hours

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	synthesis in retroviruses. Regulation of translation in virus infected cells. Basic rules of genome replication in DNA viruses, viral origins of DNA replication. Generic steps in transcription, host polymerases, initiation, splicing, alternate splicing, promoter structure, steps in regulation of transcription, enhancers, virus coded transcriptional regulators, transcriptional cascade, export.	
UNIT IV	Virus Infections basics, interaction with host, acute and persistent infections: Fundamental questions of viral pathogenesis. Virion defenses to hostile environment, viral spread,viremia, determinants of tissue tropism. Virus shedding, transmission of infection, host defense, innate immune response, virus virulence, identifying virulence genes. Toxic viral proteins, cellular virulence genes, immunopathology, systemic inflammatory response syndrome. Immune complexes, virus induced auto-immunity, general pattern of infection. Inapparent acute infections,defense against the acute infection. Influenza, Polio, Measles, Rotavirus, persistent infections, chronic and latent Infections.	12 Hours
UNIT V	Anti-Viral drugs, virus evolution and emerging viruses: Anti-viral drugs, search for anti-viral drugs, the quasi-species concept, error threshold, genetic bottlenecks, Muller ratchet, genetic shift and drift. Theories on origin of virus, evolution of new viruses,emerging viruses.	12 Hours
Suggested Readings	1. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Virusesby S.J. Flint, L.W. Enquist, V.R. Racaniello, A.M. Skalka. 4th edition. ASM Press. 2015. 2. Introduction to Modern Virology by N. Dimmock, A. Easton, K. Leppard. 7th edition.Blackwell Publishing. 2016. 3. Basic Virology by Edward K. Wanger, M. Hewiett, D. Bloom, D. Camerini. 3rd edition.Blackwell Publishing. 2007. Principles of Molecular Virology by A.J. Cann. 6th edition. Elsevier Academic Press. 2015. e protein-only hypothesis.	

Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: Second (II)**
Core Paper (Compulsory)	**Course Code: B080802T**	**IMMUNOLOGY & IMMUNOTECHNOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	Credits: 04
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The objective of this course is to understand the various components of the host immune system, their structure and organization, and functions to serve as the defense system of the body. It would also make the students understand the operational mechanisms which underlie the host defense system, allergy and organ transplantation.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will be able to understand the fundamental bases of immune system and immune response.	
CO2	Will be able to gather information about the structure and organization of various components of the immune system and Immunological techniques	
CO3	Will be able to understand the genetic organization of the genes meant for expression ofimmune cell receptors and the bases of the generation of their diversity	
CO4	Will be able to understand the operation and the mechanisms which underlie the immune response	
CO5	Will be able to apply the knowledge gained to understand the phenomena like host defense,hypersensitivity (allergy), organ transplantation and certain immunological diseases	
Contents		Duration: 60 hours
UNIT I	Basic concepts of Immunology – (a) Innate and acquired Immunity (b) concept of humoral and cell mediated Immunity. Organization and structure of lymphoid organs. Cell and the immune system: Memory, specificity, diversity, self- vs non-self-discrimination, B lymphocytes, T lymphocytes, Macrophages, Dendritic cells, NK cells, Eosinophils, Basophils, Neutrophils, Mast cells. Complement system: classical and alternative pathways.	12 Hours
UNIT II	Nature of antigen and antibody: Antigen Vs Immunogen, Superantigen, heptanes, types and structure of antibody – (i) constant and variable region Fab and Fc (ii) Isotype and idiotype. Antigen antibody interactions: detection and estimation of antigen and antibody, primary and secondary reactions, antibody affinity and acidity, equilibrium dialysis, precipitation and agglutination reactions, complement fixation test, RIA, ELISA, immunoblotting, immunofluorescence, biotin-avidin assay.	12 Hours
UNIT III	Generation of diversity in immune response: clonal selection theory, concept of antigen specific receptor, BCR, TCR, the genes encoding antigen: specific receptors on T and B lymphocytes, genetic rearrangements, class switch, comparison of receptor on B and T lymphocytes, mechanism of immune response and generation of immunological diversity	12 Hours
UNIT IV	Central role of MHC genes and products in immune response. T cell	12 Hours

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	recognition of antigen and MHC products, structure of MHC gene complex, polymorphism of MHC genes and products. Graft rejection and GVHD; HLA-matching; Use of CRISPR-Cas for generating transgenic animals for xenotransplantation, Activation of T and B cells by antigen: Antigen processing, antigen presentation on T cells, products and factors released by T cell activation: interleukins, interferons. Cell mediated cytotoxicity, mechanism of T cell and NK cell mediated lysis, ADCC, macrophage cytotoxicity.	
UNIT V	Monoclonal antibody: production, application. Immunodeficiency: T cell, B cell, combined B and T cell deficiencies, defect in phagocytes and complement components, secondary immunodeficiency, AIDS, Autoimmunity. Immunization: active and passive, Vaccines- types and importance, Tumor antigens, immune response to tumors and immunotherapy of tumors	12 Hours
Suggested Readings	1. Kuby Immunology by J.A. Owen, J. Punt , S.A. Stranford. 7th edition. WH Freeman.2013. 2. Cellular and Molecular Immunology by A.K. Abbas, A.H. Lichtman, S. Pillai. 9th edition.Saunders Elsevier. 2018. 3. Janeway's Immunobiology by K. Murphy, W. Casey. 9th edition. Garland Science Publishing.2017. 4. Review of Medical Microbiology and Immunology by W.Levinson. 15thedition.LangePublication. 2018. 5. Fundamental Immunology by W.E. Paul. 7th edition. Lippincott Williams and Wilkins. 2013. 6. Roitt's Essential Immunology by P.J. Delves, S.J. Martin, D.R. Burton, I.M. Roitt. 13thedition. Blackwell Publishing. 2017.	

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: Second (II)**
Core Paper (Compulsory)	**Course Code: B080803T**	**RECOMBINANT DNA TECHNOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The objective of this course is to make the student familiar with the currently used techniques to manipulate/ analyze DNA, RNA and proteins. The student will be made familiar with the methodsused to clone genes, make and screen libraries, and the various applications of the polymerase chain reaction. The student will be taught about the methods currently used to carry out genome- wide analyses and global analyses of transcription and protein expression. The student will be made familiar with how recombinant DNA technology has been exploited in the study of biology as well as in the production of pharmaceutical products.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will be familiar with the use of various cloning vectors and molecular scissors.	
CO2	Will be able to describe artificial transformations and can understand the concept of genomic and cDNA libraries.	
CO3	Will be able to understand the Screening and characterization of cloned DNA.	
CO4	Will have learnt about various types of PCR and their applications.	
CO5	Will be aware of DNA sequencing, RNA Interference with a brief account of proteomics, genomics, transcriptomics and metabolomics.	
Contents		Duration: 60 hours
UNIT I	Host-Vector systems, cloning vectors (plasmids, phages, cosmids, bacterial artificial chromosomes and yeast artificial chromosomes), shuttle vectors, expression vectors, screening and selection methods for recombinants. HACS. Enzymes used for manipulating DNA (restriction endonucleases, methylases, polymerases, ligases, kinases and nucleases).	12 Hours
UNIT II	Preparation of competent cells and their transformation. Isolation of DNA (plasmid, cosmid, phage and genomic DNA) and RNA from prokaryotes and eukaryotes. Construction of genomic and cDNA library.	12 Hours
UNIT III	Restriction mapping and RFLP analysis. Southern, Eastern and Northern Hybridization probe preparation, heterologous and homologous Expression of cloned genes in cultured cells, synthetic oligonucleotides probes. *In situ* hybridization. Antibodies in screening of library.	12 Hours
UNIT IV	PCR and its application. Site directed mutagenesis. DNA: protein interaction: gel mobility shift assay, DNA foot-printing, protein-protein interaction. Principles and method of genetic engineering and gene targeting. Real time PCR.	12 Hours
UNIT V	DNA sequencing: Sanger's Method, Automated sequencing. Application of recombinant DNA technology in agriculture, health	12 Hours

	and industry. RNA Interference. Brief account of proteomics, genomics, transcriptomics and metabolomics.	
Suggested Readings	1. Molecular Biology by D.P. Clarke, N. Pazdernik. 2nd edition. Academic Press. 2012. 2. Molecular Cloning: A laboratory manual by J. Sambrook, D. Russell. 4th edition. ColdSpring Harbor laboratory Press. 2012. 3. DNA Technology: The Awesome Skill by I. Edward Alcamo. Harcourt Academic Press.2001. 4. Molecular Biology of the Gene by J. Watson, T. Baker, S. Bell, A. Gann, M. Levine, R.Losick. 7th edition. Pearson. 2014. 5. Gene Cloning and DNA Analysis: An Introduction by T.A. Brown. 7th edition. Wiley-Blackwell Publishers. 2016.	

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: Second (II)**
Major Elective (Optional)	**Course Code: B080804T**	**INSTRUMENTATION & ANALYTICAL TECHNIQUES**
Marks:100	**75 (UE) + 25 (CIE)**	Credits: 04
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		

Course Objectives	To introduce the student to the variety of biophysical and biochemical techniques currently available to probe the structure and function of the biological macromolecules, make them aware of the physical principles behind each technique and the instrumentation involved, make them familiar with various methods of analyzing the output data, and to build a strong foundation in the area of bacterial cell structure, division, survival and propagation.	
Course Learning Outcomes	Upon successful completion of the course, the student will:	
CO1	Be able to carry out the analysis of the data from CD and Fluorescence experiments to monitor the stability of the protein under different environmental conditions	
CO2	Be able to evaluate the quality and highlights of the structure reported/deposited in journals/structural databases.	
CO3	Be able to design a multi-step purification protocol for a target protein	
CO4	Be able to understand and correctly interpret the migration of protein molecule on PAGE under native and SDS conditions	
CO5	Will be aware of the use of tracer techniques and safety precautions	
Contents:		Duration: 60 hours
UNIT I	Spectroscopy: Biological application and interpretations of Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR)., Absorption spectroscopy, Infrared and Raman spectroscopy, Optical Rotatory Dispersion (ORD), Circular Dichroism (CD)., Basics of X-ray Crystallography.	12 Hours
UNIT II	Basics principles and applications of various chromatography methods: Partition and Absorption chromatography, gel filtration, ion- exchange and affinity chromatography. Biological applications of HPLC.	12 Hours
UNIT III	Basics of centrifugation based methods: viscosity, diffusion, sedimentation equilibrium, dialysis, solvent fractionation, centrifugation, Biological applications and interpretations of Density Gradient methods, Ultracentrifugation methods	12 Hours
UNIT IV	Basics of electrophoresis: electrophoretic mobility and affecting factors, Biological applications and interpretation of different types of electrophoresis: PAGE, gradient gel, Agarose Gel Electrophoresis, 2D Electrophoresis, iso-electricfocusing	12 Hours
UNIT V	Radioactive methods: Basics of radioactive isotopes and radioactive decay, sample preparation, counting, Safety precautions during handling, biological applications.	12 Hours
Suggested	1. Fundamentals of Molecular Spectroscopy by Colin Banwell. 4th edition.	

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Readings:	McGrawHill.1994. 2. Principles of Fluorescence Spectroscopy by J. Lakowicz, R. Joseph. 2nd edition.Springer.1999. 3. Molecular Fluorescence: principles and Applications by B. Valeur. 2nd edition. Wiley.2013. 4. NMR – Conformation of Biological Molecules by G. Govil, R.V. Hosur. 1st edition.Springer- Verlag, 2011. 5. Biomolecular crystallography: Principles, practice and application to structural biology by B. Rupp. 1st edition. Garland Science. 2009. 6. Optical methods in Biology by E.M. Slayter. 1st edition. John Wiley. 1970. 7. NMR of proteins and nucleic Acids by K. Wuthrich. 1st edition. Wiley InterscicencePublications. 1988. Biophysical chemistry, Part 2: Techniques by C. R. Cantor, P. R. Schimmel. 1st edition, W.H Freeman and Co. 2008.

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: Second (II)**
Major Elective (Optional)	**Course Code: B080805T**	**EXTREMOPHILES AND THEIR APPLICATIONS**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**

Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The major objective of this paper is to develop an understanding about mechanisms by which microorganisms adopt to extreme environments and the critical role of extremophiles in the evolution related to the origin of life. The students will also learn about the application of extremophiles in the industrial processes that has opened a new era in the biotechnology. The study of extreme environment will develop an understanding for astrobiology that will help to understand what form life takes on another planetary bodies in our own solar system and beyond.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will be introduced to extremophiles and will understand the critical role of extremophiles in the evolution related to the origin of life.	
CO2	Will develop an understanding about mechanisms by which thermophiles and psychrophiles adopt to extreme environments.	
CO3	Will develop an understanding about mechanisms by which Halophiles Acidophiles and Alkaliphiles: adopt to extreme environments.	
CO4	Will learn about the application of extremophiles in the industrial processes.	
CO5	Will help to understand what form life takes on another planetary bodies in our own solar system and beyond.	
Contents		Duration: 60 hours
UNIT I	Introduction to Extremophiles and Origin of Life; Isolation, classification and general properties of extremophiles like thermophiles, hyperthermophiles, psychrophiles, halophiles, acidophiles, alksliphiles and polyxtremophiles, Natural habitats of extremophiles.	12 Hours
UNIT II	Thermophiles: Microbial Life at high temperature- the challenges & strategies of survival: Membrane Adaptations of (Hyper)Thermophiles to High Temperatures, Temperature-Dependent Molecular Adaptations, The Physiological Role, Biosynthesis, and Mode of Action of Compatible Solutes from (Hyper); Psychrophiles Mechanism of bacterial adaptation to low temperature, Membrane Adaptations, Cold-Adapted, The Cold-Shock Response, Perception and Transduction of Low Temperature in Bacteria	12 Hours
UNIT III	Halophiles: Biodiversity in Highly Saline, Response to Osmotic Stress in a Haloarchaeal Genome: a Role for General Stress Proteins and Global Regulatory Mechanisms; Acidophiles Aciduric Proteobacteria, Physiology and Ecology of Acidophilic Microorganisms; Alkaliphiles: Bioenergetic Adaptations that Support Alkaliphily.	12 Hours
UNIT IV	Piezophiles-Microbial Adaptation to High Pressure; Radiophiles: Radiation-resistant extremophiles and their potential in biotechnology and therapeutics; Exobiology: Astrobiology and the Search for Life in the Universe	12 Hours
UNIT V	Extremophiles as a source of novel enzymes for industrial application,	12 Hours

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	Versatile applications of natural compounds from extremophiles, Polysaccharides from extremophilic microorganisms. Importance of extremophilic microbial diversity in environment, pharmaceuticals & human health,	
Suggested Readings	1. Extremophiles: From Biology to Biotechnology, Edited by- Ravi Durvasula and D. V. Subba Rao, CRC Press, Taylor & Francis Group, ISBN 9781498774925 2. Physiology and biochemistry of extremophiles / Edited by C. Gerday and N. Glansdorff, ASM Press, American Society for Microbiology, ISBN-10: 1-55581-422-0	

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: Second (II)**
Core Paper (Compulsory)	**Course Code: B080806P**	**Practical II**
Marks:100 75 (UE) + 25 (CIE)	**Credits: 04**	**Duration: 120 hours**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 0-0-8		
Course Objectives	The course will enable students to learn basic techniques used in separation and analysis of biomolecules. The students will also explore the immunological techniques along with some molecular biology techniques.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1:	Will be able to use chromatographic and centrifugation procedures.	
CO2:	Will be able to use electrophoretic techniques.	
CO3:	Will be aware of various immunological techniques	
CO4:	Will be able to make and transform desired plasmid DNA into bacterial cells along with the other techniques used in cloning and rDNA technology.	
CO5:	Will be able to isolate Bacteriophages	

Contents:

1. Paper chromatography – Separation of pigments, amino acids
2. Separation of amino acids by Thin layer chromatography
3. Column chromatography
4. Agarose gel electrophoresis for separation of DNA
5. SDS-PAGE for separation of Proteins
6. Double immune diffusion
7. Determination of Blood group
8. Isolation of Macrophages
9. Determination of hypersensitivity
10. Immunobloting
11. Raising of Ab in mice/rabbit.
12. ELISA
13. Isolation and quantification of plasmid DNA, genomic DNA and RNA of *E. Coli*
14. Competent cells preparation of *E. coli*
15. Transformation and selection of transformant of *E. coli* cells using antibiotics and X gal selection
16. Unit determination of restriction enzyme activity
17. Restriction digestion of DNA and gene cloning
18. Demonstration of PCR
19. Isolation of Bacteriophages

Suggested Readings:	1. Microbiology: A laboratory manual by JG Cappucino, C.T. Welsh. 11th edition. Pearson. 2017. 2. Molecular Cloning: A laboratory manual by Joseph Sambrook, David Russell, 4th edition. Cold Spring Harbor laboratory Press. 2012.

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Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: First (1)**	**Semester: Second (I)**
Core Paper (Compulsory)	**Course Code: B080807R**	**Industrial Training /Surveys/Research Project II**
Marks:100	**Credits: 04**	
Course Details	This research project can be interdisciplinary / multi-disciplinary. This research project can also be in the form of industrial training / internship / survey work etc.	
	*** Students will submit the final report (project report/dissertation) of the research project carried out in both the semesters at the end of the year, which will be assessed jointly by the supervisor and the external examiner nominated by the university at the end of the year out of 100* marks**	

Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Third (III)**
Core Paper (Compulsory)	**Course Code: B080901T**	**MICROBIAL PHYSIOLOGY AND METABOLISM**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		

Course Objectives	The major objective of this paper is to develop clear understanding of various aspects of microbial physiology along with diverse metabolic pathways existing in bacteria in relation to its survival and propagation, and to enable students to better understand courses taught later such as MicrobialPathogenicity and biotechnology-based courses.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will be acquainted with methods of measuring microbial growth, calculating growth kineticparameters with understanding of steady state and continuous growth.	
CO2	Will have gained an in-depth knowledge of phototrophic and chemotrophic bacteria.	
CO3	Will have learnt central metabolic pathways for carbon metabolism in bacteria enlisting differences with eukaryotic systems and their regulation in diverse physiological conditions. This allows students to apply the acquired knowledge in engineering metabolic pathways fordeveloping industrially useful strains.	
CO4	Will have gathered understanding of inorganic and organic nitrogen assimilation and its regulation. Also knows role of glutathione in cellular redox regulation and biochemistry of glutamate overproducing strains.	
CO5	Will understand details of lipid and nucleotide metabolism in E. coli and its regulation along with biochemical basis of lipid accumulation in yeasts.	
Contents		Duration: 60 hours
UNIT I	Solute Transport: Introduction, primary and secondary transport, kinetics. Membrane transport proteins: porins and aquaporins, mechanosensitive channels, ABC transporter, group translocation PEP-PTS system. Catabolite repression, inducer exclusion and expulsion	12 Hours
UNIT II	Photosynthesis in green and purple bacteria, structural and functional properties of pigment, oxygenic and anoxygenic photosynthesis, photosystems, photodynamic death and photophosphorylation. cyanobacterial photosynthesis, photorespiration Chemolithotrophy, hydrogen-, iron- and sulfur, bacteria, methanogens and methylotrophs.	12 Hours
UNIT III	Central Metabolic Pathways and Regulation: Glycolysis and its regulation, Gluconeogenesis, Pentose-Phosphate Pathway, Entner-Doudoroff Pathway, Citric Acid Cycle, alternate TCA, Glyoxylate Pathway and its regulation. Examples of pathway engineering of carbon metabolic pathways to develop industrial useful strains: Co-metabolism of pentoses and hexoses, Succinic and citric acid production.	12 Hours
UNIT IV	Biochemistry of nitrogenase complex, nitrogenase types and function *nif* gene and genetic regulation of nitrogenase, symbiotic nitrogen fixation, regulation of nitrogenase by oxygen and combined N-sources, protection of nitrogenase against oxygen, nitrate reduction (assimilatory and	12 Hours

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	dissimilatory) and sulfate reduction, methanogenesis and acetogenesis. Hydrocarbon transformation	
UNIT V	Metabolism of lipids and nucleotides: Biosynthesis and degradation of lipids and its regulation in *E. coli*, lipid accumulation in yeast. Purine and pyrimidine biosynthesis, deoxyribonucleotide synthesis, regulation of purine and pyrimidine biosynthesis, inhibitors of nucleotide biosynthesis.	12 Hours
Suggested Readings	1. Biochemistry by Geoffrey L. Zubay. 4th Edition. Brown Co, USA. 1999. 2. Microbial Physiology by A.G. Moat, J. W. Foster, M. P. Spector. 3rd Edition. John Wiley& Sons. 2002 3. Lehninger Principles of Biochemistry by D. L. Nelson, M. M. Cox. 6th Edition. W. H.Freeman. 2012 4. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond, C. Fuqua.4th Edition. Oxford University Press. 2011. 5. Microbial Biochemistry by G. N. Cohen. 2nd Edition. Springer. 2014. 6. Lippincott's Illustrated Reviews: Biochemistry edited by D. R. Ferrier. 6th Edition.Lippincott Williams & Wilkins. 2013 7. Biochemical Calculations: by Irwin H. Segel. 2nd Edition. Wiley. 2004. 8. Understanding Enzymes by T. Palmer, E.Horwood. 3rd Edition. Wiley. 1991.	

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Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Third (III)**
Core Paper (Compulsory)	**Course Code: B080902T**	**INDUSTRIAL MICROBIOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		

Course Objectives	The course will enable students to apply the learning of microbiology concepts toward theexploitation of microbial population for industrial and human benefits. The strategies for development of microbial strains, process optimization, large scale production and product recovery will be covered for industrially relevant microbial products and therapeutic proteins. Acquires knowledge about the use of microbes as biosensors & biochips.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will understands the biochemical and industrial concepts of fermentation along with the various types of fermentation systems used in the fermentation technology.	
CO2	Will attain knowledge about designing of industrial strains and various media optimizationstrategies. Develop an understanding about design and use of various types of fermenters.	
CO3	Will acquire knowledge about various food products by the application of microrganisms.	
CO4	Will acquire knowledge about various pharmaceutical products by the application of microrganisms.	
CO5	Will understand the production of commercial products by recombinant microorganisms	
Contents		Duration: 60 hours
UNIT I	UNIT I: Introduction to the fermentation; Introduction to bioreactor: Ideal bioreactor, Reactor with non-ideal mixing. Multiphase bioreactors, animal and plant cell reactor technology.	12 Hours
UNIT II	UNIT II: Screening for new metabolites - primary and secondary metabolites. Strain development through selection, mutation, recombination and other genetic and biochemical methods. Substrates for fermentations- types and availability.	12 Hours
UNIT III	Introduction to immobilization technology for enzymes and cells, Production of alcohol (ethanol), Organic acid (citric acid. lactic acid), amino acid (lysine, glutamic acid), nucleotides and related compounds.	12 Hours
UNIT IV	Production of enzymes (protease, amylase, lipase), Production of microbial food, single cell protein and mushroom. Production of antibiotics (streptomycin, tetracycline, penicillin, ampicillin), hormones, vitamins, steroids and alkaloids.	12 Hours
UNIT V	Synthesis of commercial products by recombinant microorganisms: restriction endonucleases, biopolymers, human insulin, growth hormones, interferon and vaccines. Microorganisms in biotransformation of antibiotics and steroids; Microorganisms as biosensors & biochips	12 Hours
Suggested Readings	1. Principles of Fermentation Technology by P. Stanbury, A. Whitaker, S. Hall. 3rd edition.Butterworth-Heinemann. 2016. 2. Bioprocess Engineering: Basic Concepts by M. L. Shuler, F. Kargi, 2nd edition. PearsonEducation India. 2015. 3. Modern Industrial Microbiology & Biotechnology by N. Okafor. 1st	

	edition. CRC Press,USA. 2007. 4. Fermentation Microbiology and Biotechnology edited by E.M.T. El-Mansi, C.F. Bryce, A.L. Demain, A.R. Allman. 3rd edition. CRC Press. 2012. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer, H.Nikaido. 2nd edition. Cambridge University Press. 2007.

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Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Third (III)**
Core Paper (Compulsory)	**Course Code: B080903T**	**ENVIRONMENTAL MICROBIOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		

Course Objectives	The major objective of this paper is to impart knowledge about structure, composition andfunctioning of microbial communities of diverse environment. The use of microbial population in agriculture, mineral recovery, management of various types of pollutants and conversion processes of various types of wastes into value added products will be discussed.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will have an overview of the till date developments in the field of environmental microbiology with special emphasis on the role of microbes in mitigating environment pollution.	
CO2	Will have become acquainted with various cultural, biochemical and molecular techniques used in understanding microbial diversity.	
CO3	Will be able to describe the role of soil microbes in nutrient transformation, plant-microbe interactions and biotechnology. Also knows about potability of water and its quality control.	
CO4	Is able to describe the role of microbes in solid and liquid waste management, gaining knowledge of various methods employed in sewage treatment and solid waste treatment.	
CO5	Understands the role of microbes in bioremediation of environmental pollutants like petroleum hydrocarbons, pesticides, plastic and electronic waste; also understands utility of microbes in mineral and oil recovery.	
Contents		Duration: 60 hours
UNIT I	Development in field of environmental microbiology: Development of microbial ecology and emergence of field of environmental microbiology, significant applications of microbes in solving environmental pollution problems	12 Hours
UNIT II	Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment: Understanding microbial diversity in the environment by culture-dependent and culture-independent approaches, Analysis by FAME, measuring metabolic capabilities using BIOLOG, G+C analysis, slot-blot hybridization of community DNA, and fluorescent *in situ* hybridization of intact cells, metagenomic analysis of solid and aquatic sediments	12 Hours
UNIT III	Soil and water microbiology: Importance of soil microorganisms, nutrient transformation processes, plant-microbe symbiosis, microbial antagonism, biofilms and their biotechnological applications, drinking water microbiology and quality control.	12 Hours
UNIT IV	Liquid and solid waste management: Treatment of sewage (primary, secondary and tertiary treatments), treatment of industrial effluents (distillery, textile, pulp and paper), methodsto detect various pollutants (metals, sediments, toxin and organic matters). Solid waste types, composting, landfill development, incineration methods, composting and sustainable agriculture, biogas production, plastic degrading	12 Hours

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	microorganisms as a tool for bioremediation, challenges in waste management.	
UNIT V	Lignocellulolytic microorganisms, enzymes and their biotechnological applications in: biopulping, biobleaching, textiles biofuels, animal feed production. Bioremediation of environmental pollutants: Petroleum hydrocarbons and pesticides,use of biosensors for their detection. Microbial enhanced oil recovery, bioleaching of copper, goldand uranium, electronic waste management.	12 Hours
Suggested Readings	1. Microbial Ecology by R.M. Atlas, R. Bartha. 3rd edition. Benjamin Cummings Publishing Co, USA. 1993. 2. Environmental Microbiology by A.H. Varnam, M.G. Evans. Manson Publishing Ltd.2000. 3. Manual of Environmental Microbiology edited by C.J. Hurst, R.L. Crawford, J.L. Garland, D.A. Lipson, A. L. Mills, L.D. Stetzenbach. 3rd edition. Blackwell Publishing. 2007. 4. Environmental Microbiology edited by R. Mitchell, J-D Gu. 2nd edition. Wiley-Blackwell.2009. 5. Environmental Microbiology by R. Maier, I. Pepper, C. Gerba. 2nd edition. AcademicPress. 2009. 6. Environmental Microbiology: Principles and Applications by P.K. Jjemba, SciencePublishing Inc. 2004. 7. Lignocellulose Biotechnology: Future Prospects by R.C. Kuhad, A. Singh. I.K.International. 2007. 8. Environmental Microbiology of Aquatic & Waste systems by N. Okafor. 1stedition,Springer, New York. 2011.	

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Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Third (III)**
Major Elective (Optional)	**Course Code: B080904T**	**BIOSTATISTICS AND BIOINFORMATICS**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The course will introduce the student to the variety of computational methods currently available for predicting functional behavior of biological systems. The algorithms behind each method and the shortcomings in present methods will be discussed. Students should be able to analyze the output data to predict a biologically relevant function.	
Section A: Biostatistics		
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will understand various methods of collection and representation of biological data.	
CO2	Will be able to understand the concepts of statistical population and samples and will become aware of Measures of Central tendencies and Dispersion.	
CO3	Will learn about sample size calculation and distribution. He/ She will also learn about principles of probability.	
CO4	Will be able to understand the concepts of correlation and regression.	
CO5	Will learn about basic idea of significance,	
Contents:		Duration: 30 hours
UNIT I	Scope of biostatistics, variables in biology. Collection, classification, tabulation and diagrammatic presentation of statistical data.	06 hours
UNIT II	Concepts of statistical population and samples. Measures of Central tendencies and Dispersion.	06 hours
UNIT III	Sample size calculation. Simple measure of Skewness and Kurtosis Probability: definition, simple theorems of probability and simple application of probability. Binomial and Poisson distributions.	06 hours
UNIT IV	Correlation, correlation coefficient, standard error of estimate and regression. Linear regressions, least square method of fitting.	06 hours
UNIT V	Testing level of significance, random variations. Statistical analysis test e.g. Chi square test, students 't' test.	06 hours
Section B: Bioinformatics		
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will be able to gain elementary knowledge of computers	
CO2	Will be able to access and derive information from various primary and secondary databases	
CO3	Will be able to create and usefully interpret the results of a multiple sequence alignment.	
CO4	Can create and correctly interpret phylogenetic trees to gain insight into evolutionary pathof the target molecule	
CO5	Will be able to use various protein databases and will learn about primer designing	
Contents		Duration: 30 hours
UNIT I	Elementary ideas of applications of common spreadsheet, word processing, graphics, DOS and Windows based software packages, MS	06 hours

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	office.	
UNIT II	Biological Databases: Introduction. Types of databases in terms of biological information content. Protein and gene information resources. Different formats of molecular biology data.	06 hours
UNIT III	Molecular Phylogenetics: Sequence Alignment: Methods and algorithms of pairwise and multiple sequence alignment. Global and local alignment. Alignment scoring matrices. Database similarity searching.	06 hours
UNIT IV	Methods and tools for phylogenetic analysis. Creation evaluation and interpretation of evolutionary trees. Advantages and disadvantages of phenetic and cladistic approaches.	06 hours
UNIT V	Protein database: Retrival of protein sequence from PDB, Primer designing.	06 hours
Suggested Readings	1. Introduction to Computational Biology: An Evolutionary Approach by Haubold, Wiele. 1st edition. Springer International. 2006. 2. Introduction to Bioinformatics by A. Lesk. 3rd edition. OUP India. 2009. 3. Statistical methods in Bioinformatics: An introduction by W. Ewens, G.R. Grant. 2nd Edition.Springer-Verlag. 2006. 4. Bioinformatics: Sequence and genome analysis by D. Mount. 2nd edition. Cold Spring HarborLab Press. 2004. 5. Bioinformatics: A practical guide to the analysis of genes & proteins. Edited by Baxevanis,Outlette. 2nd edition. John Wiley and Sons. 2001. 6. An Introduction to Protein Informatics by K-H Zimmermann. 1st edition, SpringerInternational. 2007. 7. Fundamental Concepts of Bioinformatics by Krane. 1st edition. Pearson Education. 2003. 8. Discovering Genomics, Proteomics and Bioinformatics by Campbell. 2nd edition. CampbellPearson Education. 2007. 9. Structural bioinformatics: an algorithmic approach by F. J. Burkowski. 1st edition, Chapman &Hall/CRC. 2009. 10. Structural Bioinformatics edited by J. Gu, P.E. Bourne. 2nd Edition. Wiley-Blackwell. 2009.	

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Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Third (III)**
Major Elective (Optional)	**Course Code: B080905T**	**MICROBIAL DIVERSITY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The objective of this course is to introduce the students with enormous range of biological diversity in the microbial world. The course will develop an understanding about the "big picture" of the microbial world and the power of the phylogeny.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will establish a point of view to examine microbial diversity.	
CO2	Will learn how to construct and interpret evolutionary trees from DNA sequences.	
CO3	Will develop a basic understanding about the major branches of the "tree of life," and establish a base of knowledge about the microbial world.	
CO4	Will learn how new organisms are identified (usually without being cultivated) and will progress in steps to broad surveys of entire microbial communities.	
CO5	Will understand how specific kinds of organisms contribute to the ecosystem.	
Contents		Duration: 60 hours
UNIT I	Introduction to Microbial Diversity: Facets of microbial diversity, the fundamental similarity of all living things, Taxonomy and phylogeny, Phylogenetic Information, Obtaining the required sequence data, assembling sequences in a multiple-sequence alignment.	12 Hours
UNIT II	Constructing a Phylogenetic Tree. Tree Construction Complexities, Alternatives to Small-Subunit rRNA Analysis, SSU rRNA cannot be used to distinguish closely related organisms.	12 Hours
UNIT III	General properties of Primitive Thermophilic Bacteria: Green Phototrophic Bacteria: Proteobacteria (purple bacteria and relatives), Gram-Positive Bacteria, Firmicutes (low G+C gram-positive bacteria), Actinobacteria (high G+C gram-positive bacteria): Spirochetes and Bacteroids: Deinococci, Chlamydiae and Planctomycete: Archaea: Introduction to Eukaryotic Microorganisms	12 Hours
UNIT IV	Microbial Populations: Identification of Uncultivated Organisms, Sequence-Based Microbial Surveys, Fluorescent In Situ Hybridization Surveys, Molecular Fingerprinting of Microbial Populations, Linking Phenotype and Phylotype.	12 Hours
UNIT V	The Phylogenetic Perspective, Genomics, Comparative Genomics, and Metagenomics, Origins and Early Evolution, the timescale, Ancient microbial fossils, The last common ancestor, The RNA world hypothesis, The emergence of life.	12 Hours
Suggested Readings	1. Principles of microbial diversity / James W. Brown, Department of Biological Sciences, North Carolina State University, Raleigh, North Carolina. ISBN 978-1-55581-442-7 2. Microbial Diversity: Form and Function in Prokaryotes by Oladele Ogunseitan; 2005; Blackwell Science Ltd.; ISBN 0-632-04708-9	

Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Third (III)**
Core Paper (Compulsory)	**Course Code: B080906P**	**Practical III**
Marks:100 75 (UE) + 25 (CIE)	**04 credits**	**Duration: 120 hours**

Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 0-0-8	
Course Objectives	The course will enable students to apply the learning of microbiology concepts toward the exploitation of microbial population for industrial and human benefits.
Course Learning Outcomes	Upon successful completion of the course, the student:
CO1	Will be able to analyze the water quality and potability by using various techniques.
CO2	Will be able to use various bioinformatics tools.
CO3	Will be aware of various biochemical tests used in bacterial identification.
CO4	Will be able to use special staining procedures.
CO5	Will be able to use microorganisms for production of various useful and industrially important products.

Contents

1. Analysis of water quality: DO, BOD, alkalinity, free CO2, free chloride, TS, TSS, TDS, nitrate, phosphate
2. Determination of most probable number (MPN) for coliform bacteria
3. Isolation of bacterial strains from different soil samples
4. Analysis of sequence data and searching of research papers from various national and international journals
5. Retrieval of gene and protein sequences from data bank
6. Sequence comparisons and alignment (8P)
7. Visualisation and other utilities (PDB viewer)
8. Biochemical tests for characterization of microbes (based on metabolic properties:
   a. Carbohydrate fermentation
   b. H_2S production
   c. Nitrate reduction
   d. Urease activity
   e. IMViC test
   f. Gelatine liquefaction
   g. Starch hydrolysis
   h. Glycine decarboxylation
   i. Catalase oxidase peroxidase test
9. Staining of polyphosphate bodies, polyhydroxybutyrate and endospore
10. Isolation of protease, amylase and lipase producing bacterial strains and estimation of enzyme activity
11. Mushroom production
12. Cell and enzyme immobilization.
13. Production of alcohol from molasses/cane sugar.
14. Production of vinegar.
15. Production of citric acid.
16. Isolation of cellulose producing strain.

Suggested Readings:	
	1. Microbiology: A laboratory manual by JG Cappucino, N Sherman. 10th edition. Pearson. 2014. 2. Environmental Microbiology: A lab manual by I. Pepper, C. Gerba, J. Brendecke. 46th edition. Academic Press. 2011. 3. Sequence - Evolution - Function: Computational Approaches in Comparative Genomics by E.V. Koonin , M.Y. Galperin. Kluwer Academic, USA. 2003. 4. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins edited

	by A. D. Baxevanis, B.F. Francis Ouellette . 3rd edition. Wiley and Sons. 2004

Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Third (III)**
Core Paper (Compulsory)	**Course Code: B080907R**	**Industrial Training /Surveys/Research Project III**
Marks:100	**Credits: 04**	
Course Details	This research project can be interdisciplinary / multi-disciplinary. This research project can also be in the form of industrial training / internship / survey work etc.	
	*** Students will submit the final report (project report/dissertation) of the research project carried out in both the semesters at the end of the year, which will be assessed jointly by the supervisor and the external examiner nominated by the university at the end of the year out of 100* marks**	

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Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Fourth (IV)**
Major Elective (Optional)	**Course Code: B081001T**	**FOOD MICROBIOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The course will enable students to understand the taxonomical classification, phenotypic andbiochemical identification of food associated molds, yeasts, yeast-like fungi and bacteria. The course will teach the strategies to develop fermented and non-fermented milk products, plant-based products, fish products, meat products bioactive compounds and malt beverages, wines, distilled liquors and vinegar. The role of microbes in food spoilage, preservation and various foodborne diseases will be discussed.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will know about microbial spoilage of various kinds of food.	
CO2	Will be aware of general principles of food preservation.	
CO3	Gathers information regarding fermented food products.	
CO4	Knows about indicator Microorganisms and microbial standards for food safety, quality assurance programs that revolutionize food safety.	
CO5	Gains knowledge about food borne microorganisms and food poisoning.	
Contents:		Duration: 60 hours
UNIT I	Food as a substrate for microorganisms, Microbial spoilage of Meat, Poultry, and Seafood; Milk and Dairy Products; Fruits and Vegetables; Nuts, Seeds, and Cereals	12 Hours
UNIT II	Food preservation: Various classical, physical, chemical, and biological methods of preservation. New developments in food preservation techniques. Analysis of practical implementation of such techniques.	12 Hours
UNIT III	Fermented Dairy Products, Microbial habitat of specific food materials, adaptations and changes in microbiome of vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats, poultry and non-dairy fermented foods, Fermented Vegetables, Fermented Meat, Poultry, and Fish Products, Cocoa and Coffee, Beer, Wine, Vinegar, Probiotics and Prebiotics,	12 Hours
UNIT IV	Indicator Microorganisms as an indicator of good quality, Food adulteration (DART) and prevailing food standards in India (*fssai*, Agmark and BIS), Hazard Analysis and Critical Control Point System	12 Hours
UNIT V	Food borne infections including bacterial, viral and fungalinfections. Study of infections due to food borne parasites. In depth study of various types and causes of food intoxication.	12 Hours
Suggested Readings	1. Food Microbiology by W.C. Frazier, D.C. Westhoff , K.N. Vanitha. 5th edition. McGrawHill Education. 2013. 2. Modern Food Microbiology by J.M. Jay, M.J. Loessner, D.A. Golden. 7th edition.Springer. 2006. 3. Fundamental Food Microbiology by B. Rayand A. Bhunia. 5th edition. CRC press. 2013. 4. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Societyof Chemistry. 2015. 5. Food Microbiology: Fundamentals and Frontiers by M. P. Doyle, L. R.	

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	Beuchat. 3rd edition. ASM press. 2007. 6. Food Microbiology: An Introduction by T. Montville, K. Matthews, K.Kniel. 4th edition.ASM press. 2017.

Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Fourth (IV)**
Major Elective (Optional)	**Course Code: B081002T**	**AGRICULTURAL MICROBIOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The course will facilitate in understanding of major groups of soil microorganisms along with the pathogens that interact with various plants and can affect the plant by causing changes in physiology, photosynthesis, respiration, transpiration and translocation. The course will cover the applications of Plant Growth Promoting Rhizobacteria and microbial biopesticides along with their detailed mode of action.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will have acquired knowledge about the role of soil microorganism in various soil processes.	
CO2	Will learn about plant growth promotion attributes of PGPR and their mechanism of action. Will also learn about biostimulants.	
CO3	Understands about various types of plant microbe interactions.	
CO4	Will be introduced to mechanism of action of various bacterial biopesticides.	
CO5	Will be introduced to mechanism of action of various viral biopesticides.	
Contents:		Duration: 60 hours
UNIT I	Soil microorganisms, major groups, decomposition of organic matter, soil health, root exudates and rhizospheric effect, manipulation of rhizospheric microflora in plant productivity, microbial biomass, microbial transformation of phosphorus and sulphur, minor nutrients, role of biofertilizers in agriculture and forestry, bioremediation of problem soils.	12 Hours
UNIT II	Plant Growth Promoting Rhizobacteria and their mode of action, formation and composition of soil organic matter- Fulvic acid and humic acid	12 Hours
UNIT III	Plant microbe relationships: Association and pathogenicity, Mycorrhizal association: Their types and role in plant nutrition.	12 Hours
UNIT IV	Bacteria as biopesticides: production and method of application, Mechanism of action of common bacterial biopesticides *(Bacillus thuringiensis, Pseudomonas* spp*).*	12 Hours
UNIT V	Viral biopesticides *(nuclear polyhedrosis virus, cytoplasmic polyhedral virus)* and fungal biopesticides (*Metarrhinium anisoplial, Beauveria bassiana, Verticellum lecani, Hirsutella thomsonii*)	12 Hours
Suggested Readings	1. Plant Pathology by Agrios GN. Fifth edition, Elsevier Academic press. 2. Principles of plant pathology by R.S. Singh, Oxford and IBH Publishing Company Pvt. Ltd. 3. Plant Diseases by R.S. Singh, CBS Publisher. 4. Agriculture Microbiology by Rangaswami, G, and Bagyaraj, DJ, edition 2nd, Prentice Hall of India Pvt. Ltd., New Delhi. 5. Advances in Agriculture Microbiology by Subba Rao, NS, Oxford & IBH Pub. Molecular plant pathology by M. Dickinson, Bios Scientific Publishers, New York.	

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Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Fourth (IV)**
Major Elective (Optional)	**Course Code: B081003T**	**CLINICAL MICROBIOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The course will facilitate in understanding of major groups of Human pathogens along with their mechanism of action. The course will develop an understanding about mechanism of action of various antibiotics along with the mechanisms developed in microbes to counteract the action of various antimicrobial agents. The course will also aware the students with current scenario by an introduction to emerging infections.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will have acquired knowledge about the normal microflora of human body along with the methods for collection and transportation of pathological specimens.	
CO2	Will have learnt about principles of pathogenicity.	
CO3	Understands about various bacterial and fungal diseases along with their symptoms and mechanism of action.	
CO4	Will have learn about various viral diseases along with their symptoms and mechanism of action.	
CO5	Will have been introduced to mechanism of action of various antibiotics alond with the mechanism of development of antimicrobial resistance in microbes.	
Contents		Duration: 60 hours
UNIT I	History of medically important microorganisms; normal microflora of Human body. Collection, transportation and examination of pathologic specimens. Isolation and identification of pathogenic organisms.	12 Hours
UNIT II	Pathogenicity: Virulence factors, spreading and establishment of pathogens, bacterial toxins-their types, mycotoxins, involvement of extra-genetic elements. Epidemiology of infection diseases.	12 Hours
UNIT III	Brief account of bacterial diseases spread through air (diptheria, tuberculosis and pertusis), food and water (typhoid, cholera and dysentery) soil (anthrax, tetanus, and gas gangrene) and contact (leprosy, conjunctivitis and venereal diseases). Bacterial zoonoses(brucellosis, bubonic plague and salmonellosis) and protozoal diseases (malaria, filarial and kalazar). Etiology, epidemiology, pathogenesis, symptomology, pathology, disease diagnosis and treatment of fungal diseases: Candidiasis, histoplasmosis, aspergillosis, cryptooccosis and dermatomycosis.	12 Hours
UNIT IV	General characteristics of common viral diseases like influenza (pneumotropic): herpes simplex, small pox, measles and rubella (dermotropic); dengue fever, hepatitis and AIDS (viscerotropic): rabies, poliomyelitis and slow virus disease (neurotropic). encephalitis and yellow fever viral zoonoses).	12 Hours
UNIT V	Principles of chemotherapy, role of antimicrobial agents and mechanisms of their action with special reference to antibiotics. Molecular basis of drug resistance in bacteria, and drug sensitivity test. Introduction to Nosocomial infections and emerging microbial infection diseases. Biosafety practices in biological sciences and disposal of biomedical waste, bio-terrorism.	12 Hours
Suggested Readings	1. Medical Microbiology by Murray, PR, Rosenthal, KS, Kobayashi, GS & Pfaller, MA (ed III) Mosby Inc.	5.

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	2. Essentials of Medical Microbiology By Volk WA, Gebhardt, BM, Hammarskjold, ML & Kadner RJ (Ed V) Lipincott-Raven Publisher, Philadelphia 3. Jawetz, Melnick & Adelberg's medical microbiology by Brooks, GF, Carroll, KC, Butel, JS, Morse, SA, Edition 24th, McGraw-Hill Medical, 4. Medical Microbiology by Cruikshank, Edition 12th, Churchill Livingstone Pub.	

Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Fourth (IV)**
Major Elective (Optional)	**Course Code: B081004T**	**IPR AND BIOSAFETY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The course will develop an understanding about Intellectual Property Right and International framework for the protection of IP. The course will also aware the students about Biosafety when dealing with different categories of microbes.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will have acquired basic knowledge about IPR and different types of Intellectual Property.	
CO2:	Will have learnt about international framework for the protection of IP	
CO3	Understands the basics of patents.	
CO4	Will be introduced to various levels of Biosafety.	
CO5	Will be introduced to GRAS organisms and biosafety levels of specific microorganisms.	
Contents:		Duration: 60 hours
UNIT I	Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs	12 Hours
UNIT II	International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to Microbiology and few case studies;	12 Hours
UNIT III	Introduction to history of GATT, WTO, WIPO and TRIPS. Basics of patents.	12 Hours
UNIT IV	Introduction to Biosafety; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels;	12 Hours
UNIT V	GRAS organisms, Biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs	12 Hours
Suggested Readings:	An Introduction to Intellectual Property Rights (Third Edition, 2012) by J. P. Mishra. Intellectual Property Rights by Neeraj Pandey and Khushdeep Dharni Fundamentals of Intellectual Property Rights : For Students, Industrialist and Patent Lawyers *by Ramakrishna B & Anil Kumar H.S.*	

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Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Fourth (IV)**
Major Elective (Optional)	**Course Code: B081005T**	**MICROBIAL PATHOGENICITY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The objective of this course is to make the students understand various attributes which make the microbes pathogenic or disease-causing, the emergence of newer pathogens with relevance to India and the various tools for their local or global spread. The students would also learn the mechanisms of resistance of bacteria to antibiotics and role of newer vaccines in controlling infectious diseases. The course would also enable students to describe the molecular diagnostic methods and automated equipment which may be used for diagnosis of diseases caused bymicroorganisms.	
Course Learning Outcomes	Upon successful completion of the course, the student will be able:	
CO1	To understand classical and molecular determinants of disease-causing microbes	
CO2	To describe the characteristics of newer disease-causing bacteria and viruses	
CO3	To study and critique the various molecular tools available to work on the molecular epidemiology of disease-causing microorganisms	
CO4	To study and evaluate mechanisms underlying resistance of bacteria to antibiotics, spread ofresistance and the use of newer vaccines to control infectious diseases	
CO5	To gather information as to how the infectious diseases may be diagnosed using newer diagnostic tools and what automated equipment are available for use in diagnostic microbiology laboratories.	
Contents:		Duration: 60 hours
UNIT I	Classical view of microbial pathogenicity: Define pathogenicity and virulence; Quantitative measures of pathogenicity: minimal lethal dose (MLD), LD_{50}, ID_{50}, $TCID_{50}$. Virulence determinants: colonization, toxins, enzymes and invasiveness. Facultative/ obligate intracellular pathogens.	12 Hours
UNIT II	Molecular microbial pathogenicity: Molecular Koch's postulates, multiplicity of virulence determinants, coordinated regulation of virulence genes, and environmental regulation of virulence determinants by two component signal transudation systems, antigenic variation; clonal and panmictic nature of microbial pathogens, type three secretion system (TTSS, T3SS), Role of biofilms and quorum sensing in microbial pathogenicity	12 Hours
UNIT III	Molecular microbial epidemiology: Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing, multilocus enzyme electrophoresis (MLEE); Molecular typing: RAPD, rep (REP, ERIC, BOX)-PCR, IS based typing, PFGE, AFLP, MLST, VNTR and whole genome sequence, use of geographical information system (GIS) for microbial epidemiology.	12 Hours
UNIT IV	Antimicrobial resistance (AMR): Recent concepts – multidrug efflux pumps, extended spectrum β-lactamases (ESBL), X-MDR *M. tuberculosis*, methacillin-resistant *S. aureus* (MRSA),role of integrons.	12 Hours
UNIT V	Rapid diagnostic principles: Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, real-time PCR, lateral flow assays, diagnostic	12 Hours

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	sequencing and mutation detection, automated instruments for detection/diagnosis of infectious agents (BACTAC and Vitek-2, GeneXpert).	
Suggested Readings	1. Jawetz, Melnick, & Adelberg's Medical Microbiology by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. 27th edition. Lange Publication, 2016. 2. Beginner's guide to comparative genome analysis using next generation sequence data by Edward DJ and Holt KE in Microbial Informatics and Experimentation, 3:2, https://doi.org/10.1186/2042-5783 3-2, 2013. 3. Bacterial Pathogenesis: A molecular approach by Wilson BA, Salyers AA, Whitt DD, Winkler ME. 3rd edition. American Society for Microbiology Press, Washington, DC USA, 2011. 4. Bacterial Pathogenesis: Molecular and Cellular Mechanisms by Locht C, Simonet M, Caister Academic Press, 2012. 5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. 3rd edition. Washington, American Society for Microbiology Press, 2016 6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM. 4th edition. Jones and Bartlett, 2019.	

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Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Fourth (IV)**
Major Elective (Optional)	**Course Code: B081006T**	**PLANT-PATHOGEN INTERACTIONS**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**

Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The course will facilitate in understanding of how pathogens interact with various plants and effect plant physiology, photosynthesis, respiration, transpiration and translocation. The involvement of various enzymes and toxins and understanding the molecular interaction will help in designing biocontrol strategies and development of transgenic plants. The course covers the novel molecular diagnostic approaches and correct forecasting of plant diseases.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will have gained insight into genetics of host-pathogen interactions, resistance genes, resistance mechanism in plants.	
CO2	Will have been introduced to plant disease control, physical, chemical and biological methods of disease control	
CO3	Understands about crown gall, symptoms of viral diseases and their control, diseases ofsome important cereals, vegetables and crops	
CO4	Will have attained knowledge about designing of molecular diagnosis of plant disease anddevelopment of transgenic plants with applications and constraints.	
CO5	Will be able to describe various important milestones in disease control and disease forecastingrelevant in Indian farming.	
Contents:		Duration: 60 hours
UNIT I	Genetic basis of plant diseases: Genetics of host-pathogen interactions, resistancegenes, resistance mechanisms in plants.	12 Hours
UNIT II	Disease control: Principles of plant disease control, physical and chemical methods of disease control, biocontrol, biocontrol agents - concepts and practices, fungal agents, *Trichoderma*as biocontrol agent, biocontrol agents – uses and practical constraints.	12 Hours
UNIT III	Some important plant diseases and their etiological studies: Crown gall, symptomsof viral diseases and their control, diseases of some important cereals, vegetables and crops.	12 Hours
UNIT IV	Molecular approach: Molecular diagnosis, transgenic approach for plant protection,futuristic vision of molecular diagnosis, applications and constraints.	12 Hours
UNIT V	Disease forecasting: History and important milestones in disease control, diseaseforecasting and its relevance in Indian farming.	12 Hours
Suggested Readings:	1. Plant Pathology by G. N. Agrios. 5th edition. Academic Press. 2005 2. Plant Pathology by R.S. Mehrotra, and A. Aggarwal, 3rd edition. Tata McGraw Hill. 2017 3. Bacterial plant pathology: cell and molecular aspects by D. C. Sigee. Cambridge UniversityPress.1993. 4. Molecular plant pathology by M. Dickinson. BIOS Scientific Publishers, London. 2003. 5. The essentials of Viruses, Vectors and Plant diseases by A.N. Basu& B.K. Giri. Wiley EasternLimited.1993.	

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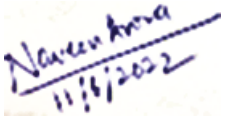
	6. Biocontrol of Plant Diseases (Vol. I) by K.G. Mukerji and K.L.Garg. CRC PressInc.,USA.1988. 7. Molecular Biology of Filamentous Fungi by U. Stahl and P. Tudzyski. VCHVerlagsgesellschaftmbH. 1992.

Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Fourth (IV)**
Major Elective (Optional)	**Course Code: B081007T**	**MYCOLOGY AND PHYCOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The course will develop a basic understanding about classification and characteristics of basic groups of algae and fungi along with their symbiotic associations and economic importance.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will gain knowledge about occurrence and distribution of fungi along with the characteristics of different classes of fungi.	
CO2	Will have been introduced to different classes of fungi.	
CO3	Understands about economic importance of fungi	
CO4	Will attain knowledge about salient features of algae.	
CO5	Is able to know about economic importance of algae.	
Contents:		Duration: 60 hours
UNIT I	Introduction to fungi: Contributions of Mycologists in India, Introduction of fungi: Occurrence and distribution, somatic structure, hyphal growth,nutrition, heterothallism, sex hormones in fungi, physiological specialization in fungi, fungi and ecosystem; saprophytic parasitic, mutualistic and symbiotic relationship with plants and animals. Classification of fungi. Reproduction in fungi: asexual, sexual and parasexual.	12 Hours
UNIT II	Study of the different classes of fungi: Salient features of division and sub division of myxomycota, mastigomycota, zygomycota, ascomycotina, basidiomycotina and euetromycotina. Structure and reproduction of: *Dictyostelium, Allomyces, Pilobolus, Claviceps* and *Fusarium*	12 Hours
UNIT III	Economic importance of fungi: Economic importance of Mycorrhiza: ecto-, endo and ect-endo VAM, Fungi as insect symbionts, fungi as biocontrol agents, attack of fungi on other microorganisms, potential application in Agriculture, environment, industry, food. Role of fungi in bio deterioration of wood, paper, textile. Mycotoxins, quorum sensing in fungi.	12 Hours
UNIT IV	Salient Features of Algae: Contributions of Phycologists in India, Distribution, morphology and classification of algae. Isolation from soil and water, algal ecology, media and methods used for cultivating algae. Measurement of algal growth, strain selection and large scale cultivation. General features and life cycle pattern in different classes of algae	12 Hours
UNIT V	Microalgal biotechnology: Algae as source of food and feed, pigments, fine chemicals, fuel and bioactive compounds Uses of algae in heavy metal removal, algal blooms and toxins.	12 Hours
Suggested Readings	1. Alexopoulos, C.J. and C.W. Mims 1979. Introduction to Mycology (3rd Ed.) Wiley Eastern Ltd., NewDel 2. Charlile M. & Watkinson S.C. The Fungi, Publisher: Academic Press. 3. E.Moore –Landeekeer: Fundamentals of the fungi, Publisher: Prentice Hall. 4. L. Barsanti, Paolo Gualtieri: Algae: anatomy, biochemistry, and biotechnology 5. AyhanDemirbas, M. FatihDemirbas: Algae Energy: Algae as a New Source ofBiodiesel (2010) 6. Linda E. Graham, James Graham, James M. Graham: Algae (2009) Burnett J.H., Publisher: Edward, Arnold Crane Russak: Fundamentals of Mycology.	



Programme/Class: M. Sc. Microbiology (II)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Fourth (IV)**
Major Elective (Optional)	**Course Code: B081008T**	**BIOPROCESS TECHNOLOGY**
Marks:100	**75 (UE) + 25 (CIE)**	**Credits: 04**
Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 4-0-0		
Course Objectives	The course will develop a basic understanding about biochemical engineering. The course will develop an idea about microbial growth kinetics, transport phenomenon and various control systems used to control various parameters during the course of fermentation process.	
Course Learning Outcomes	Upon successful completion of the course, the student:	
CO1	Will gain knowledge about upstream and downstream processing along with the growth behavior.	
CO2	Will have been introduced to volumetric mass transfer coefficient along with the methods of determination.	
CO3	Understands about rheological properties of fermentation broths and mass energy balance.	
CO4	Will attain knowledge about various types of bioreactors.	
CO5	Will be able to know about various control systems used to control various parameters.	
Contents:		Duration: 60 hours
UNIT I	Introduction to the bioprocess technology; Microbial growth kinetics: batch, continuous and fed batch culture.	12 Hours
UNIT II	Transport phenomenon in bioprocess: Introduction, oxygen requirement in industrial fermentation, oxygen supply and oxygen transfer rate, factors affecting oxygen transfer rate, determination of Kla values.	12 Hours
UNIT III	Non-Newtonian fluids, heat transfer and heat transfer correlation, and mass and energy balance.	12 Hours
UNIT IV	Introduction to bioreactor: Ideal bioreactor, Reactor with non-ideal mixing, Sterilization reactors, Multiphase bioreactors, animal and plant cell reactor technology.	12 Hours
UNIT V	Instrumentation and control systems: A. Methods of measuring process variability a. Temperature b. Flow c. Pressure d. DO and free CO_2 e. pH and other chemical factors B. Control systems a. Manual b. Automatic c. Computers and interface	12 Hours
Suggested Readings	1. Principles of Fermentation Technology by P. F. Stanbury, A. Whitaker and S. J. Hall; Second Edition; Butterrworth Heinemann Publications; ISBN: 0-7506-4301-6. 2. Putting Biotechnology to Work: Bioprocess Engineering; Committee on Bioprocess Engineering, National Research Council Washington, D.C. 1992; ISBN: 0-309-58487-6. 3. The encyclopedia of bioprocess technology : fermentation, biocatalysis, and	

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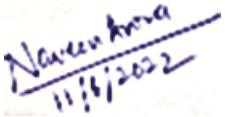
	bioseparation by Michael C. Flickinger, Stephen W.Drew; John Wiley & Sons, Inc.; ISBN 0-471-13822-3



Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Fourth (IV)**
Core (Compulsory)	**Course Code: B081009P**	**Practical III**
Marks:100 75 (UE) + 25 (CIE)	**04 credits**	**Duration: 120 hours**

Total Number of Lectures-Tutorials-Practical (in hours per week L-T-P: 0-0-8	
Course Objectives	The course will enable students to apply the learning of microbiology concepts toward the exploitation of microbial population for industrial and human benefits.
Course Learning Outcomes	Upon successful completion of the course, the student:
CO1	Will be able to measure various bioprocess parameters.
CO2	Will be able to microbiological quality of milk.
CO3	Will be aware of isolation procedure of various PGPR and their efficiency assessment
CO4	Will be able to determine Determination of antibiotic sensitivity and MIC by different procedures.

Contents:

1. Measurement of *K*s value
2. Determination of specific growth rate and generation time
3. Estimation of KLa value by sufite oxidation method
4. Milk quality test- methylene blue reduction test,
5. Ames test
6. Isolation of PGPR from soil.
    a. Isolation of *Azotobacter*
    b. Isolation of *Azospirillum*
    c. Isolation of *Pseudomonas*
    d. Isolation of *Rhizobium*
7. Determination of plant growth promotion activity of bacterial isolates
    a. IAA Production
    b. Ammonia Production
    c. Siderophore production
    d. Phosphate solubilization
    e. Ammonia production
    f. HCN Production
8. Determination of antibiotic sensitivity by
    a. Well diffusion method.
    b. Disk diffusion method.
    c. Plug diffusion method..
9. Determination of MIC for selected antibiotics

Suggested Readings:	1. Microbiology: A laboratory manual by JG Cappucino, C.T. Welsh. 11th edition. Pearson. 2017. 2. Environmental Microbiology: A lab manual by I. Pepper, C. Gerba, J. Brendecke. 46th edition. Academic Press. 2011.

Programme/Class: Bachelor's Degree with Research / M. Sc. Microbiology (I)		
Subject: Microbiology	**Year: Second (2)**	**Semester: Third (IV)**
Core Paper (Compulsory)	**Course Code: B081010R**	**Industrial Training /Surveys/Research Project IV**
Marks:100	**Credits: 04**	
Course Details	This research project can be interdisciplinary / multi-disciplinary. This research project can also be in the form of industrial training / internship / survey work etc.	
	*** Students will submit the final report (project report/dissertation) of the research project carried out in both the semesters at the end of the year, which will be assessed jointly by the supervisor and the external examiner nominated by the university at the end of the year out of 100* marks**	

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