Learning Outcomes-based Curriculum Framework
(Under CBCS)

For

M.Sc. (Microbiology)
Postgraduate Programme

(w.e.f. 2022-23)

Department of Biotechnology
Chaudhary Devi Lal University
Sirsa-125055

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1. About the Department

The Department of Biotechnology, Chaudhary Devi Lal University, Sirsa was established in June 2004 with major funding from the State Government. The Department is located at the first floor of CV Raman Bhawan of the University. The first batch of students was admitted in August 2004. So far, the department has produced about 600 postgraduate and 29 Ph.D. students, most of them have preferred to go for higher studies, some are actively engaged in jobs in various fields and some have developed their own businesses.

The department has been running M.Sc. Biotechnology (two year) and Ph.D. Biotechnology programs, and from session 2022-23, M.Sc. Microbiology is also introduced. The Department of Biotechnology has two well-aerated classrooms for M.Sc. (Previous) and M.Sc. (Final) with defined sitting arrangement, electricity facility with power back up, projector and smart boards. Department has one bioinformatics lab having twenty computers with LAN internet facility. Department has two well-equipped laboratories for M.Sc. Programme and four separate air-conditioned research laboratories for Ph.D. programme.

2. Learning Outcomes based Curriculum Framework

The Choice Based Credit Scheme has evolved into learning outcomes-based curriculum framework and provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses are evaluated following the grading system, which is considered better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enables the potential employers in assessing the performance of the candidates.

2.1 Objectives of the Programme

- To provide a multidisciplinary quality learning experience to students that will empower them for dreaming big.
- To provide skill-based education to the students in the field of Microbiology that make them suitable for various job-roles, in industry as well as in academia.
- To inculcate the qualities of entrepreneurship in students.

2.2 Programme Outcomes (POs)

After completion of the programme, the students will have

PO1	*Knowledge*: Knowledge in the basic and advanced fields of the core and applied disciplines, for the fulfilment of professional requirements
PO2	*Critical Thinking*: Capability of critical thinking based on the contextual knowledge of living beings/organisms, non-living components and environmental basis of life, enabling them to critically analyse the day-to-day problems faced by the society.
PO3	*Interdisciplinary approach* & *Adaptation*: Understanding of the vital connections, within and among-the flora, fauna and the physical environment, enabling them to integrate and synthesize the acquired knowledge within their fields and beyond
PO4	*Application Development*: Understanding for the development of the applications of biological materials in food, health, medicine and environment for sustainable development of the society
PO5	*Ethics and Leadership*: Awareness about sound professional and character ethicsas well as the qualities of leadership and team building skills
PO6	*Problem Solving*: Capability for developing innovative and solution cantered approach for handling any kind of problem and the paradigm of scientific temperament
PO7	*Skills and Inferential knowledge*: knowledge about various core and advanced skills for theoretical and practical understanding of different descriptive and inferential statistical tools and techniques
PO8	*Specialization and Employability*: specialization in various skills based on

	practical training, fields visits and project based vocational training as well as specialization for an entrepreneurial thinking and career-oriented approach in research as well as in industries

2.3 Programme Specific Outcomes (PSOs)

After completing the programme, the student will

PSO1	gain core and advanced knowledge in different areas of microbiology which will enable them to develop the powers of inquiry, critical analysis, logical thinking for finding solutions for biological problems
PSO2	become trained in high quality practical techniques and skills in various fields of microbiology which will enable them to launch start-ups and become entrepreneurs for novel microbiological products and processes in various industries
PSO3	become acquainted with high standards of academic integrity, research ethics, bio-ethics, entrepreneurial values, statistical tools, life skills as well as with principles and concepts of applied areas of microbiology which will help them in emerging as strong personalities with good leadership qualities in academics, research as well as industry.
PSO4	become capable for conceptualization on the basis of acquired knowledge that will help them to design, review and execute any project. Students will develop qualities of critical thinking, methodology designing (for synthesis of core and advanced scientific concepts) and will learn the art of effective communication during project writing and presentation

3. Programme Structure

M.Sc. Microbiology programme is a four-semester postgraduate programme consisting 102 credits weightage of Core Courses (CC), Discipline Specific Elective Courses (DSC), Skill Enhancement Courses (SEC) and Open Elective Courses (OEC).

Table 1: Courses and Credit Scheme

Semester	**Core Courses (CC)**		**Discipline Specific Elective Courses (DSC)**		**Skill Enhancement Courses (SEC)**		**Open Elective Courses (OEC)**		**Grand Total Credits**
	1	**2**	**3**	**4**	**5**	**6**	**7**		
	No. of Courses	**Total Credits**	**No. of Courses**	**Total Credits**	**No. of Courses**	**Total Credits**	A total of 12 credits are to be earned from other Departments or from MOOCs *Students have to opt open elective course in consultation with chairperson and Director, University Centre for Outreach Programmes and Extension*		**2+4+6+7**
I	6	**24**	-	**0**	-	**0**			**106**
II	4	**16**	2	**8**	1	**2**			
III	3	**10**	2	**8**	3	**8**			
IV	2	**6**	1	**4**	2	**8**			
Total	**Core Credits**	**56**	**Discipline Specific Elective Credits**	**20**	**Skill Enhancement Credits**	**18**	**Open Elective Credits**	**12**	**106**
Per-cent	**Core Credits**	**52.94**	**Discipline Specific Elective Credits**	**19.60**	**Skill Enhancement Credits**	**15.68**	**Open Elective Credits**	**11.76**	**100**

Table 2: Detailed break-up of Credit Courses

	Core Courses	Discipline Specific Elective Courses	Skill Enhancement Courses	Open Elective Courses	Total Courses
	CC	DSC	SEC	OEC	CC+DSC +SEC
Semester I	CC1 CC2 CC3 CC4 CC5 CC6	-		OECs offered by other departments or MOOCs **(May be enrolled in any of the four semesters)** *Students have to opt open elective course in consultation with chairperson and Director, Centre for Outreach Programmes and Extension*	6
Semester II	CC7 CC8 CC9 CC10	DSC1 DSC2	SEC1		7
Semester III	CC11 CC12 CC13	DSC3 DSC4	SEC2 SEC3 SEC4		8
Semester IV	CC14 CC15	DSC5	SEC5 SEC6		5

Table3: Course code and title along with credits detail

Sr. No.	Course Code	Course Title	Credits		
Semester I			**Theory**	**Practical**	**Total**
1.	MSc/Mic/1/CC1	General Microbiology	4		4
2.	MSc/Mic/1/CC2	Microbial Physiology and Metabolism	4		4
3.	MSc/Mic/1/CC3	Principles of Biochemistry	4		4
4.	MSc/Mic/1/CC4	Microbial genetics	4		4
5.	MSc/Mic/1/CC5	Practical 1 (Based on CC1 & CC2)		4	4
6.	MSc/Mic/1/CC6	Practical 2 (Based on CC3 and CC4)		4	4
		Total	**16**	**8**	**24**
Semester II					
1.	MSc/Mic/2/CC7	Bacteriology	4		4
2.	MSc/Mic/2/CC8	Virology	4		4
3.	MSc/Mic/2/CC9	Mycology and Phycology	4		4
4.	MSc/Mic/2/DSC1	A. Food and Dairy Microbiology	4		4
		B. Industrial Microbiology			
		C. MOOC			
5.	MSc/Mic/2/DSC2	Practical 3A (Food and Dairy Microbiology)		4	4
		Practical 3B (Industrial Microbiology)			
6.	MSc/Mic/2/CC10	Practical 4 (Based on CC7, CC8, and CC9)		4	4
7.	MSc/Mic/2/SEC1	Industrial training (One month) during summer*		2	2
		Total	**16**	**10**	**26**
Semester III					
1.	MSc/Mic/3/CC11	Immunology	4		4
2.	MSc/Mic/3/CC12	Molecular Biology	4		4
3.	MSc/Mic/3/DSC3	A. Medical Microbiology	4		4
		B. Plant Pathology			
		C. MOOC			
4.	MSc/Mic/3/DSC4	A. Soil and Agricultural Microbiology	4		4
		B. Environmental Microbiology			
		C. MOOC			

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5.	MSc/Mic/3/SEC2	Practical 5 (Techniques in Medical Microbiology and Immunology)		4	4
6.	MSc/Mic/3/SEC3	Practical 6 (Techniques in environmental and agricultural microbiology)		4	4
7.	MSc/Mic/3/CC13	Seminar**	2		2
8.	MSc/Mic/3/SEC4	Life skills and Humanistic Values***	Non-credit		0
Total			**18**	**8**	**26**
Semester IV					
1.	MSc/Mic/4/CC14	Cardinal Principles of Academic Integrity and Publications Ethics	2		2
2.	MSc/Mic/4/CC15	Recombinant DNA Technology	4		4
3.	MSc/Mic/4/SEC5	Bioinformatics	4		4
4.	MSc/Mic/4/SEC6	Practical 7 (Based on CC15 and SEC5)		4	4
5.	MSc/Mic/4/DSC5	A. Dissertation		4	4
		B. Review Project			
		C. MOOC			
		Total	**6**	**8**	**18**
		Grand Total (I+II+III+IV) = 24+26+26+18 = 94			

Notes:

1. For one credit of theory, one hour of lecture will be delivered while for one credit of practical, two hours of laboratory work will be conducted, per week.
2. Practical will be conducted in groups; one group will have maximum of 20 students.
3. Evaluation of Non-credit courses will be entirely internal. Award will be submitted in the form of Satisfactory (S) (in case marks obtained are 60 % or more) or Unsatisfactory (US) (in case marks are less than 60 %) grades.
4. Besides credits from above courses, students will need to earn additional 12 credits from open elective courses (OECs) offered by other departments of the University or from MOOCs on SWAYAM portal. Students are free to get enrolled for this category courses in any of the semesters. Further, students may get enrolled in any of the various PG MOOCs available at SWAYAM portal for this category for the desired credits.
5. MOOC coordinator will display the list of MOOCs for each Discipline Specific Elective Course (DSC) before the commencement of respective semester.

6. A Discipline Specific Elective Course will be started only when least 10 students opt for a particular course.
7. *Students will need to submit a certificate declaring their successful completion of 'Industrial Training'. The industrial training reports will be evaluated by external examiner by conducting viva-voce.
8. **Seminars will be evaluated by a two-member committee (internal members only), constituted by the staff council.
9. ***Two classes per week will be held for 'Life skills and Humanistic values' course.
10. Rules pertaining to Dissertation/Research-Review Project:
    i. Allotment of students for 'Dissertation/Research-Review Project' will be done in the beginning of third semester.
    ii. The work will commence with third semester and will continue till the last day of teaching term of fourth semester (as notified in Academic Calendar).
    iii. The last day of fourth semester (as notified in Academic Calendar), will be the last date for submission of dissertation/research-review project.
    iv If any student fails to submit within the stipulated period, an extension of three months may be granted by the chairperson by imposing a fine of Rs 500. Extension, beyond three months, may also be granted by the chairperson, but only under special circumstances and with a fine of Rs 1000.
    v 'Dissertation or Research-Review Project Report will comply by the Plagiarism Policy' of the University.
    vi. Three paperback copies and one soft copy of the Dissertation or Research-Review Project Report will be prepared. The soft copy will be sent to the library while the paperback copies will be one each for student, supervisor and department record.
    vii. Any patent/IPR based on the experimental work will be filed in the name of the University. The concerned student/s and guide will be the inventors.
    viii A publication based on dissertation or research review project should be with consent of guide only
    ix. Guidance of students for Dissertation/Research-Review Project will contribute towards 1 credit of workload for teachers if the number of students is less than 5. In case, number of students being guided by one teacher is 5 or more, teacher will be credited with workload of 2 credits.
    x. The Dissertation and Research-Review Project Report will be compiled in the following format:

Dissertation
Acknowledgement
Certificate of Supervisor
Plagiarism Verification report
Introduction
Review of Literature

Research-Review Project Report
Acknowledgement
Certificate of Supervisor
Plagiarism Verification report
Introduction
Overview of theme and Discussion in the light of available literature

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Materials and Methods	Conclusions and Future Prospects
Results and Discussion	
Summary	
Bibliography	Bibliography

Table 4: Core Courses Offered by the Department

Course Code	Course Title	Credits
Core Courses		
MSc/Mic/1/CC1	General Microbiology	4
MSc/Mic/1/CC2	Microbial Physiology and Metabolism	4
MSc/Mic/1/CC3	Principles of Biochemistry	4
MSc/Mic/1/CC4	Microbial Genetics	4
MSc/Mic/1/CC5	Practical 1 (Based on CC1 and CC2)	4
MSc/Mic/1/CC6	Practical 2 (Based on CC3 and CC4)	4
MSc/Mic/2/CC7	Bacteriology	4
MSc/Mic/2/CC8	Virology	4
MSc/Mic/2/CC9	Mycology and Phycology	4
MSc/Mic/2/CC10	Practical 4 (Based on CC7, CC8, and CC9)	4
MSc/Mic/3/CC11	Immunology	4
MSc/Mic/3/CC12	Cell and Molecular Biology	4
MSc/Mic/3/CC13	Seminar	2
MSc/Mic/4/CC14	Cardinal Principles of Academic Integrity and Publications Ethics	2
MSc/Mic/4/CC15	Recombinant DNA Technology	4
Total		**56**

Table No. 5 Discipline Specific Courses offered by Department

MSc/Mic/2/DSC1	A. Food and Dairy Microbiology	4
	B. Industrial Microbiology	
	C. MOOC	
MSc/Mic/2/DSC2	A. Practical 3A (Food and Dairy Microbiology)	4
	B. Practical 3B (Industrial Microbiology)	
MSc/Mic/3/DSC3	A. Medical Microbiology	4
	B. Plant Pathology	
	C. MOOC	
MSc/Mic/3/DSC4	A. Soil and Agricultural Microbiology	4
	B. Environmental Microbiology	
	D. MOOC	
MSc/Mic/4/DSC5	A. Dissertation	4
	B. Review Project	
	C. MOOC	
	Total	**20**

Table No. 6 Skill Enhancement Course offered by the Department

MSc/Mic/2/SEC1	Industrial Training	2
MSc/Mic/3/SEC2	Practical 5 (Techniques in Clinical Microbiology and Immunology)	4
MSc/Mic/3/SEC3	Practical 6 (Techniques in environmental and agricultural microbiology)	4
MSc/Mic/3/SEC4	Life Skills and Humanistic Values	0
MSc/Mic/4/SEC5	Bioinformatics	4
MSc/Mic/4/SEC6	Practical 7 (Based on CC13 and CC14)	4
	Total	**18**

4. Attainment Level

Table No. 7: CO-PO-PSO mapping matrix for all the courses

Course Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4
Semester-I												
MSc/Mic/1/CC1	3	2	1.5	2.125	1.5	1.75	1.875	2	3	2	2	2
MSc/Mic/1/CC2	3	2	1.5	2.125	1.5	1.75	1.875	2	3	2	2	2
MSc/Mic/1/CC3	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
MSc/Mic/1/CC4	3	2	1.25	2.25	1.5	1.75	1.75	2	3	3	3	2
MSc/Mic/1/CC5	3	2	1.5	2.25	1.75	1.75	1.75	2	1.87	2	2	2
MSc/Mic/1/CC6	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
Semester-II												
MSc/Mic/2/CC7	3	2	2	2	1.25	2	3	2	3	2	2	1.5
MSc/Mic/2/CC8	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
MSc/Mic/2/CC9	3	2	1.5	2	1.75	1.75	1.75	2	3	2.5	2.5	2
MSc/Mic/2/DSC1 A/B/C	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
	MOOC											
MSc/Mic/2/DSC2 3A/3B	3	2	1.61	2	1.5	1.75	2	2	3	2	2	2
	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
MSc/Mic/2/CC10	3	2	1.5	2	2	2	2	2	3	2	2	2
MSc/Mic/2/SEC1	2.5	2	2	1.5	1.75	1.5	1.5	2	2.5	2	1.5	2
Semester-III												
MSc/Mic/3/CC11	3	2	1.5	2	1.5	1.75	1.75	2	3	1.75	1.75	2
MSc/Mic/3/CC12	3	2	1.5	2	1.75	1.62	1.5	2	3	2	2	2
MSc/Mic/3/DSC3 A/B/C	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
	3	2	1.5	2	2	2	1.75	2	3	2	2	2
	MOOC											
MSc/Mic/3/DSC4 A/B/C	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
	MOOC											
MSc/Mic/3/SEC2	3	2	2	2	1.5	2	3	2	3	2	2	1.5

MSc/Mic/3/SEC3	3	2	1.5	2	1.75	1.75	1.75	2	3	2	2	2
MSc/Mic3/CC13	2.5	2	1.5	2	1.5	1.5	1.5	2	2.5	3	2	2
MSc/Mic/3/SEC4	Non-credit											
Semester-IV												
MSc/Mic/4/CC14	3	2	2	1.75	3	1.75	1.75	1.75	1.75	1.75	1.75	1.5
MSc/Mic/4/CC15	3	2	2	2	1.5	2	3	2	3	2	2	1.75
MSc/Mic/4/SEC5	3	1.5	2	1.75	1.75	2	1.75	2	3	2	2	2
MSc/Mic/4/SEC6	3	2	1.5	2.12	1.75	2	1.75	2	3	2	2	2
MSc/Mic/4/DSC5 A/B/C	2.5	2	1.25	2	1.75	1.25	1.75	2	2.5	3	2	2
	2.5	2	1.25	2	1.75	1.25	1.75	2	2.5	3	2	2
	MOOC											
Average	2.93	1.98	1.57	1.99	1.72	1.75	1.87	1.99	2.85	2.13	2.01	1.94

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4.1 Attainment of COs:

Table No. 8: CO Attainment Levels for a Semester Examination of a course

Attainment Level	
1 (Low level of attainment)	50% of students obtained letter grade of A or above (for CBCS programs) or score more than 60% of marks (for non-CBCS programs) of a course.
2 (Medium level of attainment)	60% of students obtained letter grade of A or above (for CBCS programs) or score more than 60% of marks (for non-CBCS programs) of a course.
3 (High level of attainment)	70% of students obtained letter grade of A or above (for CBCS programs) or score more than 60% of marks (for non-CBCS programs) of a course.

The CO attainment level for all the courses of the program can be obtained in a similar manner.

4.2 Calculation of Attainment values of POs and PSOs:

PO attainment value (for example for PO1) for a course (e.g. CC1) can be obtained as follows:

$$\text{AV for PO1} = \frac{(\text{MFCPO1})\text{X CO attainment value for the course CC1 (as per table 8)}}{3}$$

Where, AV = Attainment value
MFCPO1 = Mapping factor for course CC1 with PO1 as obtained from table 7

Likewise, PSO attainment value (for example for PSO1) for a course can be obtained as follows:

$$\text{AV for PSO1} = \frac{(\text{MFCPSO1})\text{X CO attainment value for the course (as per table 8)}}{3}$$

Where, AV = Attainment value
MFCPSO1 = Mapping factor for a course with PSO1 as obtained from table 7

After finding the attainment values of each PO and PSO for various courses, we may write them in table form as given below:

Table No. 9: The calculated PO and PSO Attainment Values for all the courses

Course Code	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4
Semester-I												
MSc/Mic/1/CC1												
MSc/Mic/1/CC2												
MSc/Mic/1/CC3												
MSc/Mic/1/CC4												
MSc/Mic/1/CC5												
MSc/Mic/1/CC6												
Semester-II												
MSc/Mic/2/CC7												

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MSc/Mic/2/CC8												
MSc/Mic/2/CC9												
MSc/Mic/2/DSC1 A/B/C												
MSc/Mic/2/DSC2 A/B												
MSc/Mic/2/CC10												
MSc/Mic/2/SEC1												
Semester-III												
MSc/Mic/3/CC11												
MSc/Mic/3/CC12												
MSc/Mic/3/DSC3 A/B/C												
MSc/Mic/3/DSC4 A/B/C												
MSc/Mic/3/SEC2												
MSc/Mic/3/SEC3												
MSc/Mic/3/CC13												
MSc/Mic/3/SEC4												
Semester-IV												
MSc/Mic/4/CC14												
MSc/Mic/4/CC15												
MSc/Mic/4/SEC5												
MSc/Mic/4/SEC6												
MSc/Mic/4/DSC5 A/B/C												
Average												

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The attainment of POs and PSOs is the average of individual PO and PSO attainment values. The PO and PSO attainment values obtained above will be compared with set target. The set target for each PO and PSO may be different and can be finalized by the staff councils of the departments/institutes as described in the following table:

Table No. 10: PO and PSO Attainment Values and Set Target values

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
PO attainment Values	2.75	1.96	1.68	1.86	1.74	1.71	1.88	1.94	2.71	2.05	2.03	2.02
Target Values	2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2	2	2	2

If PO and PSO attainment value is less than the set target value then an action plan may be prepared for improvement in the subsequent academic session.

6. Course-wise contents details

The course-wise contents details are presented on following pages:

M.Sc. Microbiology-1st Semester
MSc/Mic/1/CC1 General Microbiology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. Theory: 70; IA: 30

Objectives: The objective of this course is to introduce students to the field of Microbiology with special emphasis on historical developments in microbiology, microbial systematics & diversity, microbial interactions and their applications.

Course outcomes (COs): After successful completion of this course, students should be able to:	
CO1	Understand the historical developments and analyze the scope and importance of microbiology,
CO2	Exhibit the knowledge for classification, nomenclature and identification of microorganisms and their diversity.
CO3	Learn about microbial cultures, methods of sterilization and microbial growth and interactions.
CO4	Demonstrate Application of microbes in industrial, agricultural and medical sector.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each coveringthe whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT I

Introduction: History of development of Microbiology; Scope and applications of microbiology; Beneficial and harmful microbes; Contribution of pioneer microbiologists; Structural organization of prokaryotic and eukaryotic cells; General features of microorganisms - Bacteria, Algae, Fungi and Protozoa; The spontaneous generation controversy; Germ theory of disease; Koch's postulates.

UNIT II

Biodiversity of microbes: Biodiversity of microbes; Microbes in different environments (Air, water, soil) and extreme environment (thermophilic, methanogenic and halophilic); Photosynthetic bacteria; bio-aerosols, Aeroallergens; Basic principles and techniques used in bacterial classification and identification; Binomial Nomenclature.

Classification of microbes: Whittaker's five kingdom classification; Haeckel's three kingdom classification; Woese's three kingdom classification; Different groups of acellular microorganisms - viruses, viriods and prions; Classification of bacteria, Algae, Fungi and Protozoa; Bergey's Manual.

UNIT III

Methods of studying micro-organisms: Culture media, Sterilization (physical and chemical methods), Biochemical techniques, Aseptic techniques, Micrometery, Microscopy (light, confocal and electron).

Bacterial growth and interaction: Bacterial growth and metabolism, Interactions of micro-organisms (mutualism, symbiosis, commensalism, predation, parasitism, amensalism,

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competition);Concept of rizosphere, mycorhizosphere and actinorrhizae; biogeochemical cycles.

UNIT IV

Applied microbiology: Application of microbes in industrial, agricultural and medical sector; Biodegradation; Biofilms; Cleaning oil spills; Microbes in composting; Biocontrol agents; Bioremediation; Bioleaching; Microbial enzymes and fermented food production; Sewage treatment; Bioluminescence; Human, animals and plant diseases and their causative agents.

Suggested readings:

1. Atlas RM (1997). Principles of Microbiology, Wm C Brown Publishers, USA.
2. Brock TD (1961). Milestones in Microbiology, Infinity Books.
3. Madigan MT, Martinko JM, Parker J (2015). Brock Biology of Microorganisms, 14th edition, Pearson Education Ltd, Prentice-Hall, Englewood Cliffs, NJ, Inc USA.
4. Pelczar MJ, Chan ECS, Kreig NR (1993). Microbiology: Concepts and Application, 5th edition, Tata McGraw Hill, New Delhi.
5. Prescott, L.M. et al. (2005).Microbiology, McGraw Hill International Edition, USA.
6. Stanier RY, Ingraham JL, Wheelis ML, Painter PR (1976). General Microbiology, 4th edition, MacMillan, New Jersey, USA.

Research/Review Papers:

1. Kolter, R. (2021). The History of Microbiology—A Personal Interpretation. *Annual Review of Microbiology*, *75*.
2. Early, R., & Tamime, A. Y. (2017). Microbial Toxins–An Overview. *MicrobialToxins in Dairy Products*, 1.
3. Velavan, T. P., & Meyer, C. G. (2020). The COVID-19 epidemic. *Tropical medicine& international health*, *25*(3), 278.

On-line Resources

1. https://www.brainkart.com/article/Contributors-to-Microbiology_35211/
2. https://nios.ac.in/media/documents/dmlt/Microbiology/Lesson-01.pdf
3. https://micro.cornell.edu/research/epulopiscium/bacterial-endospores/
4. https://www.lekarski.umed.wroc.pl/sites/default/files/mikrobiologia/files/STERILIZATION_and_DESINFECTION_1.pdf

CO, PO, PSO matrix of MSc/Mic/1/CC1												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	1.5	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2.5	1.5	2	2.5	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2.125**	**1.5**	**1.75**	**1.875**	**2**	**3**	**2**	**2**	**2**

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M.Sc. Microbiology-1st Semester MSc/Mic/1/CC2
Microbial Physiology and Metabolism

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. Theory: 70; IA: 30

Objectives: To develop the understanding of microbial physiology with specific emphasis on different metabolic pathways.

Course outcomes (COs): At the end of the course, the students will be able to:	
CO 1	Gain fundamental knowledge of metabolism of carbohydrates, generation of energy and maintenance of blood glucose level in the body.
CO 2	Understand the oxidation and biosynthesis of fatty acids with special emphasis on synthesis of lipids and cholesterol
CO 3	Gain the knowledge about metabolism of amino acids and release of urea from the body.
CO 4	Acquire the knowledge about movement of electron in respiratory chain and generation of energy through phosphorylation.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each coveringthe whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT I

Microbial growth - Definition balanced and unbalanced growth, growth curve, generation time, specific growth rate, batch and continuous culture, synchronous growth, diauxic growth curve; Effect of physical and chemical factors on growth; Composition, structure, and biosynthesis of bacterial cell wall of gram positive and gram negative bacteria.
Movements in microorganisms - flagella, cilia, pseudopoda, gas vesicles, magnetosomes.

UNIT II

Nutrition in microbes - Nutritional categories of microorganisms based on carbon and energy sources; Autotrophy - oxygenic, anoxygenic photosynthesis; Autotrophic generation of ATP; Fixation of CO2; Calvin cycle pathway. Chemolithotrophy - Sulphur, iron, hydrogen, nitrogen oxidations; Methanogenesis; Luminescence.
Transportation of metabolite: passive and facilitated, primary and secondary active transport, group translocation (phosphotransferase system), symport, antiport and uniport, electrogenic and electroneutral transport, transport of iron.

UNIT III

Respiratory metabolism - Embden-Mayer Hoff pathway, Entner Doudroff pathway, Pentose phosphate pathway, Krebs cycle, Branched TCA cycle, Reverse TCA cycle, Glyoxalate pathway, Oxidative and substrate level phosphorylation, Gluconeogenesis, Pasteur effect; Fermentation of carbohydrates - homo and heterolactic fermentations; Halophiles and ATP synthesis.

Physiological Adaptation and intracellular signaling: Introduction to two component system, Response to physiological stress: FNR regulon, osmotic homeostasis, Response to nutritional stress: phosphate supply- pho regulon. Stringent response.

UNIT IV

Biosynthesis of major components used in cell metabolism: biosynthesis of peptidoglycan, polysaccharides, major amino acids, polyamines, lipids, nucleotides - purines and pyrimidines; Assimilation of nitrogen.

Reproduction in microbes: Microbial Differentiation, Sporulation and morphogenesis, Dormancy and germination; Cell division cycle in E. coli and yeast.

Suggested Readings:

1. Caldwell D.R. (1995). Microbial Physiology and Metabolism. Brown Publishers.
2. Doelle HW (1969). Bacterial Metabolism, Academic Press, USA.
3. Gottschalk G (1979). Bacterial Metabolism, Springer Verlag, New York, USA.
4. Moat AG (1979). Microbial Physiology, John Wiley & Sons, New York, USA.
5. Moat AG, Foster J W, Spector M P (2009). Microbial Physiology, 4th edition, Wiley India Pvt Ltd, Country.
6. Sokatch JR (1969). Bacterial Physiology and Metabolism, Academic Press, USA.

CO, PO, PSO matrix of MSc/Mic/1/CC2												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	1.5	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2.5	1.5	2	2.5	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2.125**	**1.5**	**1.75**	**1.875**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology-1st Semester
MSc/Mic/1/CC3 Principle of Biochemistry

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. Theory: 70; IA: 30

Objectives: The objective of the course is to introduce students to the world of basic biochemistry. This course covers structure and function and metabolism of biomolecules, and details of physical chemical basis of biomolecules involved in life processes.

Course outcomes (COs): At the end of this course, students will be able to:	
CO1	Understand cellular, organism basis and role of biomolecules in living Organisms.
CO2	Gain the fundamental knowledge about structure and functional relationships of biomolecules (proteins) significant to health of living beings.
CO3	Gain fundamental knowledge of metabolism of carbohydrates and generation of energy to carry out the daily life processes.
CO4	Know the role of the enzymes, vitamins in biochemical reaction and hormones to coordinate the body activities.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT I

General concept: Scope and importance of biochemistry; Fundamental principles governing life; Structure of water; Acid base concept and buffers; pH; Hydrogen bonding; Hydrophobic, electrostatic and Vander Waal forces; General introduction to physical techniques for determination of structure of biopolymers.

UNIT II

Biomolecules: Classification, structure and function of carbohydrates, lipids, amino acids and proteins; Types of nucleic acid, their structure and functions. Vitamins and their role as co-enzymes

UNIT III

Enzymes: Classification, mechanism of action; Factors affecting enzyme action; Immobilized enzymes; Hormones; Ribozyme and abzyme; Thermodynamic principles and biological processes, Bioenergetics.

UNIT IV

Metabolism: Catabolic principles & breakdown of carbohydrates and anaplerotic reaction. β-oxidation of fatty acids. Deamination of amino acids and urea cycle. Biosynthesis of lipids-fatty acids. Triacyl glycerol, phospholipids. Denovo and salvage pathways of synthesis of purine and pyrimidine.

Suggested readings:

Books:

1. Lehninger; Principle of Biochemistry, 8th Edition by David L. Nelson and M.M Cox[2021]

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Free and company. New York.
2. Fundamental of Biochemistry. D. Voet and J. G. Voet [2013] John Wiley and SonsNew York.
3. Biochemistry 9th Edition by L. Stryer [2019], W.H Freeman and New York
4. Biochemistry 6thEdition by R.H Garrett and C.M. Grisham [2017] Saunders college Publishing, New York
5. Biochemistry 4th edition by G. Zubay [1998] Wm .C Brown Publishers.
6. Outline of Biochemistry by Conn E.E, Stumpf P.K. Bruening G. and Dvi R.H [1999]John Wiley and Sons Inc New York and Toronto.
7. Fundamental of Biochemistry by J.L. Jain, Sanjay Jain, Nitin Jain (2004) S. Chand & Company Ltd.

Research/Review Papers:

1. Shakya, A. K. (2020). Unit-7 Polysaccharides. Indira Gandhi National Open University, New Delhi.
2. Postnikova, G. B., & Shekhovtsova, E. A. (2016). Hemoglobin and myoglobin as reducing agents in biological systems. Redox reactions of globins with copper and iron salts and complexes. *Biochemistry (Moscow)*, *81*(13), 1735-1753.
3. Kumar, G. A., & Chattopadhyay, A. (2016). Cholesterol: an evergreen molecule in biology. *Biomedical Spectroscopy and Imaging*, *5*(s1), S55-S66.
4. Shakya, A. K. (2020). Unit-12 Vitamins. Indira Gandhi National Open University, New Delhi.

On-line Resources

1. https://www.patnauniversity.ac.in/econtent/science/zoology/Carbohydrate(PG)_BiochemistryCC7_Zoology_Gajendra%20Azad.pdf
2. http://eagri.org/eagri50/BIC101/pdf/lec12.pdf
3. https://comis.med.uvm.edu/VIC/coursefiles/MD540/MD540-Protein_Organization_10400_574581210/Protein-org/Protein_Organization_print.html
4. https://www.onlinebiologynotes.com/classification-of-lipid/
5. https://www.ncbi.nlm.nih.gov/books/NBK26821/

CO, PO, PSO matrix of MSc/Mic/1/CC3												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

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M. Sc. Microbiology – 3rd
Semester MSc/Mic/3/CC4
Microbial Genetics

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. Theory: 70; IA: 30

Objectives: The objective of this course is to introduce students to the field of Microbial genetics with special emphasis on overview of an microbial genetics, Concept of gene and DNA repair mechanism and genetic analysis of bacteria and their test, Bacterial genetics: transformation, conjugation and transduction and virus genetics.

Course outcomes (COs): After successful completion of this course, students should be able to:

CO1	Understand the overview of microbial genetics, experimental proof of DNA and RNA as genetic material and its properties, Molecular organization of bacterial and viral chromosomes.
CO2	Exhibit the knowledge for Gene, Molecular concept of gene and mechanism of gene and DNA repair mechanism.
CO3	Genetic analysis of bacteria mutation analysis, types of mutation, isolating and selecting mutants, Complementation tests, recombination tests and gene replacements. Cloning genes by complementation. Cloning genes by marker rescue
CO4	Gain the knowledge of Bacterial Genetics: Transformation, Conjugation, and Transduction and Viral genetics :

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT 1

Essential of genetics: A brief Overview of Microbial genetics; Beginning of experimental proof of DNA**:** Transforming principle contribution of Griffith, Macleod, Avery, McCarty, Hershey and Chase. RNA as a genetic material, DNA and RNA structure, different types of DNA, Denaturation and Renaturation Kinetics , Cot value, DNA polymerases , Proof reading activity , C- value paradox,Superhelicity in DNA, Linking No. Topological Properties.

Molecular Organizations of Chromosomes: Viral and bacterial chromosomes, Nucleosome and chromatin structure, Structure of centromere and telomere, Euchromatin andheterochromatin, Polytene and lamp brush chromosomes, Genome complexity.

UNIT 2

Gene Concept: Classical concept, Fine structure of the gene, Molecular concept of the gene, Pseudogenes, Overlapping genes, Oncogenes, Repeated genes, Gene amplification.

Mutation: Molecular mechanism of spontaneous mutations, Molecular mechanism of mutations

induced by known chemical mutagens, DNA repair mechanisms - excision, mismatch, SOS, photo-reactivation, recombination repair and glycocylase system., Molecular mechanism of suppression, Somatic mutations.

UNIT 3

Genetic analysis of bacteria: Importance and uses of mutation analysis. Inheritance in bacteria, types of mutations, spontaneous and induced mutagenesis, isolating mutants, selecting mutants, mutant enrichment. Reversions versus suppression.

Complementation tests, recombination tests and gene replacements. Cloning genes by complementation. Cloning genes by marker rescue.

UNIT 4

Bacterial Genetics: **Transformation, Conjugation, and Transduction**

Natural transformation and competence. Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Regulation of competence in *B.subtilis*. Importance of natural transformation. Artificially induced competence. Generalized versus specialized transduction - T4 and lambda phage. Mapping bacterial genes by transduction.

Viral Genetics Lytic cascade and lysogenic repression.

Suggested readings:

Books:

1. Molecular Genetics of Bacteria by L. Snyder, J. Peters, T. Henkin, W. Champness [2013] 4th edition. ASM Press.
2. Lewin's GENES XII by Krebs JE, Elliott S and Goldstein (2017) 12th ed. Jones and Bartlett Publishers. ISBN: 9781284104493.
3. Concepts of Genetics by Klug, Cummings and Spencer (2016) 10th ed. Pearson Education India. ISBN: 9332577463.
4. Microbial Diversity in the Genomic Era by Das S and Dash HR (2018) 1st ed. Academic Press, ISBN: 9780128148495.
5. Principles of Genetics by Gardner, Simmons and Snustad (2010) 8thed. Wiley India Pvt Ltd ISBN: 9788126510436.
1. Mining of Microbial Wealth and MetaGenomics Kalia VC, Shouche Y, Purohit HJ and Rahi P (2017) 1st ed. Springer Nature Singapore Pte Ltd. ISBN: 9789811057076.

Research/Review Papers:

1. Falk, R. (2010). What is a gene?—Revisited. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, *41*(4), 396-406.
2. Brady, A., Felipe-Ruiz, A., Gallego del Sol, F., Marina, A., Quiles-Puchalt, N., & Penadés, J. R. (2021). Molecular basis of lysis-lysogeny decisions in Gram-positive phages.
3. Thierauf, A., & Perez, G. (2009). Generalized transduction. In *Bacteriophages* (pp. 267-286). Humana Press.
4. Erasimus, H., Gobin, M., Niclou, S., & Van Dyck, E. (2016). DNA repair mechanisms and their clinical impact in glioblastoma. *Mutation Research/Reviews in Mutation Research*, *769*, 19-35.
5. Zhang, Y., Pan, V., Li, X., Yang, X., Li, H., Wang, P., & Ke, Y. (2019). Dynamic DNA structures. *Small*, *15*(26), 1900228.

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On-line Resources:

1. https://www.scienceabc.com/pure-sciences/avery-macleod-and-mccarty-hershey-chase-dna-experiments.html
2. https://microbenotes.com/dna-structure-properties-types-and-functions/
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4168728/
4. https://www.biologyexams4u.com/2013/02/cot-value-and-cot-curve-analysis.html
5. differencebetween.com/difference-between-reversion-and-suppression-mutation
6. https://agrilife.org/gold/files/2012/08/Lecture-18.pdf

CO-PO-PSO Matrix of MSc/Mic/3/CC4												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.25	1.5	2	2	3	3	3	2
CO2	3	2	1	2	1.5	1.5	1.5	2	3	3	3	2
CO3	3	2	1	2.5	1.5	2	1.5	2	3	3	3	2
CO4	3	2	1.5	2.5	1.75	2	2	2	3	3	3	2
Average	**3**	**2**	**1.25**	**2.25**	**1.5**	**1.75**	**1.75**	**2**	**3**	**3**	**3**	**2**

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M.Sc. Microbiology-1st Semester

MSc/Mic/1/CC5- General Microbiology, Physiology and Metabolism

Credits: 4 (Lab Hrs: 120) **Marks: 100**

Duration of exam: 4 Hrs. Theory: 70; IA: 30

Course Outcomes (COs):After completion of this Lab. course, students will be able to:	
CO1	knowledge about various technique for growth of microorganism-pouring, spreading, streaking and preparation of different type of culture media
CO2	Understanding the various factor- incubation temperature and time, pH, salt, U.V. and nutritional sources for microbial growth
CO3	Able to measure the total number of colony, motility of microbe and also different type of growth
CO4	Identify the metabolic pathway product and biochemical characterization

Practical's in Basic Microbiology

1. Preparation of liquid and solid culture media for growth of microorganisms.
2. Pure Culture Techniques: Streak plate, pour plate, spread plate. Preparation of slants andstab cultures. Storage of microorganisms
3. Isolation and enumeration of microorganisms from soil and water and biochemical characterization of selected microbes
4. Microscopic examination of bacteria, actinomycetes, algae, fungi and protozoa
5. Measurement of microbial growth and study of effect of various factors on growth ofmicroorganisms: temperature, pH, U.V. and carbon and nitrogen sources on growth.
6. Isolation of thermophiles from compost.

Microbial Physiology and Metabolism

1. Use of simple techniques in laboratory (Colorimetry, Centrifugation; Electrophoresis and TLC)
2. Measurement of the size of bacterial cell
3. Motility of bacterial cell (Hanging drop method)
4. Staining of microorganism (gram staining, capsule staining, acid fast staining)
5. Measurement of viable and total number of cell in a culture
6. Measurement of Growth – types of growth (synchronous, diauxic)
7. Study of bacterial growth under aerobic, micro aerophilic and anaerobic conditions
8. Fermentation of simple carbohydrates
9. Extra cellular enzyme of bacteria
10. Identification of product of metabolic pathway
11. Biochemical characterization of bacterial culture: catalase, urease, cytochrome oxidase

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12. Perform IMVIC Test
13. Production of amino acids and vitamins by microorganisms.

Suggested Readings:

Text/ReferencesBooks:

1. Laboratory Manual In Microbiology by P. Gunasekaran [2007], New Age International, ISBN: 8122407838, 9788122407839
2. Microbiology Applications – (A Laboratory Manual in General Microbiology) by Benson H.J., Wm C Brown Publishers
3. Microbes in Action: A Laboratory Manual of Microbiology by Harry W, Seeley, Paul JV, John J, (1990) 4th Addition, W. H. Freeman ISBN: 978-0716721000
4. Laboratory Manual of Microbiology and Biotechnology by Aneja KR (2014) 1st ed., Scientific International Pvt., Ltd. ISBN: 9789381714553.
5. Microbiology: A Laboratory Manual by Cappuccino, JH, Sherman, N., (2017) 11th ed., Pearson Education Inc, ISBN: 9780134298597

Research/ReviewPapers:

1. Lagier, J. C., Dubourg, G., Amrane, S., & Raoult, D. (2017). Koch postulate: why should we grow bacteria?. *Archives of Medical Research*, *48*(8, SI), 774-779.
2. MV, K., & Kharat, A. R. ISOLATION, IDENTIFICATION AND BIOCHEMICAL CHARACTERIZATION OF HYDROCARBON DEGRADING MICROORGANISM FROM CONTAMINATED SITES OF KOPARGAON, MAHARASHTRA.
3. Bhattacharyya, S., Prasad, A., Sarfraz, A., Jaiswal, N. K., & Kumar, R. (2015). Evaluation of a new method for Gram staining of bacteria. *Med. Sci*, *18*(73), 16-17.
4. Kaviyarasan, G. P., Shricharan, S. P., & Kathiravan, R. P. (2020). Studies on isolation, biochemical characterization and nitrogen fixing ability of Azotobacter sp. isolated from agricultural soils. *International Journal of Scientific Engineering and Applied Science (IJSEAS)–6*, 11-118.

On-line Resources:

1. https://microbenotes.com/imvic-tests/
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3335093/
3. https://youtu.be/ujzSmsmg7ok
4. https://www.micro.iastate.edu/video/microbiology-007-carbohydrate-fermentation-test
5. https://www.sigmaaldrich.com/IN/en/applications/microbiological-testing/microbial-culture-media-preparation
6. https://microbenotes.com/streak-plate-method-principle-methods-significance-limitations/

CO,PO,PSO matrixofMSc/Mic/1/CC5												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	2	2	2	2
CO2	3	2	1.5	3	2	1.5	1.5	2	2	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	2	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	1.5	2	2	2
Average	**3**	**2**	**1.5**	**2.25**	**1.75**	**1.75**	**1.75**	**2**	**1.87**	**2**	**2**	**2**

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M.Sc. Microbiology-1st Semester
MSc/Mic/1/CC6 Lab Biochemistry & Molecular Biology

Credits: 4 (Lab Hrs: 120) Marks: 100
Duration of exam: 4 Hrs.

Course Outcomes (COs): After completion of this Lab. course, students will be able to:	
CO1	Identify various laboratory equipments and describe their functioning
CO2	Prepare various solutions, reagents needed in the estimation of proteins, lipids, carbohydrates as well as for isolation of DNA, RNA and proteins
CO3	Carry out experiments of Thin Layer Chromatography, Agarose Gel Electrophoresis and spectrophotometry
CO4	Check enzymatic activity in different conditions and run PAGE set up

Biochemistry

1. Introduction to various instruments and their working principles used in biochemistrylaboratory.
2. Qualitative estimation of amino acids and proteins.
3. Qualitative estimation of lipids.
4. Qualitative estimation of carbohydrates.
5. Quantitative estimation of protein by Lowry's method.
6. Determination of total soluble sugars by ferricyanide method (Volumetric procedure)
7. Separation of various components in the different lipid fraction by thin layer chromatography.
8. To measure the activity of enzyme (alpha-amylase) or any other enzyme.
9. To study the effect of temperature on enzyme activity.
10. To study the effect of substrate concentration on enzyme activity.

Molecular Biology

1. Introduction to various instruments and their working principles used in Molecular Biology laboratory.
2. Preparation of normal and molar solutions, buffers, pH setting etc.
3. Isolation of genomic DNA from bacteria.
4. Isolation of genomic DNA from plant/animal source.
5. Checking quality and quantity of DNA.
6. Gel electrophoretic separation of nucleic acids.
7. Molecular size determination of DNA samples by Agarose gel electrophoresis.
8. Isolation of total RNA.
9. Isolation of proteins.
10. Polyacrylamide Gel Electrophoresis (PAGE) for separation of Proteins.

Suggested Readings:

Text/References Books:

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1. Experiments in Microbiology, Plant Pathology and Biotechnology 4th Edition. Aneja,K.R. (2010) New Age International Publishers, New Delhi.
2. Introductory practical biochemistry by S. K. Sawhney and Randhir Singh (2000)-Narosha Publishing House, New Delhi.
3. Principles and techniques of practical biochemistry by K. Wilson and Wolker (1994)Cambridge University Press, Cambridge.
4. Sambrook J, EF Fritech and T. Maniatis (2000) Molecular Cloning: A laboratoryManual, cold spring Harbor Laboratory Press, New York.
5. Glover DM and BD Hames (2006), DNA cloning: A practical Approach, IRL Press,Oxford.
6. Priyanka Siwach and Namita Singh (2007) Molecular Biology, Theory and Practices,Laxmi Publication.
7. Lodish et al., Molecular Cell Biology Freeman and Company 2016.

On-line Resources:

1. https://labmonk.com/estimation-of-protein-by-folin-lowry-method
2. https://sciencing.com/effects-temperature-enzyme-activity-biology-6049.html
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3841988/

CO, PO, PSO matrix of MSc/Mic/1/CC6												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

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M.Sc. Microbiology-2nd Semester

MSc/Mic/2/CC7- Bacteriology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: - 3 Hrs. **Theory: 70; IA: 30**

Objective: The objective of the course is to make the students understand the nature, fields and scope of bacteriology, and to make them aware about various career options.

Course outcomes (COs): At the end of the course, the students will:	
CO1	Have the understanding of the nature,
CO2	To understand pathogenic bacteria their diagnosis and related disease
CO3	To understand pathogenic fungi their diagnosis and related disease
CO4	To understand various virus, their diagnosis and related disease

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

UNIT 1

Bacteria: General characteristics of bacteria. Bacterial growth, Synchronous growth, Continuous culture Measurement of growth, Cell division and reproduction.

Isolation & identification of bacteria, the low G+C Gram Positive Bacteria: Clostridia, Mollicutes, Bacilli. The high G+C Gram Positive Bacteria; *Actinobacteria*, *Planctomycetes*, *Spirochetes*, *Fibrobacters*, *Bacteriodes*, *Fusobacteria*, Anaerobic Bacteria of Medical Importance which includes Spore and non-spore forming bacteria.

UNIT 2

Gram negative bacilli-I: A detailed account of cultural and morphological characteristics, pathogenicity, clinical manifestations and laboratory diagnosis of *Pseudomonas aeruginosa* and Vibrio, *Haemophilus influenzae* and *Campylo bactorjejuni*

Gram negative bacilli-II: A detailed account of cultural and morphological characteristics, pathogenicity, clinical manifestations and laboratory diagnosis of *Bordetella pertussis* and *Yersinia pestis, Bacteroides and Helicobacter pylori*

UNIT 3

Miscellaneous bacteria-I: A detailed account of cultural and morphological characteristics, pathogenicity, clinical manifestations and laboratory diagnosis of Mycoplasma and Rickettsia, *Ehrlichia,Chlamydiae* and *Moraxella catarrhalis*

Miscellaneous bacteria-II: A detailed account of cultural and morphological characteristics, pathogenicity, clinical manifestations and laboratory diagnosis of Actinomycetes (Actinomyces and Nocardia) and Spirochaetes (Treponema, Borrelia, Leptospira), Brucellae and Listeria monocytogenes

UNIT 4

A detailed account of cultural and morphological characteristics, pathogenicity, clinical manifestations and laboratory diagnosis of Entero bacterifamilies like *E.Coli* and Klebsiella, Shigella and Salmonella, Proteus and Acinetobacter,

Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis). Molecular principles of drug targeting. Drug delivery system in gene therapy Bacterial resistance to antibiotics. Mode of action of bacterial killing by quinolinones. Bacterial resistance to quionolinones. Mode of

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action of non – antibiotic antimicrobial agents.

Suggested Readings:

Text/Reference Books:

1. Ananthanarayan, R. (2006). Ananthanarayan and Paniker's textbook of microbiology. Orient Blackswan
2. Panjarathinam R. (2007). Medical microbiology.New Age International.
3. Kumar, S. (2012). Textbook of microbiology. JP Medical Ltd.
4. Willey, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott's Microbiology 9th Edition, McGraw Hill Education, (2014).
5. Tortora, G. J., Funke, B. R., & Case, C. L. (2007). Microbiology: an introduction (p. 912). San Francisco, CA: Pearson Benjamin Cummings.
6. Holt,J.G., Krieg, N.R., Sncath, P.H.A., Atalay, J.T.. and William, S.T. (Eds) Bergey's Manual of Determinative Bacteriology, 9th Edition (William R.Hensyl Ed)
7. Davis, B.D. Delbecco. R. Eisen, H.N. Ginsberg. H.S. and Wood, W.B. Jr. Microbiology, Harper & Row, 2006
8. Stanier, R.Y., Ingraham, J.L. Wheelis, M.L. and Painter, P.R. General Microbiology, Mac. Millan Press Ltd. U.K., 2005.

Research/Review Papers:

1. https://doi.org/10.1111/j.1600-0463.1948.tb06699.x
2. Zhang W, Hu E, Wang Y, Miao S, Liu Y, Hu Y 3rd, Liu J, Xu B, Chen D, Shen Y. Emerging Antibacterial Strategies with Application of Targeting Drug Delivery System and Combined Treatment. Int J Nanomedicine. 2021 Sep 3;16:6141-6156. doi: 10.2147/IJN.S311248. PMID: 34511911; PMCID: PMC8423451

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/books/NBK8326/
2. https://www.cdc.gov/cholera/pdf/laboratory-methods-for-the-diagnosis-of-vibrio-cholerae-chapter-6.pdf

CO-PO-PSO Matrix of MSc/Mic/2/CC7												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	1	2	3	2	3	2	2	1.5
CO2	3	2	2	2	1	2	3	2	3	2	2	1.5
CO3	3	2	2	2	1.5	2	3	2	3	2	2	1.5
CO4	3	2	2	2	1.5	2	3	2	3	2	2	1.5
Average	**3**	**2**	**2**	**2**	**1.25**	**2**	**3**	**2**	**3**	**2**	**2**	**1.5**

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M.Sc. Microbiology- 2nd Semester
MSc/Mic/2/CC8 Virology

Credits: 4 (Lectures: 60) **Marks: 100**
Time: 3 Hrs. Theory: 70; IA: 30

Objectives: The objective of the course is to understand virology by examining common processes and principles in viruses to illustrate viral complexity and molecular biology of viral reproduction. The course will teach the strategies by which viruses spread within a host, and are maintained within populations. It also addresses the interplay between viruses and their host organisms.

Course outcomes (COs): By the end of the course, the student:	
CO 1	Is able to describe the isolation, purification, cultivation and classification of viruses
CO 2	Is able to explain the lytic and lysogenic cycle in phages, regulation of transcription and phage therapy.
CO 3	Is able to explain the modes of transmission of plant and animal viruses, viral multiplication and replication strategies.
CO 4	Is able to understand the about the various types of diseases caused by viruses in human, animals and plants.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT I

General virology: Discovery and general characteristics of viruses; Capsid symmetry; Enveloped and nonenveloped viruses; Isolation, purification and cultivation of viruses; Viral taxonomy - classification and nomenclature of different groups (animal viruses and plant viruses) of viruses; Basic understanding of viroids, virusoids, satellite viruses and prions.

UNIT II

Bacteriophages: Diversity and classification of bacteriophages; One step multiplication curve; Lytic and lysogenic phages (lambda phage); Concept of early and late proteins; Regulation of transcription in lambda phage; Phage therapy.

UNIT III

Molecular virology: Salient features of viral nucleic acid - Unusual bases (TMV, T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (Lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (Retrovirus), segmented genomes (Influenza virus), non-segmented genomes (Picornavirus), capping and tailing (TMV); Modes of transmission of plant and animal viruses; Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses; Replication of viruses as per Baltimore classification - assembly, maturation and release of virions.

UNIT IV

Disease caused by viruses and antiviral compounds: Polio, influenza, rabies, common cold, AIDS, hepatitis, chikungunya, dengue, ebola, foot and mouth disease, blue tongue disease, mad cow disease, bud necrosis, tobacco mosaic disease and cauliflower mosaic disease; Introduction to oncogenic viruses; Types of oncogenic DNA and RNA viruses; Mechanism of disease causation by plant

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viruses; Antiviral compounds and their mode of action; Interferon and their mode of action; Use of viral vectors in cloning, expression, and gene therapy.

Suggested Reading:

1. Introduction to Modern Virology, 6th edition by Dimmock NJ, Easton AL, Leppard KN (2007). Blackwell Publishing Ltd, UK.
2. Virology: Principles and Applications by Carter J, Saunders V (2007). John Wiley and
1. Sons, New York.
2. Principles of Virology, Molecular biology, Pathogenesis and Control, 2nd edition, Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). ASM press, Washington DC.
3. Basic Virology, 2nd edition by Wagner EK, Hewlett MJ (2004). Blackwell Publishing, UK.
4. Plant Virology by Hull R. Academic Press, New York.
5. A Color Atlas of Virology by Versteeg J (1985). Wolfe Medical Publication, New York

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7149719/
2. https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/late-protein
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7149683/

CO, PO, PSO matrix of MSc/Mic/2/CC8												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology- 2nd Semester
MSc/Mic/2/CC9 Mycology and Phycology

Credits: 4 (Lectures: 60) **Marks: 100**
Time: 3 Hrs. Theory: 70; IA: 30

Objectives: To build upon the knowledge about fungi and algae and their importance in biotechnology and ecosystem.

Course outcomes (COs): At the end of the course, the students will be able to:	
CO 1	Gain fundamental knowledge about basic cell structure, distribution, nutrition and reproduction of fungi.
CO 2	Understand the role of fungi in ecosystem and its biotechnological applications.
CO 3	Gain the knowledge about about basic cell structure, distribution, nutrition and reproduction of algae.
CO 4	Acquire the knowledge about role of algae in ecosystem and its biotechnological applications.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT I

Basic mycology: Cellular Organization of fungal cells in detail; Occurrence & distribution offungi, somatic structure, hyphal growth, nutrition; Classification of fungi; Reproduction in fungi, Sex hormones in fungi, Heterothallism, Heterokaryosis, Dimorphism in fungi. Life cycle of *Rhizopus, Aspergillus, Penicillium Cladosporium, Trichoderma, Saccharomyces, Phytophthora, Puccinia.*

UNIT II

Basic phycology : Cellular organization algae in detail, Occurrence and distribution of algae, Algal thallus structure, Characteristics, Algal nutrition, Classification and reproduction, Microalgae, lifecycle of microbiologically important taxa of Chlorophyceae, Phaeophyceae, Bacillariophyceae and Rhpdophyceae.

UNIT III

Fungal biotechnology and ecology: Fungal metabolites and their potential applications in food, agriculture, industry and environment; Fungi as symbionts; Biocontrol agents; Role of fungi in deterioration of biomolecules and biomaterials; Mycotoxins.

Fungi and ecosystem: saprophytes, fungi and bioremediation, parasitism, mutualism, and symbiosis with plants (Mycorrhiza) and animals, attack on fungi by other microorganisms.

UNIT IV

Algal biotechnology and ecology: Algae as pollution indicators and eutrophication agent; Role of algae in bioremediation; Algae in global warming and environmental sustainability; Cyanobacteria and selected microalgae in agriculture as biofertilizer; Importance of algae in production of algal pigments, biofuels, hydrogen production and important bioactive molecules, Lichens, Algal ecology.

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Suggested Readings:

1. Alexopolus CJ, Mims CW, Blackwell M (2002). Introductory Mycology, 4th edition, Wiley India Pvt. Ltd, India.
2. Barsanti L, Gualtieri P (2005). Algae, Anatomy, Biochemistry & Biotechnology,CRC press, Taylor & Francis, Florida, USA.
3. Carlile MS, Watkinson SC, and G. Gooday (2001). The Fungi, 2nd edition, Academic Press, New York.
4. Graham LE, Graham JM, Wilcox LW (2009). Algae, 2nd edition, BenjaminCummings, San Francisco.
5. Moore –Landcker , E.(1996).Fundamentals of the Fungi. Prentice Hall.
6. Sumbali G (2005). The Fungi, 2nd edition, Narosa Publishing India House, India.

Research/Review Papers:

1. Newbound, M., Mccarthy, M. A., & Lebel, T. (2010). Fungi and the urban environment: A review. Landscape and urban planning, 96(3), 138-145.
2. Sharma, P., & Sharma, N. (2017). Industrial and biotechnological applications of algae: a review. Journal of Advances in Plant Biology, 1(1), 01.
3. Manganyi, M. C., & Ateba, C. N. (2020). Untapped potentials of endophytic fungi: A review of novel bioactive compounds with biological applications. Microorganisms, 8(12), 1934.
4. Ścieszka, S., & Klewicka, E. (2019). Algae in food: A general review. Critical reviews in food science and nutrition, 59(21), 3538-3547.

On-line Resources

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4329327/
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8144266/
3. https://www.psaalgae.org/educational-materials
4. http://www.fungimag.com/

CO, PO, PSO matrix of MSc/Mic/2/CC9												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	3	3	2
CO4	3	2	1.5	2	1.5	2	2	2	3	3	3	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2.5**	**2.5**	**2**

M.Sc. Microbiology- 2nd Semester

MSc/Mic/2/DSC1-A Food and Dairy Microbiology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. Theory: 70: IA: 30

Objectives: The course will enable students to understand microflora associated with the food. It will teach the strategies to develop fermented food products. The role of microbes in food spoilage, preservation and various foodborne diseases will be discussed.

Course outcomes (COs): At the end of the course, the student	
CO 1	Gain the knowledge of major food borne out breaks and sources of contamination of foods.
CO 2	Knows traditional as well as modern food preservation techniques
CO 3	Gain the knowledge regarding microbes causing food intoxications and food-borne infections
CO 4	Is aware of fermentation protocols for production of milk, meat, fish and plant based fermented products

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT – I

History, Natural flora, factor affecting growth of M.Os: Historical development and major food borne outbreaks in the 21st Century. Natural flora and source of contamination of foods; Intrinsic (Nutrient contents, pH, moisture contents/water activity, antimicrobial barriers, Antimicrobial substances) and extrinsic factors (relative humidity, temperature, gaseous atmosphere) that affect growth and survival of microbes in foods.

UNIT – II

Microbial spoilage of foods: Microbiology of spoilage of bread, cakes, fruits, vegetables, juices, bottled water, milk, meat and meat products, canned foods, sausages, poultry, eggs, sea foods and fish.

Food preservation: Physical methods–temperature (low, high, canning and drying), dehydration, water availability, lyophilisation, osmotic pressure, filtration, irradiation; Chemical methods- salt, sugar, organic acids, SO_2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins

UNIT – III

Food borne intoxication and infections- Major differences and examples of infective and toxic types, Botulism, Staphylococcal food poisoning, *Clostridium perfringens* food poisoning, *Bacillus cereus* gastroenteritis, Salmonellosis, *Escherichia coli* diarrhea, colitis and *Vibrio cholerae*. Fungal poisonings: *Aspergillus, Penicillium, Claviceps, Fusarium*, Protozoan poisoinings: Amoebiasis (*Entamoeba histolytica*), Giardiasis (*Giardia lamblia*). Conventional and recent methods for detection of food-borne pathogens.

UNIT – IV

Fermented foods: Sauerkraut, soy sauces, tempeh, pickles, silage, bread, baker's yeast, yogurt, curd, kefir, kumiss and cheese. Probiotics and prebiotics -health benefits, types of microorganisms used, probiotic foods available in the Indian market

Suggested readings:

Text/Reference Books:

1. New Methods of Food Preservation by Gould GW (1995). Blackie Academic and Professional, London, UK.
2. Modern Food Microbiology, 7th edition by Jay JM, Loessner MJ, Golden DA (2005). CBS
3. Publishers and Distributors, Delhi, India.
5. The Microbiological Safety and Quality of Foods. Vol. 1-2, Lund BM, Baird Parker AC, Gould GW (2000). ASPEN Publication, Gaithersburg, MD.
6. Microbiology: An Introduction, 9th editionby Tortora GJ, Funke BR, Case CL (2008).
4. Pearson Education, New York, USA.
5. Fundamental Food Microbiology, 5th edition, Rayand B. Bhunia A. (2013). CRC press.
6. Food Microbiology by. 4th edition, Adams M. R., Moss M. O., McClure P. (2015). Royal Society of Chemistry.
7. Food Microbiology: Fundamentals and Frontiers by. 3rd edition by Doyle M. P., Beuchat L. R. (2007). ASM press.
8. Food Microbiology: An Introduction, 4th edition. Montville by T., Matthews K. Kniel K (2017). ASM press.

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7127387/
2. https://microbiologynote.com/contamination-of-foods/
3. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/food-contamination
4. https://www.sciencedirect.com/science/article/abs/pii/S1357303906001046

CO, PO, PSO matrix of MSc/Mic/2/DSC1 A												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology- 2nd Semester
MSc/Mic/2/DSC1-B Industrial Microbiology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. Theory: 70; IA: 30

Objectives: The objective of the course is to create general understanding among the students toward the exploitation of microbial population for industrial and human benefits. The strategies for development of microbial strains, preservation, process optimization, large scale production and recovery of the product will be covered for industrially relevant microbial products.

Course outcomes (COs): After successful completion of this course, students should be able to:	
CO 1	Attains knowledge about designing of industrial strains, various media optimization strategies, fermentation kinetics and process technology for the production of different industrial important products.
CO 2	Learns about the design, types of fermenters and various critical components of bioreactors
CO 3	Gain insight on industrially important microbes, recent developments in fermentation processes and various optimization strategies at fermenter level.
CO 4	Acquires knowledge about various industrially relevant microbial products and their production processes

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

UNIT I

Isolation and improvement of industrially important M.Os. Introduction and scope of industrial microbiology; Biology of industrially important microbes (metabolic pathways and control mechanisms); Isolation and selection of industrially important microorganisms; Genetic improvement of microbes by using classical and r-DNA techniques; Preservation and maintenance of microbial cultures.

UNIT II

Fermentation system: Microbial substrates - Media formulation, optimization of media; **B**atch, fed batch and continuous fermentation system; Fermentation kinetics, chemostat, turbidostat, gas exchange and mass transfer; Design of laboratory bioreactor; Types of bioreactor - Stirred tank reactor, airlift reactor, packed bed reactor and fluidized bed reactors; Scale-up principles; Downstream processes.

UNIT III

Commercial production of microbial products; Types of microbial products; Production of biomass: Baker's yeast, single cell proteins, biopesticides and biofertilizers; Production of primary metabolites: Beer, wine, organic acids (citric acids and lactic acids), amino acids (glutamic acid and lysine); industrial enzymes (amylase, protease and lipase) and bioplastics

UNIT IV

Production of secondary metabolites: Primary and secondary metabolites; Production of Antibiotics (penicillin, cephalosporin, streptomycin), pigments; Microbial transformation; Production

of metabolites of non-microbial origin like insulin, interleukins and growth hormones using rDNA technology. Development of designer microbes for food and health care products

Suggested Readings:

Text/References Books:

1. Biotechnology and Genomics. Gupta, P.K. (2010) Rastogi Publications,Meerut, India.
2. Principles of fermentation technology-3rd Edition, Stanbury, P.F.,Whitaker, A. andHall, S.J.(2016), Elsevier.s
3. Manual of Industrial Microbiology and Biotechnology– third edition. Demain, A.L.and Davies, J.E. (2010) American Society for Microbiology Press, USA.
4. Industrial Microbiology-An introduction. Waites,M.J., Morgan,N.L., Rockey,J.S. andHigton, A.G. (2014) Blackwell Science Ltd. France.
5. Biotechnology–A text book of industrial microbiology (Second Edition) Crueger,Wand Crueger, A. (2004) Panima Publishing Corporation, New Delhi.

Research/Review Papers:

1. Singh, R., et al. (2016). Microbial enzymes: industrial progress in 21st century. 3 Biotech, 6 (2), 1-15.
2. Waheed, M., et al. (2021). Biosynthesis of poly (Hydroxyalkanoates). Biological and Clinical Sciences Research Journal, 2021(1), e023-e023.
3. Watling, H. (2016). Microbiological advances in biohydrometallurgy. *Minerals*, *6*(2), 49.
4. Giorgi, V., et al. (2019). Microbial transformation of cholesterol: reactions and practical aspects—an update. World Journal of Microbiology and Biotechnology, 35(9), 1-15.
5. Mezzomo, N., & Ferreira, S. R. (2016). Carotenoids functionality, sources, and processing by supercritical technology: a review. Journal of Chemistry, 2016.

On-line Resources

1. https://run.edu.ng/directory/oermedia/422231995398.pdf
2. https://www.fpl.fs.fed.us/documnts/pdf1996/kirk96a.pdf
3. https://microbenotes.com/scope-and-applications-of-microbiology/
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2447884/

CO, PO, PSO matrix of MSc/Mic/2/DSC1-B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology-2nd Semester

MSc/Mic/2/DSC2 3A – Food and Dairy Microbiology

Credits: 4 (Lab Hrs.120) **Marks: 100**

Duration of exam: (4Hrs.)

Objectives: The objective of this laboratory course is to provide practical skills of the techniques related to food and dairy microbiology.

Course outcomes (COs): Students will be able:	
CO 1	To understand the key concepts in food and dairy microbiology
CO 2	To understand the significance and activities of microorganisms in food and role of intrinsic and extrinsic factors on growth and survival of microorganisms in food and dairy.
CO 3	To recognize and describe the characteristics of important pathogens and spoilage microorganisms in foods and dairy.
CO 4	To identify ways to control microorganisms in food and dairy and thus know the principles involving various methods of food preservation

1. Introduction to microbiological techniques: Requirements of a microbiology lab, Safety rules to be followed in the lab, Cleaning and sterilization techniques.
2. Preparation of different types of growth media. Culture techniques- dilution technique. Isolation of bacteria by serial dilution (streak plate), pour plating and spreading, bacterial population count- standard plate count Isolation and identification of microbes from infected fruits and vegetables
3. Bright field microscopy and examination of living micro-organisms, direct microscopic count of micro-organisms– use of Neubauer counting chamber.
4. Staining techniques: simple staining, gram staining, spore staining and negative staining etc.,
5. Study of food-borne pathogens - Clostridium, Staphylococcus and Salmonella
    a. Isolation and identification of microbes from home-made and commercial curd
    b. Bacterial examination of milk by:
6. SPC, DMC, MBRT, Rapid platform test, COB, Alcohol test
4. Estimation of fat content of milk by Gerber's method
7. Estimation of Lactose in milk
8. Estimation of Lactic acid in milk
9. Production of yoghurt

Suggested readings:

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1. Jay J.M., Modern Food Microbiology, CBS Publishers and Distributors, New York
2. Experiments in Microbiology, Plant Pathology and Biotechnology 5th Edition. Aneja, K.R. (2018) New Age International Publishers, New Delhi.
3. Microbiology a laboratory manual 10th edition. Cappuccino, J. and Sheeman, N. (2016) Addison Wesley, California.
4. Beety C. Hobbs, Food Microbiology, Arnold-Heinemann Publishing Private Limited, New Delhi 2. Frazier and Wasthoff, Food Microbiology, Tata McGraw-Hill Publishing Company Limited, New Delhi

Research/Review Papers/On-line Resources:

1. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=4203
2. https://www.journalofdairyscience.org/article/S0022-0302(61)89935-9/pdf
3. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=65153
4. https://microbenotes.com/direct-microscopic-counts/
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846335/
6. https://krishi.icar.gov.in/jspui/bitstream/123456789/32554/1/4_Plating%20methods.pdf
7. https://bio.libretexts.org/Learning_Objects/Laboratory_Experiments/Microbiology_Labs/Microbiology_Labs_II/Lab_03%3A_Obtaining_Pure_Cultures_from_a_Mixed_Population

CO, PO, PSO matrix of MSc/Mic/2/DSC 3A												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO3	3	2	1.75	2	1.5	2	2	2	3	2	2	2
CO4	3	2	1.75	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.61**	**2**	**1.5**	**1.75**	**2**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology-2nd Semester

MSc/Mic/2/DSC2 3B - Industrial Microbiology

Credits: 4 (Lab Hrs.120) **Marks: 100**
Duration of exam: (4Hrs.)

Objectives: The objective of this laboratory course is to provide practical skills of the techniques related to Industrial microbiology.

Course outcomes (COs): Students will be able:	
CO 1	To understand bio-safety measures related to microbial biotechnology techniques.
CO 2	To develop practical skill and acquaint with recent knowledge and techniques in the field of microbial biotechnology. They will be able to understand various biological aspects related to organismal, cellular, biochemical and molecular biological.
CO 3	To analyses and solve various problems related to microbial biotechnology and fermentations. They would be able to launch start-ups and become entrepreneurs for various products and processes.
CO 4	To imbibe the value of team spirit. They will be able to work independently, able to write and manage their research experimentation.

1. General laboratory-safety and bio-safety measures in microbial biotechnology laboratory.
2. Introduction to various instruments and their working principles used in microbiology.
3. Isolation of industrially important microorganisms for microbial processes.
4. Types of industrial fermentation processes – Batch, continuous, surface, submerged, and solid state fermentation
5. Media components and formulation, crude media components, antifoam agents, precursors, inducers and inhibitors and buffering agents. Inoculum preparation.
6. Sterilization of media and raw materials and maintenance of sterility at critical points during fermentation
7. Production of various products in the lab i.e. alcohol and wine.
8. Microbial production of citric acid using *Aspergillus niger*.
9. Microbial production of antibiotics (penicillin) and testing of antimicrobial activity.
10. Isolation of streptomycin resistant mutants.
11. Isolation of U.V. induced auxotrophic mutants.
12. Production and estimation of alkaline proteases.
13. Production of sauerkraut by fermentation.
14. Determination of antibacterial activity of lactic acid bacteria using agar well diffusion method.

Suggested readings:

5. Experiments in Microbiology, Plant Pathology and Biotechnology 5th Edition. Aneja, K.R. (2018) New Age International Publishers, New Delhi.
6. Microbiology a laboratory manual 10th edition. Cappuccino, J. and Sheeman, N. (2016) Addison Wesley, California.
7. Environmental Microbiology– A laboratory manual 3rd Edition. Pepper, I.L.; Gerba, C.P. and Brendecke, J.W. (2015) Academic Press, New York

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Research/Review Papers:

1. Zabat, M. A., et al. (2018). Microbial community analysis of sauerkraut fermentation reveals a stable and rapidly established community. *Foods*, *7*(5), 77.
2. Chatterjee, S. (2015). Production and estimation of alkaline protease by immobilized Bacillus licheniformis isolated from poultry farm soil of 24 Parganas and its reusability. *Journal of advanced pharmaceutical technology & research*, *6*(1), 2.
3. Wdowiak-Wróbel, S., et al. (2017). Diversity and plant growth promoting properties of rhizobia isolated from root nodules of Ononis arvensis. *Antonie van Leeuwenhoek*, *110*(8), 1087-1103.

On-line Resources

8. http://legacy.geneticsgsa.org/education/pdf/GSA_DeStasio_Ames_Student_Resources.pdf
9. https://www.researchgate.net/publication/8091547_Isolation_of_Auxotrophic_Mutants_of_Diploid_Industrial_Yeast_Strains_after_UV_Mutagenesis
10. https://www.researchgate.net/publication/258523492_Isolation_and_characterization_of_streptomycin-resistant_mutants_in_Nicotiana_plumbaginifolia
11. https://labmonk.com/fermentation-process-of-alcohol-production

CO, PO, PSO matrix of MSc/Mic/2/DSC 3B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology-2nd Semester

MSc/Mic/2/CC10- Bacteriology, Virology, Mycology and Phycology

Credits: 4 (Lab Hrs: 120) **Marks: 100**
Duration of exam: - 4 Hrs.

List of Practical's / Experiments

1. Skin/pus pathogens: Isolation and identification of microbes from skin/pus
2. Blood pathogens: Isolation and identification of microorganisms from blood sample
3. Pathogens in urine: Isolation and identification of microorganisms from urine sample
4. Respiratory tract: Isolation and identification of microorganisms from throat
5. Lower respiratory tract: Isolation and identification of microorganisms from sputum sample
6. Air-borne pathogens: Bacteriological examination of pathogens present in air
7. To perform slide culture technique for studying morphology of mold
8. To isolate and identify Candida sp. and perform germ tube test
9. To perform staining of fungi with 10% and 40% KOH
10. To perform serodiagnosis of HIV infection by tridot kit
11. To perform staining of fungi by lacto phenol cotton blue
12. To perform serodiagnosis of hepatitis B infection by cassette method

Suggested readings/Online resources

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1994958/
2. https://www.ncbi.nlm.nih.gov/books/NBK563195/
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7580478/
4. https://www.mdpi.com/2079-6382/10/7/851/htm

CO, PO, PSO matrix of MSc/Mic/2/CC10												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	2	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	2	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology- 2nd Semester

MSc/Mic/2/SEC1- Industrial Training

Credits: 2 (80 hours) **Marks: 50**

Mode of Exam: Viva-Voce by external expert

Objective: The objective of this course to give an opportunity to the students for realwork experience in commercial laboratories or relevant industries

Course outcomes (COs): At the end of the course, the students will be:	
CO1	Trained to work as professional
CO2	Trained to coordinate with the team

1. Perform sample preparation for analysing the samples received in the laboratory, Carry out analysis of incoming materials as per SOPs
2. Carry out regular observations for the tests performed and maintain records in logbooks
3. Assist in research work to support the development of new products
4. Carry out test procedures using correct testing equipment as per SOP
5. Maintain a healthy, safe and secure working environment in line with organizational procedures and policies
6. Ensure workplace cleanliness
7. Coordinate with shift supervisor, cross functional teams and within the team, Follow organizational reporting and documentation procedure

CO, PO, PSO matrix of MSc/Mic/2/SEC1												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	1	1.5	1	1	2	2	2	1	2
CO2	2	2	2	2	2	2	2	2	3	2	2	2
Average	**2.5**	**2**	**2**	**1.5**	**1.75**	**1.5**	**1.5**	**2**	**2.5**	**2**	**1.5**	**2**

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M.Sc. Microbiology- 3rd Semester

MSc/Mic/3/CC11- Immunology

Credits: 4 (Lectures: 60) **Marks: 100**

Duration of exam: 3 Hrs. Theory: 70; IA: 30

Objective: The objective of the course is to make the students understand the basic concepts of immunology. Students will gain knowledge of cells and organ of immune system, antigen – antibody interaction, immune system cell regulation, different immunological techniques, disease and health condition.

Course outcomes (COs): At the end of the course, the students will be able to describe:	
CO1	The introductory concept of immunity and cells and organs of immune system
CO2	The nature of antigen and antibody and their interaction and mechanism of MHC
CO3	The Genomic organization of immune cell and its regulation and mechanism of cytotoxicity
CO4	The immunological techniques for detection and identification of disease

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT-I

Introduction: Phylogeny of immune system; innate & acquired immunity; clonal nature of immune system; primary & secondary lymphoid organs.

Cells of Immune System: Haematopoesis & differentiation; B-lymphocytes, T-lymphocytes, macrophages, dendritic cells, natural killer & lymphokine activated killer cells; eosinophils, neutrophils & mast cells; lymphocyte trafficking; humoral & cell mediated immune response.

UNIT-II

Immune System: Nature & biology of antigens & superantigens; immunoglobulins-structure & functions of different classes; antigenic determinants (Isotype, Allotype & Idiotype); antigen-antibody interactions; antibody engineering.; MHC, structure of MHC I & II, genomic organization and MHC polymorphism; antigen processing & presentation;.

UNIT-III

Regulation of Immune Response: Genomic organization and generation of diversity of B-Cell and T-Cell receptors, B-Cell and T-cell Regulation.

Antibody dependent cell mediated cytotoxicity & macrophage mediated cytotoxicity, cytokines & their role in immune regulation, Complement system

UNIT-IV

Immunological Techniques: Immunoprecipitation reactions; agglutination reactions; complement tests; ELISA; RIA; Immunofluorescences.

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Immune System in Health & Diseases: Hypersensitive reactions; auto immunity; AIDS and other immunodeficiencies; tumor immunology –tumor antigens; immune response to tumors and tumor evasion of the immune system; cancer immunotherapy.

Text/references books:

1. Immunology, 8th Edition, Goldsby, R.A., Kindt T.J., Osborne B.A. (2012) W.H. Freedom & Comp, NY.
2. Essential of Immunology, 10th Ed. Riott, Ivon, Delves, Peter (2001) BlackwellScientific Publications, Oxford.
3. Fundamentals of Immunology: Paul W.E. (Eds.) Raven Press, New York.
4. Immunology – A short course – Eli Benzamini, R Coico, G Sunshine (Wiley-Liss).
5. Immunology – An introduction 5th Edition (2013) Tizard I.R. Philadelphia Sauders College Press.
6. Basic Immunology, Sharon J (1998) Williams and Wilkins, Battimore. Janeway et al., Immunobiology, 8thEdition, Current Biology publications, 2012.

Research/Review Papers:

1. Buqué, A., & Galluzzi, L. (2018). Modeling tumor immunology and immunotherapyin mice. *Trends in Cancer*, *4*(9), 599-601.
2. Rosenblum, M. D., et al. (2015). Mechanisms of human autoimmunity. *The Journalof clinical investigation*, *125*(6), 2228-2233.
3. Ochoa, M. C., et al. (2017). Antibody-dependent cell cytotoxicity: immunotherapystrategies enhancing effector NK cells. *Immunology and cell biology*, *95*(4), 347-355.
4. Attaf, M., et al. (2015). αβ T cell receptors as predictors of health and disease. *Cellular & molecular immunology*, *12*(4), 391-399.
5. Saeed, A. F.,et al. (2017). Antibody engineering for pursuing a healthierfuture. *Frontiers in microbiology*, *8*, 495.

On-line Resources:

1. **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC164256/**
2. https://www.ncbi.nlm.nih.gov/books/NBK27156/
3. https://www.ncbi.nlm.nih.gov/books/NBK27092/
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC497975/
5. https://www.researchgate.net/publication/320180727_Difference_Between_Humoral_ and_Cell_Mediated_Immunity

CO-PO-PSO matrix of MSc/Mic/3/CC11												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	1.5	2	2	3	2	1.5	2
CO2	3	2	1.5	2	1.5	1.5	1.5	2	3	2	1.5	2
CO3	3	2	1.5	2	1	2	1.5	2	3	1.5	2	2
CO4	3	2	1.5	2	2	2	2	2	3	1.5	2	2
Average	**3**	**2**	**1.5**	**2**	**1.5**	**1.75**	**1.75**	**2**	**3**	**1.75**	**1.75**	**2**

M.Sc. Microbiology-3rd Semester
MSc/Mic/3/CC12- Cell and Molecular Biology

Credits: 4 (Lecture: 60) **Marks: 100**
Duration of exam: 3 Hrs. **Theory: 70; IA: 30**

Objective: The objective of the course is to make the students understand the basic concepts of cell biology and to have knowledge of various aspects and processes involved in functioning and maintenance of cell-the basic unit of life.

Course outcomes (Cos): At the end of the course, the students will:	
CO1	Have the knowledge and understanding of the fundamentals of cellular organization and cell signaling
CO2	Be able to understand the mechanism of protein sorting, cell division and cancer development
CO3	The structure of DNA and RNA, organization of prokaryotic and eukaryotic genomes
CO4	The mechanism of DNA replication, transcription, translation and its regulation in prokaryotes and eukaryotes

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

UNIT – I

Introduction: Origin and evolution of cells; structural organization and diversity of eukaryotic and prokaryotic cells; various cellular organelles of animal and plant cells; plasma membrane, cell wall and their structural organization; transport of nutrients, ions, and macromolecules across membranes; chromosome and karyotype.
Cell Signaling: Signaling molecules and their receptors; mechanism of signal transduction, and cytoskeleton-a brief introduction; developmental abnormalities due to defective signaling pathways; signal transducing machinery as targets for potential drugs; cell adhesion, cell junctions, extracellular matrix.

UNIT-II

Protein Sorting and Transport: Endoplasmic reticulum, golgi apparatus and lysosomes; mechanism of vesicular transport.
Cell cycle: Molecular events and model systems; cellular basis of differentiation and development – gametogenesis and fertilization; cell cycle and cancer, development and causes of cancer; tumor viruses; oncogenes; tumor suppressor genes; cell division controls and mechanism of apoptosis.

UNIT III

The Nature of Genetic material: DNA as genetic material; chemical structure and base composition of nucleic acids; double helical structures; different forms of DNA; forces stabilizing nucleic acid structure; super coiled DNA, properties of DNA; renaturation and

denaturation of DNA; Tm and Cot curves; structure of RNA; organization of prokaryotic and eukaryotic genomes- chromatin arrangement; nucleosome formation; satellite DNA.

UNIT IV

DNA replication, transcription and translation: General features of DNA replication; Models of replication; prokaryotic and eukaryotic replication mechanism; mechanism of transcription in prokaryotes and eukaryotes, transcription factors as activators and repressor, regulation of transcription, post- transcriptional processing of tRNA, rRNA and mRNA (5' capping, 3' polyadenylation and splicing), antisense RNA, RNA as an enzyme- Ribozyme.

Suggested Readings:

Text/Reference Books:

1. Molecular biology of cell 6th Edition Alberts, Bruce; Watson, JD (2015) Garland Science Publishing, New York.
2. Molecular cell biology 8th Edition, Lodish, H.; Berk, A.; Matsudaira, P.; Kaiser, C.A.; Krieger, M. *et al*. (2016) W.H. Freeman and Co., New York.
3. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. & Martin, K.C., Molecular Cell Biology (8th Ed.). W. H. Freeman & Co. 2016.
4. Malacinski, G.M., Freifelder's Essentials of Molecular Biology (3rd Ed.). John and Bartlett Publishers. 2015.

Research/Review Papers:

1. Tilman Schneider-Poetsch and Minoru Yoshida (2018) Along the Central Dogma—Controlling Gene Expression with Small Molecules. Annual Review of Biochemistry 87(1). 10.1146/annurev-biochem-060614-033923
2. Change et al., (2020) The New Central Dogma of Molecular Biology https://www.researchgate.net/publication/340062231_The_New_Central_Dogma_of_Molecular_Biology
3. Arata Yukinobu and Takagi Hiroaki (2019). Quantitative Studies for Cell-Division Cycle Control. Frontiers in Physiology. 10, 1022. https://doi.org/10.3389/fphys.2019.01022

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/books/NBK21120/
2. http://dosequis.colorado.edu/Courses/MCDB3145/Docs/Karp-617-660.pdf
3. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000035ZO/P000894/M017781/ET/1498717596StructuralorganizationofgenomeGenomestructureandorganizationQuad1.pdf

CO-PO-PSO Matrix of MSc/Mic/3/CC12												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	1.5	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	2	1.5	2	2	3	2	2	2
Average	3	2	1.5	2	1.75	1.62	1.5	2	3	2	2	2

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M.Sc. Microbiology-3rd Semester

MSc/Mic/3/DSC 3A-Medical Microbiology

Credits: 4 (Lectures: 60) **Marks: 100**

Duration of exam: - 3 Hrs. Theory: 70; IA: 30

Objective: The objective of the course is to make the students understand the nature, fields and scope of biotechnology, and to make them aware about various career options.

Course outcomes (COs): At the end of the course, the students will:	
CO1	Have the understanding of the nature,
CO2	To understand pathogenic bacteria their diagnosis and related disease
CO3	To understand pathogenic fungi their diagnosis and related disease
CO4	To understand various virus, their diagnosis and related disease

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

UNIT I

Early discovery of pathogenic microorganisms, development of medical microbiology as a discipline, normal microbial flora of the human body and their importance.

Host parasite relationships: Definitions: infection, invasion, pathogen, pathogenicity, toxigenicity, virulence, carrier, types of carriers, nosocomial infections, opportunistic infections. Role of aggressins, depolymerizing enzymes, organotrophism. Transmission and spread of infection.

UNIT II

Pathogenic Bacteria: Morphological characteristics, pathogenesis and laboratory diagnosis including rapid methods of following pathogenic bacteria; Staphylococcus, Neisseria, Klebsiella, Proteus, Salmonella, Campylobacter, Pseudomonas, Yersinia, Haemophilus, Clostridium, Mycobacterium, Actinomyces.

UNIT III

Pathogenic Fungi: Morphological characteristics, pathogenesis and laboratory diagnosis of following pathogenic fungi; - Microsporum; *Trichophyton; Histoplasma capsulatum; Blastomyces dermatitidis; Candida albicans; Pneumocystis carinii*. Protozoal Pathogens: General description, biological properties and diseases caused by Protozoa- Plasmodium spp, *Giardia intestinalis, Entamoeba histolytica*, *Pneumocystis jiroveci, Leishmania tropica*.

Unit IV

Study of important viral diseases with reference to causative agent, pathogenesis, symptoms, transmission, control measures, epidemiology and diagnosis. Hepatitis, rabies, polio, chicken pox, dengue fever, AIDS and viral cancers.

An overview of emerging and reemerging viral diseases: Ebola, SARS, Hanta. Introduction to protozoan, fungal and helminthes diseases: Malaria, *Entamoeba histolytica*, toxoplasmosis & leishmaniasis; Superficial, subcutaneous, systemic and opportunistic mycoses, *Echinococcus granulos Filariasis.* Hospital acquired infections and their management

Suggested Readings

1. Ananthanarayanan R. and C.K. Jayaram Panicker Orient Longman Text of Microbiology, 1997.
2. Mackie and McCartney Medical Microbiology Vol.1: Microbial Infection. Vol.2: Practical Medical Microbiology Churchill Livingstone, 1996.
3. Shanson D.C., Wright PSG, Microbiology in Clinical Practice., 1982.
4. Baron EJ, Peterson LR and Finegold SM Mosby, Bailey and Scott's Diagnostic Microbiology, 1990.
5. Smith, C.G.C. "Epidemiology and Infections' (1976): Medowfief Press Ltd., Shildon, England.

Research/Review Papers:

1. COVID-19 vaccination efficacy in numbers including SARS-CoV-2 variants and age comparison: a meta-analysis of randomized clinical trials
2. Prevalence of colistin resistance of *Klebsiella pneumoniae* isolates in Iran: a systematic review and meta-analysis
3. Emerging vancomycin-non susceptible coagulase negative Staphylococci associated with skin and soft tissue infections
4. Recurrent bacteremia with a hypermucoviscous *Escherichia coli* isolated from a patient with perihilar cholangiocarcinoma: insights from a comprehensive genome-based analysis

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/books/NBK7617
2. https://www.ncbi.nlm.nih.gov/books/NBK559312/
3. https://www.mayoclinic.org/diseases-conditions/infectious-diseases/symptoms-causes/syc-20351173
4. https://www.ncbi.nlm.nih.gov/books/NBK549988/
5. https://www.who.int/news-room/fact-sheets/detail/ebola-virus-disease
6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3963198/
7. https://www.researchgate.net/publication/225289612_Classification_of_subcutaneous_and_systemic_mycoses

CO, PO, PSO matrix of MSc/Mic/3/DSC 3A-Medical Microbiology												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology- 3rd Semester
MSc/Mic/3/DSC-3B Plant Pathology

Credits: 4 (Lectures: 60) **Marks: 100**
Time: 3 Hrs. Theory: 70; IA: 30

Objectives: Objective of this course is to develop the understanding about Pathogenesis and plant defense mechanisms, different causal organism of diseases, symptoms and its management.

Course outcomes (COs): At the end of the course, the students will be able to:	
CO 1	Develop basic understanding about plant pathology and learn about various factors causing plant disease.
CO 2	Gain the knowledge about behavior of pathogens and host parasite interactions during pathogenesis.
CO 3	Understand various plant diseases and their causal organisms.
CO 4	Acquire the knowledge about plant protection.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT-I

Introduction: Basic introduction and history of plant pathology; Definitions and concepts of plant diseases; Classification of plant diseases; Biotic and abiotic factors responsible for plant diseases; General characteristics and symptoms caused by - agents of infectious diseases (fungi, bacteria, mycoplasma, virus and nematodes) and Agents of non- infectious diseases (air pollution, chemicals, minerals excess, temperature); Interaction of microorganisms with plants and their effect on plant growth.

UNIT-II

Pathogen behavior and pathogenesis: Growth, reproduction, survival and dispersal ofimportant plant pathogens; Production of various enzymes, toxins and other metabolites by pathogens for causing disease; Role of environment and host nutrition on disease development; Host parasite interactions - recognition and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies, oxidative burst; Phenolics, phytoalexins, PR proteins, elicitors and their effects on host plants.

UNIT-III

Plant diseases and pathogens: Symptoms of important viral diseases and their control; Major fungal diseases ; Plant parasitic namatodes; Important bacterial disease: bacterial leaf blight of rice, cotton bacterial blight, soft rot of vegetables and black rot of crucifers; Phytoplasma; Casual Organism, symptoms and management of: Late and early blight of potato, Downy mildew of grapes, Green ear disease of bajra, Apple scab, Karnal bunt of wheat, Rust of wheat, Wilt of pigeon pea, Tikka disease of ground nut, Crown gall of stone fruits, TMV, Tristeza of citrus and Sandal spike.

UNIT-IV

Plant protection: Plant disease resistance – Pathogen Associated Molecular patterns, Pattern Recognition Receptors, PTI, Effectors, ETI, 'R' genes; Mechanism of genetic variation in pathogens; Disease control in plants - physical, chemical methods; Use of biocontrol agents –bacteria, and fungi; Baculoviruses; Molecular markers for disease resistance in plants; Transgenic approach for plant protection - applications and constraints. Practices of nametode management, Mode of action of antifungal, anti-viral and antibacterial chemicals, Integrated plant disease management (IDM), Management strategies of bacterial, fungal disease ofplants.

Suggested Readings:-

1. Agrios GN (2005). Plant Pathology, 5th edition, Academic Press, New York.
2. Butler, E.J. & Jones, S.G. (1976): Plant Pathology, Periodical Expert Book Agency,New Delhi.
3. Dickinson M (2003). Molecular Plant Pathology, BIOS Scientific Publishers, London.
4. Mukerji KG, Garg KL (1988). Biocontrol of Plant Diseases (Vol. I) CRC Press, Inc.,Boca Raton, Florida, USA.
5. Sigee DC (1993). Bacterial Plant Pathology, Cell and Molecular aspects, CambridgeUniversity Press, UK.

Online Resources:

1. https://www.frontiersin.org/articles/10.3389/fpls.2013.00139/full
2. https://www.sciencedirect.com/science/article/pii/S1674205214605323
3. https://www.differencebetween.com/difference-between-early-blight-and-late-blight-of-potato/
4. https://cropscience.bayer.co.uk/threats/diseases/potato-diseases/early-blight-potatoes/

CO,PO,PSO matrix of MSc/Mic/3/DSC-3B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.75	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.75	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**2**	**2**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology- 3rd Semester

MSc/Mic/3/DSC-4A Soil and Agriculture Microbiology

Credits: 4 (Lectures: 60) **Marks: 100**

Time: 3 Hrs. Theory: 70; IA: 30

Objectives: The objective of the course is to create general understanding of soil microbiota and their interaction, transformation of different element in the soil to increase the soil properties and soil fertility hence production for the welfare of human beings.

Course outcomes (COs): By the end of the course, the student should be able to:	
CO 1	Have an overview regarding the influence of soil and environmental factors on microflora and microbial dynamics.
CO 2	Understand the role of microbes in biogeochemical cycle and biodegradation of pesticides and organics waste.
CO 3	Describe the role of microbes in biological nitrogen fixation and as PGPR.
CO 4	Understand the application of soil microbes in development of eco-friendly product, processes and also in solving the global environment problems

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT – I

History of development of soil microbiology; Soil microbiota and their interactions; Unculturable soil microbiota; Soil microbial ecology; Microorganisms in soil fertility; Influence of soil and environmental factors on microflora; Microbial population in manure and composts; Soil amendments and microbial dynamics.

UNIT – II

Microorganisms in biogeochemical cycles; Microbial transformations of carbon, nitrogen, phosphorus, sulphur, iron and manganese; Biodegradation of pesticides and other organic wastes; Production of biogas; Production of manure using organic waste; Methods to improve soil structure and soil health by microorganisms.

UNIT – III

Interrelationships between plants and microorganisms – Rhizosphere (Quantitative and qualitative studies – R:S ratio), Rhizoplane, spermosphere, phyllosphere microorganisms; Nitrogen fixation by soil bacteria - symbiotic, non-symbiotic, associative symbiotic and endophytic organisms, process of nitrogen fixation; Molecular biology of nitrogen fixation; PGPR (plant growth promoting rhizobacteria), siderophore producers and biocontrol agents.

UNIT –IV

Biofertilizers – Mycorrhizal inoculants, Mass cultivation of microbial inoculants; Green manuring; Microbial products and plant health; Microbial Pesticides: development and their significance.

Suggested readings:

1. Introduction to Soil Microbiology, 3rd edition, Alexander M (1985). Wiley Eastern, New Delhi.

2. Microbial Ecology: Fundamentals and Applications, 4th editions by Atlas RM, Bartha R (1998). Benjamin Cummings, San Francisco.
3. Soil Microbiology, Ecology and Biochemistry, 3rd edition by Paul EA (2007). Academic Press, New York, USA.
4. Principles and Applications of Soil Microbiology, 2nd edition by Sylvia D, Fuhrmann J, Hartel P, Zuberer D (2005). Pearson Education, USA.
5. Modern Soil Microbiology by van Elsas JD, Trevors JT, Wellington EMH (1997). Marcel Dekker, New York, USA.

Online Resources:

1. https://www.frontiersin.org/articles/10.3389/fmicb.2016.01446/full
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8230470/
3. https://link.springer.com/chapter/10.1007/978-981-10-6593-4_18
4. https://www.intechopen.com/chapters/45111

CO, PO, PSO matrix of MSc/Mic/3/DSC-4A												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology- 3rd Semester
MSc/Mic/3/DSC-4B Environment Microbiology

Credits: 4 (Lectures: 60) **Marks: 100**
Time: 3 Hrs. Theory: 70; IA: 30

Objectives: The proposed course is designed to teach students, the scientific and engineering principles of microbiological treatment technologies to clean up contaminated environments and to generate valuable resources for the human society. Also, it is desired to make them understand the role of microbiology in environment for prevention, remediation and monitoring of pollutants.

Course outcomes (COs): By the end of the course, the student should be able to:	
CO 1	Have an overview of the developments in the field of environmental microbiology with special emphasis on the role of microbes in solid waste management.
CO 2	Describe the role of microbes in waste management, gaining knowledge of various methods employed in treatment of the wastes.
CO 3	Understand the role of microbes in bioremediation of waste land and degradation of environmental pollutants
CO 4	Understand the application of microbiology in development of eco-friendly product, processes and also in solving the global environment problems

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT – I

Microbiology of air: Issues and scope of environmental microbiology; Significant applications of microbes in solving environmental problems; Diversity of microorganisms in air and their significance; Droplet nuclei, aerosol, outdoor and indoor microflora. night fungal flora; Determination of the microbial content of the air; Aeroallergens. Mode of transmission of airborne diseases; Control of air borne microorganisms.

UNIT – II

Solid waste treatment: Solid waste types, sources and management- landfill development, incineration methods, composting, vermicomposting and methane production; Plastic degrading microorganisms as a tool for bioremediation; Challenges in waste management.

Liquid waste treatment: Microbiology of waste water treatment; Biological processes of industrial effluent treatment; Aerobic and anaerobic biological treatments; Periodic biological reactor; Membrane bioreactor; Use of immobilized enzyme and microbial cells.

UNIT – III

Bio-remediation: Bioremediation and its type; Bioremediation of contaminated soil and wasteland; Role of biosensors for detection of pollutants.

Biodegradation of xenobiotic: Xenobiotic compounds and recalcitrance; Aerobic vs anaerobic degradation, sequential degradation; Bio-oxidation/degradation of phenolic compounds, pesticides, hydrocarbons and halogenated compounds; Microbial treatment of oil spills and treatment of hazardous waste. Microbial enhanced oil recovery: bioleaching of copper, gold and uranium.

UNIT – IV

Bio-products for environmental health: Bio-pesticides; Bio-fertilizers; Bio-energy & fuel and bio-degradable plastics.

Global environmental problems: Ozone depletion; Greenhouse effect; Acid rain their impacts andbiotechnological approaches for management (a brief account).

Air Pollution: Air pollution and its control; Metal pollution and its bio-abatement; Bioleaching of copper, gold and uranium and bio-sorption;

Suggested readings:

1. Environmental Microbiology, 2nd edition by Arnold E, Maier RM, Pepper IL, Gerba CP (2009), Academic Press, USA.
2. Environmental Microbiology by Ralph MA (1997), John Wiley and Sons Inc., New York, USA
3. Environmental Microbiology by Maier RM, Pepper IL, Gerba CP (2000), Academic Press. USA.
4. Bioremediation by Baker KH, Herson DS (1994), McGraw Hill Inc., New York.
5. Microbial Ecology: Fundamentals and Applications, 4th editions, Atlas RM, Bartha R (1998). Benjamin Cummings, San Francisco.
6. Environmental Biotechnology: Principles and Applications, Second Edition (2020). By Bruce E. Rittman, Perry L. McCarty. Pub. Mc Graw Hills
7. Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. By Jeyabalan Sangeetha, Devarajan Thangadurai, Muniswamy David, Mohd Azmuddin Abdullah (2016) Pub. Apple Academic Press.
8. Advanced Environmental Biotechnology by Agarwal S.K. (2005), APH PublishingCorp., New Delhi.
9. Microbial Biotechnology; Fundamental of Applied Microbiology by Glazer andNikaido (2007) WH Freeman & Company, New York.
10. Fulekar M.H. (2014) Environmental Biotechnology. Science Pub.

Research/Review Papers:

1. Vigneswaran, S.,et al. (2016). Sustainable operation of composting in solid waste management. *Procedia Environmental Sciences*, *35*, 408-415.
2. Dadrasnia, A., et al. (2017). Microbial Aspects in Wastewater Treatment–A Technical. *Environmental Pollution and Protection*, *2*(2), 75-84.
3. Bouabidi, Z. B., et al. (2019). Immobilization of microbial cells for the biotreatment of wastewater: a review. *Environmental Chemistry Letters*, *17*(1), 241-257.
4. Azubuike, C. C., et al. (2016). Bioremediation techniques–classification based on site of application: principles, advantages, limitations and prospects. *World Journal of Microbiology and Biotechnology*, *32*(11), 1-18.

On-line Resources

1. https://studylib.net/doc/7708086/environmental-biotechnology-definition-and-scope
2. https://www.researchgate.net/publication/323830155_Biological_approaches_to_tackle_heavy_metal_pollution_A_survey_of_literature
3. https://www.hindawi.com/journals/btri/2011/941810/
4. https://www.bio-fit.eu/q8/lo1-why-biofertilizers?start=4
5. https://www.greenpeace.org/static/planet4-eastasia-stateless/84075f56-biodegradable-plastics-report.pdf

CO, PO, PSO matrix of MSc/Mic/3/DSC-4B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

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M.Sc. Microbiology- 3rd Semester
MSc/Mic/3/SEC2 – Lab Medical Microbiology and Immunology

Credits: 4 (Lab Hrs.120) **Marks: 100**
Duration of exam: (4 Hrs.)

Objectives: The objectives of this laboratory course are to provide practical skills of the techniques related to identification and purification of cell and diagnostic method in immunology.

Course outcomes (COs): After completion of this Lab. course, students will be able to:	
CO 1	To understand bio-safety measures related to medical and immunological diagnostic techniques.
CO 2	To understand different Bacteriological examination from different body parts.
CO 3	To understand General tests for identification of bacteria from different samples.
CO 4	To develop practical skill and acquaint with recent knowledge and techniques in the field of immunology. Learning some of the simpler techniques used in the Identification and purification of different cell populations.

1 General Laboratory-safety and Bio-safety measures in medical microbiology and immunology laboratory.
2 Introduction to various instruments and their working principles used in medical microbiology and immunologylaboratory.
3 Bacteriological examination of different parts of the human body including skin and throat
4 Counting the number of viable bacteria in urine sample
5 General tests for identification of bacteria including IMViC test Carbohydrate fermentation test
6 Nitrate reduction test Hydrogen sulphide production test Urease test Catalase test Oxidase test
7 Preliminary tests for identification of Staphylococcus and Streptococcus
8 Determination of minimal inhibitory concentration
9 Blood film preparation and identification of cells
10 Immunodiffusion techniques:
a) Ouchterlony double diffusion
b) Radial immunodiffusion.
10 Immunoelectrophoresis:
   a. Counter current Immunoelectrophoresis
   b. Rocket Immunoelectrophoresis.
11 Latex agglutination technique.
12 ELISA technique
   a) Dot ELISA
   b) Sandwich ELISA

Suggested Readings:

Text/Reference Books:

1. A handbook of Practical Immunology (1983). Edited by G.P. Talwar, Vikas Publishing House Pvt. Ltd. New Delhi-110002.
2. Practical Immunology (1980), Hudson L. and Franks, C.H. Blackwell scientific Publication, Oxford.
3. Fundamental techniques in immunology and serology (2002) Singh A. International Book Distributing Co., Lucknow.
4. Bailey and Scott's Diagnostic microbiology 6th Edition by W. Robert Bailey
5. Microbiology for the Healthcare Professional Book by Karin C. VanMeter and Robert J. Hubert

Research/Review Papers:

1. Knight, J., & Nigam, Y. (2020). Lymphatic system 1: structure, function and oedema. *Nursing Times*, *116*, 39-43.
2. Michov, B. (2020). 2.3 Immunoelectrophoresis. In *Electrophoresis* (pp. 164-181). De Gruyter.

On-line Resources:

1. https://labtestsonline.org/tests/immunoglobulins-iga-igg-igm
2. https://microbenotes.com/radial-immunodiffusion/
3. http://tools.thermofisher.com/content/sfs/brochures/TR0065-ELISA-guide.pdf
4. https://www.ncbi.nlm.nih.gov/books/NBK373515/
5. https://bio.libretexts.org/Learning_Objects/Laboratory_Experiments/Microbiology_Labs/Microbiology_Labs_II/Lab_14%3A_Isolation_and_Identification_of_Streptococci

CO-PO-PSO Matrix of MSc/Mic/3/SEC2												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	1	2	3	2	3	2	2	1.5
CO2	3	2	2	2	2	2	3	2	3	2	2	1.5
CO3	3	2	2	2	1	2	3	2	3	2	2	1.5
CO4	3	2	2	2	2	2	3	2	3	2	2	1.5
Average	**3**	**2**	**2**	**2**	**1.5**	**2**	**3**	**2**	**3**	**2**	**2**	**1.5**

M.Sc. Microbiology-3rd Semester

MSc/Mic/3/SEC-3 Lab Environment and Agricultural Microbiology

Credits: 4 (Lab Hrs: 120) **Marks: 100**

Duration of exam: (4 Hrs.)

Objectives: The objective of this laboratory course is to provide practical skills of the techniques related to environment biotechnology.

Course outcomes (COs): At the end of this course, the students will have:	
CO 1	The knowledge and hands on training of techniques used in the field of Environment Biotechnology.
CO 2	Practical knowledge of methods to test the potability of different water Samples
CO 3	Practical understanding of techniques to test various qualitative aspects of diverse water samples.
CO 4	The ability to choose most appropriate technique for testing and degradation of pollutants and to imbibe the value of team spirit while working together in team during practical sessions.

1. Introduction to various instruments and their working principles used in environment biotechnology laboratory.
2. Testing of tap and pond water for its purity to potable by MPN/any other method.
3. Testing of total dissolved solids of water.
4. Testing of dissolved oxygen concentration of water sample.
5. Testing of biological oxygen demand (BOD) of sewage sample.
6. Testing of chemical oxygen demand (COD) of sewage sample.
7. Isolation of xenobiont degrading bacteria by selective enrichment technique.
8. Effect of sulphur dioxide on crop plants.
9. Estimation of nitrate in drinking water.
10. Determination of soil microbial population.
11. Isolation of different bacterial and fungal organisms important in recycling of C, N, P, S in soil. Soil microbial biomass;
12. Isolation of rhizobia from the nodule of legume plants.
13. Measurement of important soil microbial processes such as ammonification, nitrification, P solubilisation and mineralization of other micro nutrients;
14. Study of rhizosphere microflora and effect on plant growth.

Suggested readings:

1. Environmental Microbiology – A laboratory manual, L.L. Gerba, C.P. and Brendeeke. J.W. (1995) Academic Press, New York.
2. Experiments in Microbiology, Plant Pathology and Biotechnology 5th edition Aneja K.R. (2018) New Age International Publisher – New Delhi.
3. Microbiology – A laboratory manual 10th edition. Cappuceino J. and Sheeman N. (2016) Addison Wesley, California.
4. Environmental Microbiology – A laboratory manual. Pepper, I.L.; Gerba, C.P. and

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Brendecke, J.W. (2015) Academic Press, New York.

Research/Review Papers:

1. Rusydi, A. F. (2018, February). Correlation between conductivity and total dissolved solid in various type of water: A review. In *IOP conference series: earth and environmental science* (Vol. 118, No. 1, p. 012019). IOP Publishing.
2. Alegbeleye, O. O., et al. (2017). Bioremediation of polycyclic aromatic hydrocarbon (PAH) compounds:(acenaphthene and fluorene) in water using indigenous bacterial species isolated from the Diep and Plankenburg rivers, Western Cape, South Africa. *Brazilian journal of microbiology*, *48*, 314-325.

On-line Resources

1. https://serc.carleton.edu/microbelife/research_methods/environ_sampling/oxygen.htm l
2. https://www.euro.who.int/data/assets/pdf_file/0016/123091/AQG2ndEd_10effso2.pdf
3. https://archive.epa.gov/water/archive/web/html/vms52.html

CO, PO, PSO matrix of MSc/Mic/3/SEC3												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	2	2	3	2	2	2
CO2	3	2	1.5	2	2	1.5	1.5	2	3	2	2	2
CO3	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2	1.5	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2**	**1.75**	**1.75**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology-3rd Semester
MSc/Mic/3/CC13 – Seminar

Mode of Examination: As per guidelines of the University

Objectives: The objective of the course is to make the students capable of learning about personal and communication styles for team building.

Course outcomes (COs): By the end of the course, the student should be able to:	
CO 1	Hypothesize about any problem.
CO 2	Able to show competence in identifying relevant information, defining and explaining topics under discussion.

CO, PO, PSO metrics of MSc/Mic/3/CC13												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	1.5	1.5	2	3	3	2	2
CO2	2	2	1.5	2	1.5	1.5	1.5	2	2	3	2	2
Average	**2.5**	**2**	**1.5**	**2**	**1.5**	**1.5**	**1.5**	**2**	**2.5**	**3**	**2**	**2**

M.Sc. Microbiology-3rd Semester
MSc/Mic/3/SEC4 – Life Skills and Humanistic Values

Credits: Non-credit (Lectures: 30) **Marks: 50**
Duration of exam: 2 Hrs. Theory: 30, IA: 20

Course outcomes (COs): At the end of the course, the students will know:	
CO1	Happiness, Mindfulness and Meditation
CO2	Principles of human behavior and relationships for affectivity and greatness

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

UNIT I

Happiness and Life: Introduction, self-awareness; mindfulness; non-judgmental acceptance of self and others; self-love; letting-go; self-healing; meditation; the triad for happiness-sustainable happiness through learning and awareness; deeper happiness through harmony in feelings; momentary happiness through the senses.

UNIT II

Principles and skills for affectivity and greatness: Seven habits of highly effective persons-be proactive; begin with the end in mind; do first things first; think win/win; seek first to understand then to be understood, synergize, sharpen the saw; whole body paradigm- concept and principles.

Suggested Readings:

Text/Reference Books:

1. Covey S. R. (2004) Seven habits of Highly Effective People, Simon $ Schuster
2. Covey S. R. (2004). The 8th Habit, ISBN: 0-7432-8793-2
3. Nagraj, A. (2015). Philosophy of Human Behaviour, Jeevan Vidya Prakashan, Amarkantak
4. Helliwell, J. F., Huang, H., & Wang, S. (2017). The Social Foundations of World Happiness. World Happiness Report.
5. Helliwell, J., Layard, R., & Sachs, J. (2018). Sustainable Development Solutions Network. World Happiness Report 2018.
6. O'brien, C. (2008). Sustainable happiness: How happiness studies can contribute to a more sustainable future. Canadian Psychology/Psychologie canadienne, 49(4), 289.

Research/Review Papers:

1. Cheung, R. Y., & Ng, M. C. (2019). Mindfulness and symptoms of depression and anxiety: The underlying roles of awareness, acceptance, impulse control, and emotion regulation. *Mindfulness*, *10*(6), 1124-1135.
2. Eckhaus, E., & Sheaffer, Z. (2019). Happiness enrichment and sustainable happiness. *Applied Research in Quality of Life*, *14*(4), 1079-1097.

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3. Doorley, J. D., et al. (2020). The momentary benefits of positive events for individuals with elevated social anxiety. *Emotion*.
4. Puszko, K. (2021). Effectivity of Leadership. *European Research Studies*, *24*, 644-663.
5. Bakker, A. B., & Leiter, M. (2017). Strategic and proactive approaches to work engagement. *Organizational Dynamics*, *46*(2), 67-75.
6. Coyne, L. W., et al. (2020). First things first: parent psychological flexibility and self-compassion during COVID-19. *Behavior analysis in practice*, 1-7.

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4895748/
2. http://people.tamu.edu/~v-buenger/658/Steven_Covey.html
3. https://blog.hubspot.com/sales/habits-of-highly-effective-people-summary

M.Sc. Microbiology-4th Semester

MSc/Mic/4/CC14 – Cardinal Principles of Academic Integrity and Publications Ethics

Credits: 2 (Lectures: 30) Marks: 50

Duration of exam: 2 Hrs. **Theory: 30; IA: 20**

Course outcomes (COs): At the end of the course, the students will know:	
CO1	Academic Integrity, Plagiarism (prevention and detection) and UGC regulations
CO2	Research and Publications ethics and best practices

Note for the paper setter: *The question paper will consist of five questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will be set unit-wise comprising of two questions from each of the two units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Unit I

Academic Integrity: Introduction; academic integrity values- honesty and trust, fairness and respect; responsibility and courage; violations of academic integrity-types and consequences; plagiarism: definition, plagiarism arising out of misrepresentation-contract cheating, collusion, copying and pasting, recycling, avoiding plagiarism through referencing and writing skills; UGC policy for academic integrity and prevention; plagiarism detection tools.

Unit II

Research and Publication ethics: Scientific misconducts; falsifications, fabrication and plagiarism (FPP); publication ethics- definition, introduction and importance; best practices/standard setting initiatives and guidelines-COPE; WAME; violation of publication ethics, authorship and contributor-ship; identification of publications misconduct, complains and appeals; conflicts of interest; predatory publisher and journals.

Suggested Readings:

Text/References Books:

1. MacIntyre A (1967) A short History of Ethics, London
2. Chaddah P (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized. ISBN: 978-9387480865
3. National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2009) On being a Scientist: A guide to Responsible Conduct in research: Third Edition. National Academics press.
4. Resnik D. B. (2011) What is ethics in research & why is it important. National Institute of Environmental Health Sciences, 1-10.
5. Beall J (2012). Predatory publishers are corrupting open access, Nature, 489 (7415), 179.
6. Indian National Science Academy (INSA), Ethics in Science Education, Research

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andGovernance (2019). ISBN: 978-81-939482-1-7.

7. UGC regulations (2018) for Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutes.
8. Ulrike kestler, Academic Integrity, Kwantlen Polytechnic University.

Research/Review Papers:

1. Helgesson, G., Eriksson, S. (2015) Plagiarism in research. *Med Health Care and Philos* 18, 91–101, https://doi.org/10.1007/s11019-014-9583-8
2. Jensen, K. K. (2015). 2 General introduction to Responsible Conduct of Research. *RCR–A Danish textbook for courses in Responsible Conduct of Research*,5.
3. Sengupta, S., & Honavar, S. G. (2017). Publication ethics. *Indian journal of ophthalmology*, *65*(6), 429. doi: 10.4103/ijo.IJO_483_17
4. Foltýnek, T., et al. (2020). Testing of support tools for plagiarism detection. *International Journal of Educational Technology in Higher Education*, *17*(1), 1-31.

On-line Resources:

1. https://iisc.ac.in/about/student-corner/academic-integrity/
2. https://instr.iastate.libguides.com/predatory
3. https://www.atlantis-press.com/policies/publishing-ethics-and-misconduct
4. https://www.dbuniversity.ac.in/pdfs/Anti_Plagiarism_and_Academic_Integrity_Policy.pdf
5. https://www.usf.edu/graduate-studies/students/academic-integrity-of- students/violations-of-academic-integrity.aspx

CO-PO-PSO Matrix of MSc/M/4/CC14												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	2	2	2	3	1.5	2	1.5	2	2	1.5	1.5
CO2	1	2	2	1.5	3	2	1.5	2	1.5	1.5	2	1.5
Average	**3**	**2**	**2**	**1.75**	**3**	**1.75**	**1.75**	**1.75**	**1.75**	**1.75**	**1.75**	**1.5**

M.Sc. Microbiology-4th Semester

MSc/Mic/4/CC15 Recombinant DNA Technology

Credits: 4 (Lectures: 60) **Marks: 100**
Duration of exam: 3 Hrs. Theory: 70; IA: 30

Objectives: This course aims to introduce the students to field of Genetic Engineering including introduction, basic principles, milestones, scopes and advances.

Course Outcomes (COs): At the completion of this course:	
CO1	Students would understand basic concepts and requirements of Genetic Engineering including different methodologies used for manipulation of nucleic acids, gene cloning, PCR and will know its impact on society
CO2	They would be acquainted with the methodologies involved in introduction of foreign DNA into living cells and cloning of a specific gene
CO3	Students will know about various types of molecular markers, mapping of genomes and various methods for sequencing of genomes
CO4	Students will know how to carry out gene expression studies and about latest genome editing technologies.

Unit-1

Introduction: Historical background, Restriction enzymes and modifying enzymes, Restriction mapping, Construction of chimeric DNA- staggered cleavage, Addition of poly dA and dT tails, Blunt end ligation, Gene cloning.

Cloning and Expression Vectors: Vehicles for gene cloning, Plasmids, Bacteriophages, Cosmids and Phagemids as vectors, P1 vectors, F- factor based vectors, Plant and animal viruses as vector, Artificial chromosomes as vectors (YAC, BAC, PAC and MAC vectors), Expression vectors- use of promoters and expression cassettes, Bacculoviruses as expression vectors, Virus expression vectors, Binary and shuttle vectors.

Unit-2

Isolation Sequencing and Synthesis of Genes: Methods of gene isolation, Construction and screening of genomic and cDNA libraries, Chromosome walking, Chromosome jumping, Transposone tagging, Map based cloning, DNA sequencing Techniques (Maxam Gilbert's chemical degradation methods and Sanger's dideoxy chain termination method), Automated DNA sequencing, Organochemical gene synthesis, Blotting techniques- Southern, Northern and Western Blotting. PAGE, SDS-PAGE and two-dimensional PAGE analysis of proteins

Unit-3

Molecular Probes and PCR: Molecular probes, Labeling of probes, Radioactive vs Non-radioactive labeling, Uses of molecular probes. Polymerase Chain Reaction- basic principle, Modified PCR (Inverse PCR, Anchored PCR, PCR for mutagenesis, asymmetric PCR, RT PCR, PCR walking), Gene cloning Vs. Polymerase chain reaction, Applications of PCR in biotechnology

Unit-4

Molecular Markers and DNA Chip Technology: Molecular Markers- types and applications, Construction of molecular maps (genetic and physical maps), DNA chip Technology & Microarrays (a brief account).

Pharmaceutical products of DNA technology: Human protein replacements – insulin, hGH and Factor VIII. Human therapies – TPA, interferon, antisense molecules. Vaccines – Hepatitis B, AIDS, and DNA vaccines. Transgenics and animal cloning: Creating transgenic animals and plants. Animal cloning.

Recommended Books

1. Brown T.A. (2010), Gene Cloning & DNA Analysis, 6nd Edition, Wiley-Blackwell, New York.
2. Watson J.D. (2009), A Passion for DNA: Genes, Genomes & Society, Cold Spring Harbor Laboratory

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press (CSHL)
3. Glover D.M. and B.D. Hames (1995), DNA cloning: A Practical Approach, IRL Press, Oxford.
4. Primrose (2009), Principles of Gene Manipulation & Genomics, Blackwell's Publishers, 7th Edition.
5. S.M. Kingsman and A.J. Kingsman (1998), Genetic Engineering : An Introduction to Gene Analysis and Exploitation in Eucaryotes, Blackwell Scientific Publications, Oxford,.
6. Sambrook J. E.F. Fritech and T. Maniatis (2000), Molecular cloning: A laboratory Manual, Cold Spring Harbor Laboratory Press, New York
7. Hill W.E. (2000), Genetic Engineering: A Primer, Taylor and Francis.

Research/Review Papers:

1. Miao, G., Zhang, L., Zhang, J., Ge, S., Xia, N., Qian, S., ..& Qiu, X. (2020). Free convective PCR: from principle study to commercial applications—a critical review. Analytica chimica acta, 1108, 177-197.
2. Nuñez, J. K., Chen, J., Pommier, G. C., Cogan, J. Z., Replogle, J. M., Adriaens, C., ... & Weissman, J. S. (2021). Genome-wide programmable transcriptional memory by CRISPR-based epigenome editing. Cell, 184(9), 2503-2519.
3. Al-Samarai, F. R., & Al-Kazaz, A. A. (2015). Molecular markers: An introduction and applications. European Journal of Molecular Biotechnology, (3), 118-130.
4. Kang, T. S. (2019). Basic principles for developing real-time PCR methods used in food analysis: A review. Trends in Food Science & Technology, 91, 574-585.
5. Hu, T., Chitnis, N., Monos, D., & Dinh, A. (2021). Next-generation sequencing technologies: An overview. Human Immunology.

On-line Resources:

1. https://www.ncbi.nlm.nih.gov/probe/docs/applsilencing/
2. https://geneticeducation.co.in/what-is-gene-silencing-definition-process-techniques-and-applications/
3. https://www.sciencedirect.com/topics/neuroscience/whole-genome-sequencing

CO-PO-PSO Matrix of MSc/Mic/4/CC15												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	1.5	2	3	2	3	2	2	2
CO2	3	2	2	2	1.5	2	3	2	3	2	2	2
CO3	3	2	2	2	1.5	2	3	2	3	2	2	1.5
CO4	3	2	2	2	1.5	2	3	2	3	2	2	1.5
Average	**3**	**2**	**2**	**2**	**1.5**	**2**	**3**	**2**	**3**	**2**	**2**	**1.75**

M.Sc. Microbiology-4th Semester

MSc/Mic/4/SEC-5 Bioinformatics

Credits: 4 (Lectures: 60) **Marks: 100**

Duration of exam: 3 Hrs. Theory: 30; IA: 20

Objectives: The aim of this course is to introduce the students from basics to advances of bioinformatics. This includes teaching the basis of the biological system via information and technology.

Course Outcomes (COs): The programme aims at providing students with the following:	
CO1	To get introduced to basic tools and concepts of Bioinformatics and their significance in applied and basic Biology. Students will also learn applications of various bioinformatics tools, biodiversity databases and biological resources.
CO2	Students will learn the management of biological data in various biological databases, and bioinformatics tools related to homology search, protein functional analysis and sequence analysis.
CO3	To acquire knowledge about DNA sequence analysis, genome mapping, *in silico* drug designing techniques and tools.
CO4	Overview about gene and promoter prediction and molecular phylogeny.

Note for the paper setter: *The question paper will consist of nine questions in all. The first question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, eight more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions of 15 marks each, selecting at least one question from each unit.*

UNIT – I

Introduction to Bioinformatics: Definition, history, role and applications of bioinformatics.
Biodiversity databases: IUCN; Species 2000; FishBase; IPNI; ICTV; IT IS; Tree of life.
Biological materials resources: ATCC; MTCC; NCCS.

UNIT – II

Biological databases: Primary, secondary and structural Protein and Gene Information Resources – PIR; SWISSPROT; PDB; Genbank; DDBJ; EMBL-EBI; Specialized genomic resources
Bioinformatics Tools: Homology and similarity tools (BLAST, FASTA, SSEARCH, or HMMER search); protein functional analysis tools (PfamScan, HMMER3 phmmer, Phobius, Pratt RADAR); sequence analysis tools

UNIT – III

DNA sequence analysis: cDNA libraries and EST; EST analysis; Genome Survey Sequence; pairwise alignment techniques; database searching; multiple sequence alignment. Genome Mapping; Genome Sequence Assembly; Genome Annotation; Comparative Genomics. Human Genome analysis
Secondary database searching: building search protocol; basic principles of computer aided drug design; docking; QSAR.

UNIT – IV

Gene and Promoter Prediction: Categories of Gene Prediction Programs; Gene Prediction in Prokaryotes and Eukaryotes; Promoter and Regulatory Elements in Prokaryotes and Eukaryotes.
Molecular Phylogenetics: Molecular Evolution and Molecular Phylogenetics; Terminology; Gene Phylogeny versus Species Phylogeny; Forms of Tree Representation; Finding a True Tree. Distance-Based Methods; Character-Based Methods; Phylogenetic Tree Evaluation; Phylogenetic Programs.

Suggested Readings:

Text/Reference Books:

1. Attwood TK &Parry-Smith DJ. (2003). Introduction to Bioinformatics. Pearson Education.
2. Bhatia, S.C. (2015). Bioinformatics. Shree.
3. Curran, B. G. & Walker, R. J. (2010). Bioinformatics. CBS
4. Jaing, Rui/Zhang, Xuegong. (2013). Basics of Bioinformatics. Springer.
5. Krane .2003. Fundamental concept of bioinformatics, Pearson Education, Singapore.
6. Nucleic Acids Research. Genome Database issue. 2001 Jan.
7. Pevsner, Jonathan. (2009). Bioinformatics and Functional Genomics. Wiley,Caneda
8. Rastogi SC, Mendiratta N & Rastogi P. (2004). Bioinformatics: Concepts, Skills and Applications. CBS.
9. Singh, Anupam & Singh, Vishwadeep. (2013). BioInformatics Power to Biotechnology. N.P.H.
10. Singh, Rand Sharma, R. (2010) Bioinformatics: Basics, Algorithms and Applications, Universities Press.

Research/Review Papers:

1. Pearson, W. R. (2016). Finding protein and nucleotide similarities with FASTA. *Current protocols in bioinformatics*, *53*(1), 3-9.
2. Medina-Rivera, A.,et al. (2015). RSAT 2015: regulatory sequence analysis tools. *Nucleic acids research*, *43*(W1), W50-W56.
3. Lappalainen, T., et al. (2019). Genomic analysis in the age of human genome sequencing. *Cell*, *177*(1), 70-84.
4. Lees, J. A., et al. (2018). Evaluation of phylogenetic reconstruction methods using bacterial whole genomes: a simulation based study. *Wellcome open research*, *3*.

On-line Resources

1. https://microbenotes.com/bioinformatics-introduction-and-applications/
2. https://www.ncbi.nlm.nih.gov/books/NBK21122/
3. https://www.frontiersin.org/articles/10.3389/fgene.2019.00286/full
4. https://www.ncbi.nlm.nih.gov/books/NBK21116/
5. https://libraryguides.mcgill.ca/bioinformatics/databases
6. https://www.ncbi.nlm.nih.gov
7. https://www.atcc.org/
8. https://www.rcsb.org/

CO-PO-PSO matrix of MSc/Mic/4/SEC5												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**

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CO1	3	1.5	2	2	2	2	2	2	3	2	2	2
CO2	3	1.5	2	2	2	2	1.5	2	3	2	2	2
CO3	3	1.5	2	1.5	1.5	2	1.5	2	3	2	2	2
CO4	3	1.5	2	1.5	1.5	2	2	2	3	2	2	2
Average	**3**	**1.5**	**2**	**1.75**	**1.75**	**2**	**1.75**	**2**	**3**	**2**	**2**	**2**

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M.Sc. Microbiology-4th Semester
MSc/Mic/4/SEC 6- Lab Recombinant DNA Technology and Bioinformatics

Credits: 4 (Lab Hrs. 120) **Marks: 100**
Duration of exam: 4 Hrs.

Course Outcomes (COs): After completion of this course, students will be able to:	
CO1	Understand the role of computers in biological research, format of various biological databases and bioinformatics tools.
CO2	Shall be able to search the gene/protein sequence in the database, learn to use various databases and their resources and tools to analyse the sequences
CO3	Able to isolate bacterial genomic DNA
CO4	Able to understand techniques like Polymerase Chain Reaction, Southern Hybridization**,** DNA Finger printing

Scope of computers in biological research: Operating systems – type of Windows, Internet and its applications.

Databases, Tools and Applications: Retrieval of Gene and Protein Sequences; ClustalW, Omega; NCBI and its resources, BLAST; FASTA; PIBWIN; ORF finder; NCBI map viewer; ATCC; MTCC; Species 2000; Tree of life; IPNI 1999; Fishbase 2001; ICTV; Web cutter; Translation tools

Recombinant DNA Technology: Isolation of Bacterial genomic DNA, Restriction enzyme digestion of pUC18 DNA, Purification of digested DNA by column purification, Ligation of DNA fragment with cloning vector, Preparation of Competent cells, Transformation in E.coli with recombinant vector, Polymerase Chain Reaction, Southern Hybridization**,** DNA Finger printing

Suggested Readings:

1. A Text Book of Bioinformatics. Sharma, Munjal and Shanker (2016-17) Rastogi Publications, Meerut.
2. Basics of Bioinformatics. Jaing, Rui/Zhang, Xuegong. (2013). Springer.
3. Bioinformatics: Basics, Algorithms and Applications. Ruchi Singh and Richa Sharma (2010) Universities Press Pvt. Ltd.

Research/Review Papers:

1. Xia, X. (2018). DAMBE7: New and improved tools for data analysis in molecular biology and evolution. *Molecular biology and evolution*, *35*(6), 1550-1552.
2. Lafita, A., et al. (2019). BioJava 5: A community driven open-source bioinformatics library. *PLoS computational biology*, *15*(2), e1006791.
3. Lefkowitz, E. J., et al. (2018). Virus taxonomy: the database of the International Committee on Taxonomy of Viruses (ICTV). *Nucleic acids research*, *46*(D1), D708-D717.

On-line Resources:

1. https://edu.gcfglobal.org/en/computerbasics/understanding-operating-systems/1/

2. https://www.webopedia.com/insights/windows-operating-system-history/
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3531099/
4. https://www.ncbi.nlm.nih.gov/books/NBK209072/
5. https://vlab.amrita.edu/?sub=3&brch=274&sim=1447&cnt=1
6. https://www.ncbi.nlm.nih.gov
7. https://www.atcc.org/
8. https://www.rcsb.org/
9. https://google.com

CO-PO-PSO matrix of MSc/Mic/4/SEC6												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	2	2	2	3	2	2	2
CO2	3	2	1.5	2	1.5	2	1.5	2	3	2	2	2
CO3	3	2	1.5	2	2	2	1.5	2	3	2	2	2
CO4	3	2	1.5	2.5	2	2	2	2	3	2	2	2
Average	**3**	**2**	**1.5**	**2.12**	**1.75**	**2**	**1.75**	**2**	**3**	**2**	**2**	**2**

M.Sc. Microbiology-4th Semester
MSc/Mic/4/DSC5-A- Dissertation

Credits: 4 **Marks: 100**

Mode of Examination: As per guidelines of the University

Objectives: The objective of the course is to make the students capable of hypothesizing and carrying out a research project.

Course outcomes (COs): By the end of the course, the student should be able to:	
CO 1	Hypothesize about any research problem.
CO 2	Carry out exhaustive review of literature.
CO 3	Plan and execute the required experimentation
CO 4	Write and document the entire study in dissertation form

CO, PO, PSO metrics of MSc/Mic/4/DSC5-A												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	2	1.5	1.5	2	3	3	2	2
CO2	2	2	1	2	2	1	1.5	2	2	3	2	2
CO3	3	2	1	2	1.5	1.5	2	2	3	3	2	2
CO4	2	2	1.5	2	1.5	1	2	2	2	3	2	2
Average	**2.5**	**2**	**1.25**	**2**	**1.75**	**1.25**	**1.75**	**2**	**2.5**	**3**	**2**	**2**

M.Sc. Microbiology-4th Semester
MSc/Mic/4/DSC5-B- Research-Review Project

Mode of Examination: As per guidelines of the University

Objectives: The objective of the course is to make the students capable of hypothesizing andwriting about a review project.

Course outcomes (COs): By the end of the course, the student should be able to:	
CO 1	Hypothesize about any research problem.
CO 2	Carry out exhaustive review of literature.
CO 3	Carry out documentation of the work
CO 4	Write the entire study in report form

CO, PO, PSO metrics of MSc/Mic/4/DSC5-B												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1.5	2	1.5	1.5	1.5	2	3	3	2	2
CO2	2	2	1	2	1.5	1	1.5	2	2	3	2	2
CO3	3	2	1	2	2	1.5	2	2	3	3	2	2
CO4	2	2	1.5	2	2	1	2	2	2	3	2	2
Average	**2.5**	**2**	**1.25**	**2**	**1.75**	**1.25**	**1.75**	**2**	**2.5**	**3**	**2**	**2**