

**NEP-2020 BASED CURRICULA AND EXAMINATION SCHEME,
UNIVERSITY OF KOTA, KOTA**

M.Sc. Microbiology programme

CBCS pattern (with effect from 2025-2026)



DEPARTMENT OF MICROBIOLOGY

**UNIVERSITY OF KOTA
MBS Marg, KOTA (Rajasthan)-324 005
INDIA**

Course Code: MIC 12400P

Type of the Course: Professional

Title of the Course: M. Sc. Microbiology

Level of the Course: PG level

Credit of the Course: 100

Delivery subtype of the Course: Practical

Pre requisites and co requisites of the Course

- ❖ A candidate who has passed any one of the following examinations from any University recognized by the UGC shall be permitted to take admission in M.Sc. First Semester to award M.Sc. degree in Microbiology from this University after completion of a course of study of two academic years divided in the four-semester scheme of examination:
- ❖ B.Sc. (Pass / Hons) under biological science stream with subjects: Microbiology, Biotechnology, Biochemistry, Biology, Chemistry, Botany, Zoology, Genetics, Environmental Sciences, Bioinformatics, Pharmaceutical Science, etc. or
- ❖ Bachelor of Science and Education (B.Sc.-B.Ed.) with subject biology, chemistry, botany, zoology.

University of Kota, Kota

M.Sc. Microbiology

Semester wise Consolidated Common Scheme of Examinations for the Academic Sessions 2023-2024

Year / Semester	Number, Code or ID and Nomenclature of Paper				Duration of Exam. (in Hrs.)	Teaching Hrs / Week			Distribution of Assessment Marks					
	Number of Paper	Code / ID of Paper		Nomenclature of Paper					Continuous or Internal Assessment (30%)		Semester or External Assessment (70%)		Total	
						Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks			
												Th.	Pr.	Credit Point
1st Year I Semester	Paper-1.1	MIC-5101	DCC	General Microbiology	3	4	-	4	30	12	70	28	100	40
	Paper-1.2	MIC-5102	DCC	Cell Biology and Enzymology	3	4	-	4	30	12	70	28	100	40
	Paper-1.3	MIC -5103	DCC	Microbial Genetics	3	4	-	4	30	12	70	28	100	40
	Paper-1.4	MIC -5104	DCC	Biochemistry and Microbial Physiology	3	4	-	4	30	12	70	28	100	40
	Paper-1.5	MIC -5105	DCC	Lab Course-I	6	-	8	4	--	--	100	50	100	50
	Paper 1.6	MIC -5106	DCC	Lab Course-II	6	-	8	4	--	--	100	50	100	50
				Total (I Semester)	24	32		24	120	48	480	212	600	260
1st Year II Semester	Paper-2.1	MIC -5201	DCC	Microbial Diversity	3	4	-	4	30	12	70	28	100	40
	Paper-2.2	MIC -5202	DCC	Molecular Biology	3	4	-	4	30	12	70	28	100	40
	Paper-2.3	MIC -5203	DCC	Immunology and Immunotechnology	3	4	-	4	30	12	70	28	100	40
	Paper-2.4	MIC -5204	DCC	Tools and Techniques in Microbiology	3	4	-	4	30	12	70	28	100	40
	Paper-2.5	MIC -5205	DCC	Lab Course-III	6		8	4			100	50	100	50
	Paper 2.6	MIC -5206	DCC	Lab Course-IV	6		8	4			100	50	100	50
	Paper 2.7		VAC	Value Added Course (Opt from Pool-A of the Value-Added Course)				2	50	25			50	25
			Total (II Semester)	24	32		26	170	73	480	212	650	285	
2nd Year III Semester	Paper-3.1	MIC -6301	DSE	Microbial Ecology and Environmental Microbiology	3	4	-	4	30	12	70	28	100	40
	Paper-3.2	MIC -6302	SEC	Fermentation Technology & Bioinformatics	3	4	-	4	30	12	70	28	100	40
	Paper-3.3	MIC -6303	DSE	ELECTIVE I 1. Biofuel and Bioenergy 2. Pharmaceutical microbiology	3	4	-	4	30	12	70	28	100	40
	Paper-3.4	MIC -6304	DSE	ELECTIVE II 1. Antimicrobial Resistance 2. Microbial nanotechnology	3	4	-	4	30	12	70	28	100	40
	Paper-3.5	MIC -6305	DCC	Lab Course-V	6	-	8	4	--	--	100	50	100	50
	Paper-3.6	MIC -6306	DCC	Lab Course-VI	6		8	4			100	50	100	50
	Paper-3.7		VAC	Value Added Course (Opt from Pool-B of the Value-Added Course)				2	50	25			50	25
				Total (III Semester)	24	32		26	170	73	480	212	650	285
2nd Year IV Semester	Paper-4.1	MIC-6401	DSE	1. Industrial Microbiology 2. Medical Microbiology	3	4	-	4	30	12	70	28	100	40
	Paper-4.2	MIC -6402	SEC	Biostatistics &, IPR	3	4	-	4	30	12	70	28	100	40
	Paper-4.3	MIC-6403	SEC	Scientific Skills & Research Ethics	3	4	-	4	30	12	70	28	100	40
	Paper-4.4	MIC-6404	DCC	Lab Course-VII	6	-	8	4	--	--	100	50	100	50
	Paper-4.5	MIC -6405	DPR	Dissertation	3	-		8	--	-	200	100	200	100
				Total (IV Semester)	18	20		24	90	36	510	234	600	270
Grand Total (I + II + III + IV Semester)					90	116		100	550	230	1950	870	2500	1100

Note: Value Added Courses (VAC) may be opted from Pool-A and Pool-B. List of the VAC for Pool-A and Pool-B is uploaded separately on the University website i.e. www.uok.ac.in.

Salient features are as follows:

- Discipline Core (DSC) or Domain-specific Core Courses in Microbiology as Major.
- Discipline Electives (DSE) or Elective Courses in the Core Subject or Discipline.
- Open Electives (OE) are Elective Courses offered to students from non-core Subjects across disciplines.
- Skill Enhancement Courses (SEC) that are domain-specific or generic.
- Dissertation/Project/ course (DPR) or Elective course in the core subject

Objectives of the Course: Microbiology is the broad area of biology involving living systems and organisms to develop or make products, or "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use".

- Students will gain necessary knowledge and develop specialized skills in the different areas of Microbiology.
- Students will think critically and creatively about the use of Microbiology to address local and global problems.
- Students will be able to implement the scientific skills for development of industrial applications and entrepreneurship

Hyperlinks of suggested e resources on University website and on web

NPTL and UGC epathshala, SWAYAM, MH Education , NPTEL, GeoGebra and MS Excel toolbox

<https://link.springer.com/>

<https://www.tandfonline.com/>

<https://onlinelibrary.wiley.com/>

<https://ghr.nlm.nih.gov/resources#inheritance>

<https://opentextbc.ca/biology/chapter/10-1-cloning-and-genetic-engineering/>

<http://www.hoajonline.com/molbiol/geneteng>

<https://www.yourgenome.org/facts/what-is-genetic-engineering>

<https://www.immunology.org/>

<https://onlinelearning.hms.harvard.edu/hmx/courses/hmximmunology>

<https://www.rcsb.org/>

<http://jgi.doe.gov/our-science/>

<https://www.genengnews.com/>

<http://biosafety.icgeb.org/in>

<https://iop.vast.ac.vn/theor/conferences/smp/1st/kaminuma/SWISSPROT/index.html>

<http://www.ipindia.nic.in/>

<http://www.wipo.int>

<http://www.wto.org>

<http://www.nbaindia.org>

<http://www.envfor.nic.in/divisions/csurv/geac/annex-5.pdf>

Springer® Journal author tutorials now with interactive courses

Elsevier® Researcher Academy

<https://www.hhs.gov/vaccines/about/resources/smart-vaccinetool/index.html>

<https://www.cdc.gov/vaccines/pubs/pinkbook/index.html>

<https://www.embl.org/>

<https://www.cathdb.info/>

Environmental Microbiology latest research and news

Microbiology news, Science Daily, Nature News, Science News

Nature Microbiology, Journal of Applied Biology & Microbiology

Programme outcome

Upon completion of the M.Sc. Microbiology programme, the candidate should be able to:

- Demonstrate knowledge for in-depth analytical and critical thinking to identify, formulate and solve the issues related to Microbiology Industry, Pharma industry, Medical or hospital related organizations, Regulatory Agencies & Academia.
- Demonstrate skills to use modern analytical tools/ software/ equipment to design & develop experiments and analyze and solve problems in various courses of Microbiology.
- Appreciate and execute their professional roles in society as Microbiology professionals, employers and employees in various industries, regulators, researchers, educators and managers
- Acquire basic and advance skills in in various fields of Microbiology for self- employment and entrepreneurship

Duration of the Course:

The course for the degree of Master of Science in Microbiology shall consist of two academic years / sessions divided in to four equal semesters. The first academic year / session will comprise first and second semesters. The second academic year / session will comprise of the third and fourth semesters. Each semester shall comprise normally 90 working days. The course shall run on the regular basis.

Minimum Marks required in Qualifying Examination:

- ❖ Qualifying examination passed from any recognised University which is situated in Rajasthan State:
 - General Category = 55%.
 - SC / ST / OBC / SBC or MBC = Min. Pass Marks
- ❖ Qualifying examination passed from any recognised University which is situated at outside the Rajasthan State:
 - All Categories = 60%.

❖ Eligibility for Admission in M.Sc. Third Semester:

A candidate may be promoted in the next academic session (in odd semester *i.e.* III semester) if he/she has cleared collectively at least 50% of the papers of both semesters (*i.e.* semester I & II) of previous academic session with 50% of the aggregate marks. The candidate who does not fulfill the above condition will remain as an ex-student and will re-appear in the due paper's examinations along with next odd/even semester examinations.

Programme Structure

The Master of Science (M.Sc.) in Microbiology programme consists Discipline Centric Core (DCC) Courses/Papers and Discipline Specific Elective (DSE) Courses/Papers, Dissertation/ Project Course (DPR) and Value-Added Courses (VAC) under Choice Based Credit System (CBCS) being offered by any of the other Department of the University of Kota or from Government online portal like SWAYAM, MOOC etc. as per the details of the course structure given below:

S. No.	Nature of Paper / Course	Semesters Wise Papers/Course along with Credits of Theory and Practical Components				Total Credits
		I	II	III	IV	
1.	Discipline Centric Core (DCC) Course	Subject-I (4T = 4 Cr) Subject-II (4T = 4 Cr) Subject-III (4T = 4 Cr) Subject-IV (4T = 4 Cr) Subject-V (8P = 4 Cr) Subject-VI (8P = 4 Cr)	Subject-I (4T = 4 Cr) Subject-II (4T = 4 Cr) Subject-III (4T = 4 Cr) Subject-IV (4T = 4 Cr) Subject-V (8P = 4 Cr) Subject-VI (8P = 4 Cr)	Subject-V (8P = 4 Cr) Subject-VI (8P = 4 Cr)	Subject-III (8P = 4 Cr)	60
2.	Discipline Specific Elective (DSE) Course	--	--	Subject-I (4T = 4 Cr) Subject-III (4T = 4 Cr) Subject-IV (4T = 4 Cr)	Subject-I (4T = 4 Cr)	16
3	Skill Enhancement Course (SEC)			Subject-II (4T = 4 Cr)	Subject-II (4T = 4 Cr) Subject-IV (4T = 4 Cr)	12
4	Dissertation/Project course (DPR)				Subject-V Dissertation (8Cr)	08
5.	Value Added Course (VAC)	--	VAC (4P = 2 Cr) (from Pool-A)	VAC (4P = 2 Cr) (from Pool-B)	--	04
Total Credits		24	26	26	24	100

Attendance:

Every teaching faculty, handling a course, shall be responsible for the maintenance of Attendance Register for candidates who have registered for the course. The teacher of the course must intimate the Head of the Department at least seven calendar days before the last instruction day in the semester about the attendance particulars of all students. Each student should earn 75% attendance in the courses of the particular semester failing which he or she will not be permitted to sit in the end semester examinations. However, it shall be open to the authorities to grant exemption to a candidate who has failed to obtain the prescribed 75% attendance for valid reasons and such exemptions should not under any circumstance be granted for attendance below 65%.

Teaching Methodologies:

The classroom teaching would be through conventional lectures or use of OHP or power point presentations (PPT). The lecture would be such that the student should participate actively in the discussion. Student seminars would be conducted and scientific discussions would be arranged to improve their communicative skill. In the

laboratory, instruction would be given for the experiments followed by demonstration and finally the students have to do the experiments individually. For the students of slow learners, special attention would be given.

Assessment Pattern:

The assessment of the students shall be divided into two parts in which first part is continuous assessment or internal assessment or mid-term assessment (30% weightage of the maximum marks) and second part is semester assessment or external assessment or end-term assessment (70% weightage of the maximum marks). Assessment pattern and distribution of maximum marks is summarized as given below:

(i) Continuous or Internal or Mid Term Assessment:

- (a) The continuous or internal or mid-term assessment (30% weightage of the maximum marks) for each theory paper shall be taken by the faculty members of the respective Departments during each semester. There will be three internal assessment tests (*i.e.* First internal assessment test or first mid-term test and second internal assessment test or second mid-term test and third internal assessment test) each of 10% weightage of maximum marks of each theory paper. Each internal assessment shall be of one hour duration for theory paper and shall be taken according to academic calendar which will be notified by the Department / University.
- (b) For practical papers, there will be no continuous or internal or mid-term assessment. There will be only one external or semester or end-term assessment (100% weightage of maximum marks).
- (c) A student who remains absent (defaulter) or fails or wants to improve the marks in the internal assessment may be permitted to appear in the desired paper(s) (only one time) in the same semester with the permission of the concern Head of the Department. A defaulter / improvement fee of Rupees 250/- per paper shall be taken from such candidates. Duly forwarded application of such candidates by the teacher concerned shall be submitted to Head of the Department who may permit the candidate to appear in the internal assessment after production of satisfactory evidence about the reason of his/her absence in the test(s) and deposition of the defaulter / improvement fee. A record of such candidates shall be kept in the Department.
- (d) Regular attendance of the student shall be considered in the internal assessment. Some marks for regularity shall be given to the student(s) who is/are taken classes regularly from the 5% weightage of the maximum marks. The 5% weightage of the maximum marks of regularity shall be taken from the weightage given for second internal assessment (10% weightage of maximum marks). After excluding the 5% weightage of regularity, the second internal assessment shall be of 10% weightage of maximum marks. If the attendance / regularity factor is similar for all the students, then it may be merged with the weightage of second internal assessment test (class test, home assignment, quiz, seminar, *etc.*) and then second internal assessment test shall be of 15% weightage of maximum marks.
- (e) 'Student should qualify both internal & external assessment separately to pass the paper *i.e.*, if candidate passes in external & fails in internal, the candidate has to reappear in internal & external exam of that paper. But if candidate passes in the internal & fails in the external, the candidate has to reappear in external exam of the paper and in internal examination he has option either to forward the obtained internal marks of that paper in the previous attempt (on the basis of the application submitted by the candidate and approval of Head of Department for the same) or can reappear in the internal examination if he wants to improve his marks in that paper.'

(ii) Semester or External or End Term Assessment:

- (a) The semester or external or end-term assessment (70% weightage of the maximum marks) shall be three hours duration to each theory paper and twelve hours duration (spread over two days with 6 hours per day) for each practical paper and shall be taken by the University at the end of each semester.
- (b) The syllabus for each theory paper is divided into five independent units and question paper for each theory will be divided into three sections as mentioned below:
***Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.*
***Section-B** will carry 50 marks with equally divided into five long answer type question. Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.*
- (c) The syllabus of practical paper is divided according to main streams of Microbiology. Marks shall be awarded on the basis of major & minor experiments, spotting, viva-voce, practical record, regularity factor, lab skills, maintain cleanness of workplace, etc.

Question Paper Pattern:

(A) Continuous or Internal or Mid Term Assessment:

30% weightage of Maximum Marks (30 Marks out of 100 Maximum Marks).

(i) First Continuous or Internal or Mid Term Assessment:

Format

Department of

College / University

Address.....

First Internal Assessment Test 20... - 20....

Class	:	Max. Marks	:	10 marks
Semester	:	Duration of Exam.	:	
Subject	:	Date of Examination	:	
Paper	:	Name of Teacher	:	

Note: All questions are compulsory and marks are given at the end of each question. Two or three sub-divisions may be given in the question.

Q. No. 1.

or

.....

4 Marks

Q. No. 2.

or

.....

3 Marks

Q. No. 3.

or

.....

3 Marks

(ii) Second Continuous or Internal or Mid Term Assessment:

(a) Attendance:

Marks shall be given by the faculty member in each paper according to its weightage.

5% weightage of Maximum Marks

Note:

If the attendance / regularity factor is similar for all the students, then it may be merged with the weightage of second internal assessment test (class test, assignment, quiz, etc.).

(b) Seminar / Presentation/ Minor Projects

5% or 10% weightage of Maximum Marks

Format

Department of

College / University

Address.....

Second Internal Assessment Test 20... - 20....

Class	:	Max. Marks	: 10 Marks
Semester	:	Duration of Exam.	:
Subject	:	Date of Examination	:
Topic/Paper	:	Name of Teacher	:

Seminar /Presentation

(Based on Curriculum)

Format

Department of

College / University

Address.....

Third Internal Assessment Test 20... - 20....

Class	:	Max. Marks	: 10 Marks
Semester	:	Duration of Exam.	:
Subject	:	Date of Examination	:
Topic/Paper	:	Name of Teacher	:

(a) Assignment:

(May be divided in parts or questions or may not be. It will be depending on the nature of assignment).

10% weightage of Maximum Marks

or

(b) Quiz:

(May be divided in parts or questions or may not be. It will be depending on the nature of quiz).

10% weightage of Maximum Marks

Or

(c) Excursion or Industrial visit or Any other tool may be adopted for internal Assessment

10% weightage of Maximum Marks

(B) Semester or External or End Term Assessment:

70% weightage of Max Marks (i.e. 70 Marks out of 100 Max Marks).

Duration of Examination: 3 Hours

Max. Marks: 70

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions. Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

SECTION-A

Q. 1.

Unit-I

- | | | |
|------|-------|---------------|
| (i) | ..... | 2 Mark |
| (ii) | ..... | 2 Mark |

Unit-II

- | | | |
|-------|-------|---------------|
| (iii) | ..... | 2 Mark |
| (iv) | ..... | 2 Mark |

Unit-II

- | | | |
|------|-------|---------------|
| (v) | ..... | 2 Mark |
| (vi) | ..... | 2 Mark |

Unit-IV

- | | | |
|--------|-------|---------------|
| (vii) | ..... | 2 Mark |
| (viii) | ..... | 2 Mark |

Unit-V

- | | | |
|------|-------|---------------|
| (ix) | ..... | 2 Mark |
| (x) | ..... | 2 Mark |

SECTION-B

Unit-I

- | | | |
|--------------|-------|-----------------|
| Q. 2. | ..... | 10 Marks |
| | or | |
|  | ..... | 10Marks |

Unit-II

- | | | |
|--------------|-------|-----------------|
| Q. 3. | ..... | 10 Marks |
| | or | |
|  | ..... | 10 Marks |

Unit-III

- | | | |
|--------------|-------|-----------------|
| Q. 4. | ..... | 10 Marks |
| | or | |
|  | ..... | 10 Marks |

Unit-IV

- | | | |
|--------------|-------|-----------------|
| Q. 5. | | 10 Marks |
|--------------|-------|-----------------|

.....	or	.....	10Marks
Unit-V			
Q. 6.			10Marks
.....	or	.....	10 Marks

Practical Examinations: For All Lab Courses

Continuous or Internal or Mid Term Assessment: *Not applicable in practical.*

External or Semester or End Term Assessment:

Duration of Exam : 6 Hours

Maximum Marks : 100 Marks*

Distribution of Maximum Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1 : Major Experiment	20
2.	Exercise No. 2 : Major Experiment	20
3.	Exercise No. 3 : Minor Experiment	10
4.	Exercise No. 4 : Minor Experiment	10
5.	Exercise No. 5 : Spotting Experiment(5 spots)	15
6.	Laboratory Skills, Regularity, etc.	10
7.	Practical Record	5
8.	Viva-voce	10
Total Marks		100

Seminar:

The students shall compulsorily have to deliver an oral presentation on for continuous or internal or mid-term assessment in each semester. There will not be semester or external or end-term assessment for seminar.

Dissertation:

A dissertation shall be initiated at the end of the Semester III and continued during Semester IV. A dissertation may be undertaken in any research laboratories/industries/university department. The students shall compulsorily submit the certificate of completion and report to the Department during the practical examination. The marks will be awarded by the external examiner on the day of the practical examination on the basis of the experimental, presentation and viva-voce.

Minimum Pass Marks and Rules regarding Determination of Results:

Each semester shall be regarded as a unit for working out the result of the candidates. The result of each semester examination shall be worked out separately (even if the candidate has appeared at the paper(s) of the lower semester examination along with the papers of higher semester examination) in accordance with the following conditions:

- (i) The candidate shall be declared as pass in a semester examination, if he/she secures at least 40% marks in each theory paper separately in external & internal examinations and 50% marks in each practical paper and at least 50% marks in project/ dissertation with 50% aggregate marks in that semester.
- (ii) A candidate declared as fail/absent in one or more papers at any odd semester examination shall be permitted to take admission in the next higher semester (even semester) of the same academic session.
- (iii) A candidate may be promoted in the next academic session (odd semester) if he/she cleared collectively at least 50% of the papers of both semester of previous academic session with 50% of the aggregate marks.

The candidate who does not fulfil the above condition will remain as an ex-student and will appear S in the due papers with next odd/even semester exams.

- (iv) If any student who is provisionally admitted in higher odd semester but not secure prescribed minimum marks in previous semesters will be treated as ex-student and his/her admission fee will be carry forward to the next odd semester of forthcoming academic session.
- (v) A candidate may be promoted in the next semester (odd semester) if he/she has cleared collectively at least 50% of the papers of both semesters of previous academic session with 50% of the aggregate marks. The candidate who does not fulfill this condition will remain in the same semester as an ex-student and will re-appear in the due papers examination along with next odd/even semester examinations.
- (vi) If any student who is provisionally admitted in higher odd semester but could not secure prescribed minimum marks in previous semesters will be treated as ex-student and his/her admission fee will be carry forwarded to the next odd semester of forthcoming academic session.
- (vii) A candidate declared as failed in that particular paper he/she can re-appear for that paper in the next year examination as a due paper. However, the internal marks shall be carried forward for the total marks of the due examination. A candidate will not be allowed to re-appear in the practical examination.
- (viii) A candidate may be given only two additional chances for passing the semester thus maximum tenure for completing the two years' postgraduate course will be limited to four years, for three years postgraduate programme up to five years and so on.
- (ix) If the number of papers prescribed at the first and second or third and fourth semester examination is an odd number, it shall be increased by one for the purpose of reckoning 50% of the papers.
- (x) A candidate who passes in 50% or more papers of the first and second semester examination, and thereby becomes eligible for admission to the third semester examination, but chooses not to do so and desires to appear in the remaining papers of first and second semester examination only or to re-appear in all the prescribed papers and practical/dissertation/seminar of the M.Sc. first and second semester examination will be permitted to do so on the condition that in the latter case his previous performance will be treated as cancelled.
- (xi) If a candidate, who has been promoted to the next semester and wishes to improve his / her performance in the theory paper(s) of previous semester, can be permitted to do so in case of the theory papers only, not in practical / project / dissertation / seminar, belonging to the immediately preceding semester only for one time in these papers in next odd/even semester examinations. In such a case, he/she shall have to appear in these papers along with the papers of his/her own semester.
- (xii) A candidate shall be declared as passed after the result of the fourth semester examination, if he/she cleared all papers of the all the four semesters and secure minimum 40% of the aggregate marks of the maximum marks in theory papers and 50% of the aggregate marks of the maximum marks for practical / dissertation / presentation / seminar prescribed for four semesters Master's programme.
- (xiii) In the case of an ex-student, the marks secured by him/her at his/her last examination as a regular candidate shall be taken into account except in cases where a candidate is re-appearing at the examination as a regular student and in that event, he/she shall have to repeat the internal assessment test which will be finally accounted for working out his result.
- (xiv) A candidate who has failed at the M.Sc. third and fourth semester examination but has passed in at least 50% of the papers prescribed for the examination shall be exempted from re-appearing in a subsequent year in the papers in which he/she has passed.

- (xv) If a candidate clears any paper(s) prescribed at the first and second semester (previous) and/or third and fourth semester (final) examination after a continuous period of three years, then for the purpose of working out his/her division, only the minimum pass marks shall be taken into account in respect of such paper(s) as are cleared after the aforesaid period provided that in case where a candidate requires more than 40% marks in order to reach the requisite minimum aggregate, as many marks out of those secured by him/her will be taken in to account as would enable him/her to make up the deficiency in the requisite minimum aggregate.
- (xvi) In case the candidate is not able to clear his/her due paper(s) in the stipulated period as mentioned above (continuous period of three years), he/she may be given last one mercy attempt to clear due paper(s) subjected to approval of the Vice Chancellor or Board of Management.
- (xvii) The grace marks scheme shall be applicable as per University norms.

Syllabus

M.Sc. Microbiology
First Semester Examination
Paper 1.1: MIC-5101-General Microbiology

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous/Internal/Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT I **15-18L**

Overview of history of Microbiology: Contribution of Antonie Von Leeuwenhoek, Needham, Redi, Spallanzani, Tyndal, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Alexander Fleming, Scope of Microbiology.

Microbial World: Classification system and distinctive characters of major groups: Fungi, Algae, Protozoa, Viruses, Viroids, and Prions.

Nomenclature and Modern methods of Taxonomy. Classification of microbes on the basis of phenotypic and genotypic characters.

UNIT II **15-18L**

Stains and Staining Techniques: Definition of Auxochrome, Chromophores, dyes, Classification of Stains, Mechanism of Gram's, Capsule, Endospore, Flagella, Acid fast staining. Hanging drop, Wet mounting Method. Culture Media, Isolation Techniques, Maintenance and Preservation of pure cultures.

Principles and Theory of biochemical activities of microorganisms: TSI agar Test, IMViC test, Urease Test, Nitrate Reduction Test, Catalase Test, Oxidase Test, and Sugar Fermentation Test.

UNIT III **15-18L**

Concept of asepsis: Definition of Sterilization, disinfection, Sanitization, Antisepsis, Sterilant and Fumigation.

Physical methods: Moist and Dry heat, Pasteurization, Tyndallization, Radiation, Filtration. Chemical Methods: Phenol and its Derivatives, Aldehyde, Heavy metal, Halogens and Sterilizing gases. Testing and Efficacy evaluation of Antimicrobial Agents. Antibiotics their classification and Mechanism.

UNIT IV **15-18L**

Bacterial Morphology: size, shape and arrangement of bacteria. Cell: glycocalyx, capsule, flagella, fimbriae and pili. Composition and detailed structure of gram positive and gram-negative cell walls, spheroplasts, protoplasts, and L-forms. Ribosomes, mesosomes, inclusion bodies, nucleoid, Extrachromosomal genetic material. Endospore: structure, formation, stages of sporulation. Methods of reproduction in bacteria and new cell formation. Microbial Growth curve and its kinetics and growth yield. Determination of cell mass and cell number. Environmental factors affecting growth.

UNIT V

15-18L

Innovations in microbiology for human welfare: Impact of microbes on the genome project, microbial biosensors, Nanomedicines, molecular diagnostics. Probiotics microbes. Application of Artificial intelligence and machine learning in microbiology. Microbes as a biowarfare agent, Microbes in the space. Aptamers.

Text/Reference books:

1. Microbes: Concepts & Applications- P.S. Bisen, Mousumi Debnath, Godavarthi B.K.S. Prasad, John Wiley & Sons Publication 2012.
2. Brock Biology of Microorganisms, 14th Edition. Michael T. Madigan, John M. Martinko, Paul V. Dunlap and David P. Clark.
3. Bergey's manual of systematic bacteriology. George M. Garrity, David R. Boone, Richard W. Castenholz.
4. Molecular Diagnostics: Promises & Possibilities 2010. Mousuni Dabnath, G.B.K.S. Prasad P.S. Bisen.
5. General Microbiology by S. B. Sullia, 2017, Oxford Publisher's.
6. Prescott, L.M., J.P Harley and D.A Klein, 2007. Microbiology VII Ed. Mc Grow Hill,
7. Davis R.Y. E.A. Adeberg and J.L. Ingram, 1991 General Microbiology
8. Stainer. General Microbiology, V Ed., Printice Hall of India Pvt, Ltd. New Delhi
9. Ronald M. Atlas 1997. Principles of Microbiology. II Ed. Mc Graw Hill Pub.
10. Salle A.J., Fundamental Principles of Bacteriology.
11. Microbiology Vol. I & II. Power and Dagainawala
12. Microbiology. P.D. Sharma.
13. Microbiology: An Introduction. Tortora GJ, Funke BR, and Case CL.

Paper 1.2: MIC -5102-Cell Biology and Enzymology

Contact Hours / Week : 4 Hours Maximum Marks : 100 Marks

Duration of Examination : 3 Hours Continuous/Internal/Assessment : 30 Marks
Semester Assessment : 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT I **15-18L**

Cell as a unit of living organism and structure of prokaryotic cell, Structural and functional features of eukaryotic cell. Cell organelles; endoplasmic reticulum, Golgi complex, lysosomes, vacuoles, peroxisomes, mitochondria, chloroplast, cytoskeleton. Structure of nucleus and chromosomes of eukaryotes. Cancer biology: characteristics of cancer cell, types of cancer, oncogene and tumor markers.

UNIT II **15-18L**

Biological membranes: Membrane structure and transport mechanisms- diffusion, active and co-transport, secondary active transport, membrane selectivity, electrolyte selectivity, non- electrolyte selectivity, stimuli, receptors, second messengers and cellular response, membrane channels and pumps. Cell cycle: mitosis and meiosis and their regulation. Programmed Cell Death: intrinsic and extrinsic pathways. Stem cells Types: Embryonic stem cell, induced pluripotent stem cells

UNIT III **15-18L**

Cell signaling and signal transduction pathways-Signalling molecules and their receptors. Function of cell surface receptors MAPK/ERK pathway, cAMP dependent pathway, IP₃/DAG Pathway.

General properties, structure, classification and nomenclature of enzymes. Enzyme activators, co-enzymes, co-factors and prosthetic groups in enzyme catalysis, Enzyme and substrate specificity. Enzyme activation, zymogens, multi-enzymes complexes and multi-functional enzymes. Mechanism of Enzyme Action.

UNIT IV **15-18L**

Factors affecting enzyme activity. Steady state kinetics: Methods of estimation of rate of enzyme catalyzed reaction with special reference to Michaelis-menton kinetics.

Enzyme inhibition and its kinetics: Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive, mixed, partial, substrate and allosteric inhibition.

UNIT V **15-18L**

Isoenzymes and its physiological significance, Ribozymes and Abzymes.

Enzyme engineering: Chemical modification of enzymes: methods of modification of primary structure, catalytic and allosteric properties, use of group specific reagents. Enzyme Immobilization Enzymes in non-conventional media, Enzymes sensors, Enzymes as analytical reagents.

Text/Reference books:

1. Biochemistry: Lubert Stryer
2. Biochemistry: Lehninger
3. Microbial Physiology: Moat, Foster and Spector
4. Molecular biology of the cell: Bruce Alberts et. al.
5. Cell and molecular biology: Gerald Karp.
6. Cell and molecular biology: P.K. Gupta.
7. Molecular cell biology: By Lodish
8. The Cell: Cooper.
9. Enzyme: Copeland.
10. Enzyme Technology: M F Chaplin and D C Bucks.
11. Enzymology and Enzyme Technology: S M Bhatt.
12. Essentials of Biochemistry: Dr Pankaja Naik, Jaypee Brothers Medical Publishers

M.Sc. Microbiology
First Semester Examination

Paper1.3: MIC 5103- Microbial Genetics

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination : 3 Hours	Continuous/Internal/Assessment	: 30 Marks
	Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT-I

15-18L

Introduction to Microbial Genetics. DNA and RNA: structure and types. Super helicity in DNA. Law of DNA constancy, Cot curve and C value paradox, DNA renaturation kinetics and T_m value determination and interpretation, Repetitive DNA, Satellite DNA, Selfish DNA, DNA Compaction.

UNIT-II

15-18L

Recombination: Types of recombination, Models for Homologous recombination, Molecular mechanism of homologous recombination, Homologous recombination in eukaryotes, Molecular mechanism and biological role of site-specific recombination. Transposable elements in prokaryotes.

UNIT-III

15-18L

Plasmid: types and their significance. Conjugation and chromosomal mobilization. *E. coli* as model prokaryotes: Conjugation by *E. coli* F factor. (Structure of F factor and regulation of F-factor fertility), F- prime conjugation, Hfr and chromosomal mobilization.

UNIT-IV

15-18L

Transformation: Mechanism of natural competence and transformation in *Bacillus subtilis*, *Streptococcus pneumoniae* and *Haemophilus influenzae*. Transformation by artificial competence. Gene linkage and mapping by transformation. Transduction- specialized and generalized transduction and its applications.

UNIT-V

15-18L

Regulation of gene expression: Operon concept, catabolite repression, positive and negative regulation: inducers and co-repressors. Negative regulation in *E. coli* lac operon. Positive regulation in *E. coli* ara operon; regulation by attenuation of his and trp operons.

Text/Reference books:

1. Genetics of Bacterial by Sheela Shrivastava, 2013 Springer Publisher.
2. Concepts of genetics: Klug and Cummings

3. Genetics: From Genes to Genomes: Leland Hartwell, Leroy E. Hood, Michael L. Goldberg
4. Genetics: Analysis and Principles (3rd Edition): Brooker
5. Gene cloning: T.A. Brown
6. Cell and molecular Biology: P.K. Gupta.

M.Sc. Microbiology
First Semester Examination
Paper 1.4 MIC – 5104- Biochemistry and Microbial Physiology

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination : 3 Hours	Continuous/Internal/Assessment	: 30 Marks
	Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT I **15-18L**
Water, acid, base and buffers, pH and pH indicators, Solutions, Redox potential, Hydrogen bonding; Hydrophobic, Electrostatic and Vander Waal forces. Scope and importance of biochemistry. Bioenergetics and metabolism: Basic concepts. First and second law of thermodynamics. High energy phosphate compounds. Biological redox reactions, Biological reducing power and its role in biological system.

UNIT II **15-18L**
Carbohydrate and glycobiology: Structure, properties and functions of carbohydrates. Gluconeogenesis, Glycogenolysis, Glycolysis. Citric acid cycle, Electron transport system, Oxidative phosphorylation, inhibitors of oxidative phosphorylation. Chemiosmotic theory of ATP, Glyoxalate Cycle, Pentose phosphate pathway, E-D pathway, Amphibolic and Anapleurotic reaction, Photosynthesis: Oxygenic and an-oxygenic.

UNIT III **15-18L**
Amino acids: structure, classification, properties and functions. Amino Acid Metabolism- Overview of amino acid metabolism, Biodegradation of amino acids – deamination, transamination, decarboxylation, glutamine and glutamic acid pathway, urea cycle, uric acid biosynthesis. Protein structure (primary, secondary, tertiary and quaternary). Ramachandran plot. Protein degradation and targeting.

UNIT IV **15-18L**
Lipids: classification, structure, properties and functions. Steroids: Structure of steroid nucleus, biological role of cholesterol.
Lipid Metabolism- Biodegradation of fatty acids, beta – oxidations of fatty acids. Ketone bodies production during starving and diabetes.
Biosynthesis of fatty acids – Acetyl-CoA carboxylase reaction, Fatty acid synthase complex, biosynthesis of palmitate. Biosynthesis of triacylglycerols, Biosynthesis of cholesterol, Prostaglandins.

UNIT V **15-18L**
Nucleic acids: structure and properties. Nucleic Acid: Biosynthesis and degradation of Purines and Pyrimidines. Coenzymes and cofactors: Role and mechanisms of action of NAD⁺/NADP⁺, FAD, lipoic acid, thiamine,

Pyrophosphate, Biotin, Pyridoxal Phosphate, B₁₂ co-enzymes and Metal ions with specific examples. Water- and Fat-soluble vitamins; Structure, distribution, interaction and functions.

Text/Reference books:

1. Advances in Microbial Physiology, 2020 editor: Robert Poole Elsevier Publisher
2. Wilson K. and Walker J. (2008). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
3. Nelson D and Cox MM. (2009). Principles of Biochemistry. W.H. Freeman and Company, New York.
4. Voet D and Voet JG. (2003). Biochemistry. John Wiley and sons NewYork.
5. Zubay G (2000). Biochemistry. W. C. Brown, NewYork.
6. Berg J, Tymoczko J, Stryer L (2001). Biochemistry. W. H. Freeman, NewYork.
7. Moat AG and Foster J W (2003). Microbial Physiology. John Wiley and Sons, New York.
8. Robert K., Murray M.D., Granner D.K., Mayes P.A. and Rodwell V.I. Harper's Biochemistry. McGraw-Hill/Appleton and Lange.
9. Biochemistry U, SatyaNarayan.
10. Biochemistry: Lehninger
11. Fundamental of biochemistry by A.C. Dev.
12. J.L. Jain, Biochemistry.
13. Elements of biochemistry by H.R. Shrivastava.

M.Sc. Microbiology
First Semester Practical Examination
Paper 1.5 MIC - 5105 Lab Course-I

1. Good Microbiology laboratory practices: Laboratory safety (Dos and Don'ts), hazard from chemicals, handling of cultures and chemicals, disposal of chemicals and cultures.
2. Introduction to different Glass wares used in Microbiology Laboratory.
3. To learn handling of different instruments and Equipment's used for culture and Sterilization.
4. Techniques of pure culture isolation-pour plate, spread plate, streaking.
5. Preparation of Basic Liquid and Solid media for cultivation of bacteria and fungi.
6. Isolation and Enumeration of microorganisms from Air (plate exposure method), Soil and Water (serial dilution method)
7. To perform different staining methods to study morphological and structural characteristics of bacteria and fungi a. Gram Staining b. Acid fast staining c. Fungal staining (Lacto-phenol cotton blue) d. Spore staining e. Flagella staining f. Capsule staining (Negative staining)
8. To check motility of bacteria by hanging drop and semi solid agar methods
9. To learn culture preservation techniques (Agar slants, stabs and glycerol stocks)
10. Calibration of an ocular micrometre for different objectives of microscope.
11. Measurement of microorganisms by the use of an ocular micrometre.
12. To study microorganisms under dark and phase contrast microscope.
13. To study activity of disinfectants.
14. Bacterial growth curve-serial dilution, plating and turbidity measurement.
15. Standard qualitative analysis of water(microorganisms).
16. Antibiotics sensitivity test.
17. Study the effect of colchicine on the mitotic division of the Onion root tip .
18. Identification and study of cancer cells by photomicrographs.
19. Study of different stages of mitosis and meiosis.
20. Urease estimation by titrimetric method.
21. Urease estimation by colorimetric method.
22. Acid Phosphatase estimation.
23. Alkaline Phosphatase estimation.
24. Estimation of amylase.
25. Study of enzyme kinetics – calculation of V_{max} , K_m , K_{cat} values

M.Sc. Microbiology
First Semester Practical Examination
Paper 1.6 MIC - 5106 Lab Course-II

1. Triple Sugar Iron Test.
2. IMVIC Test
3. Oxidase test
4. Casein hydrolysis.
5. Urease test
6. H₂S Production
7. Catalase Test.
8. Separation of compounds by paper chromatography
9. Thin layer chromatography: Amino acids, lipids, mixture of dyes.
10. Qualitative estimation of lipid, carbohydrates & proteins.
11. Qualitative analysis of Biomolecules.
12. Colorimetry: To determine the association constant of a. given indicator calorimetrically and to prepare the buffer solutions in pH range of 2.2 to 8.0
13. Spectrophotometry: To find out absorption spectrum of given chromophore and /or oxidised and reduced forms (NAD, NADH).
14. Chlorophyll-a concentration measurement with acetone method using spectrophotometer
15. Separation of sub cellular organelles by differential centrifugation.
16. Polyacrylamide gel electrophoresis of proteins.
17. Isolation of plasmid & genomic DNA **from bacteria.**
18. Separation of DNA by gel electrophoresis.
19. To induce mutation by UV radiations and to exhibit DNA repair by photo reactivation.
20. To isolate and produce UV induced auxotrophic mutants by replica plating method.
21. Study of sex-linked gene inheritance.
22. Estimating gene frequencies in human population,
23. Recombination in Bacteria: Conjugation and Transformation
24. To check purity and quantity of DNA by Spectrophotometric method (**A₂₆₀/A₂₈₀**).
25. DNA size determination.
26. Restriction Mapping.
27. Ames Test (Mutagenicity assay using *Salmonella typhimurium*).

M.Sc. Microbiology
Second Semester Examination
Paper 2.1: MIC -5201 Microbial Diversity

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination : 3 Hours	Continuous/Internal/Assessment	: 30 Marks
	Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT- I

15-18L

Evolutionary (Phylogenetic) tree of microorganisms. Classification of microorganisms– Haeckel's three kingdom concept, Whittaker's five kingdom concept, Three domain concept of Carl Woese, Classification systems-artificial, natural and phylogenetic, Classification and salient features of bacteria according to the Bergey's manual of bacteriology.

UNIT II

15-18L

Fungi: Recent Trends in fungal systematics (Alexopolus & Mims), Fungi (habitat, nutritional requirements, fungal cell ultrastructure, thallus organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, Life cycle), heterokaryosis Parasexuality and Heterothallism. Economic Importance (Agriculture, Environment, Industry, Medicine, Food, Biodeterioration, Mycotoxins).

UNIT III

15-18L

Algae: Definition, occurrence, Classification upto class level, Ultra-structure, Reproduction and Life cycle. Economic importance (Agriculture, Industry, Environment and Food)
Protozoa (Occurrence, classification, Ultrastructure, Reproduction, Economic importance).
Virus (Definition, Structure, multiplication and replication). Virus cultivation. Bacteriophages: Structure, Life cycle –Lytic & Lysogenic

UNIT IV

15-18L

Characteristics of important genera and physiology of: Chemoautotrophic and Methanotrophs eubacteria, Gram negative aerobic eubacteria, Gilding bacteria (Myxobacteria), Enteric group and related eubacteria, Gram negative anaerobic eubacteria, Gram negative eubacteria- Rickettsia, Chlamydia and Spirochaetes. Gram positive eubacteria- Unicellular endospore forming eubacteria, Actinomycetes.

UNIT V

15-18L

Cyanobacteria: General characters, Ultra structure, Reproduction and Economic importance. Photosynthetic eubacteria: Anoxygenic and oxygenic photosynthesis, Sulfur or Non-Sulfur Bacteria (purple and green), Gram positive fermentative eubacteria. *Bdellovibrio* and its Periplasmic growth cycle, Mollicutes.

General Characters, Classification, Adaptations and Physiology of Archaeobacteria: methanogens, Acidophiles, Halophiles, Thermoacidophiles.

Text/Reference books:

1. Michael T. Madigan, John M. Martinko, Paul V. Dunlap and David P. Clark, Brock Biology of Microorganisms, 13th Edition, Pearson Education, Limited, 2011.
2. Microbial Diversity: Principles of microbial diversity. James W. Brown. Wiley Blackwell Publishers. 2014.
3. Microbes: Concepts & Applications- P.S. Bisen, Mousuns Debnath, Godavarthi B.K.S. Prasad, Wiley Blackwell. John Wiley & Sons Publication 2012.
4. Pelczar, M.J., Chan E.C.S. and Krieg, N.R., Microbiology –Application based approach, 5th edition, Mc Graw Hill, 2009.
5. Tortora, G. Microbiology: An Introduction-Benjamin Cummings, 10th Edition, 2009.
6. Willey J, Sherwood and Woolwerton C, Prescott, Harley and Klein's, Microbiology, 8th Edition, McGraw Hill International, 2010.
7. Singh, Pandey, Jain. A text Book of Botany, 2016

M.Sc. Microbiology
Second Semester Examination
Paper 2.2 MIC -5202- Molecular Biology

Contact Hours / Week : 4 Hours Maximum Marks : 100 Marks

Duration of Examination : 3 Hours Continuous/Internal Assessment : 30 Marks
Semester Assessment : 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT I

15-18L

The nature of Genetic material: The structure of DNA and RNA. Organization of Microbial Genomes, Organization of Eukaryotic Genomes, Chromatin arrangement, nucleosome and solenoid structure of DNA. Genetic code. introduction of Central dogma.

UNIT II

15-18L

DNA Replication: DNA replication in prokaryotes and eukaryotes- Initiation, elongation and termination. Enzymology of replication. Regulation of replication. Proofreading of DNA with reference to specific enzymes and co-factors. Mutations: Types of Mutations and mutagens. Molecular mechanisms of induced mutation, DNA damages and its repair pathways.

UNIT III

15-18L

Transcription: Transcription machinery and process of prokaryotes and eukaryotes -initiation, elongation and termination, various transcription enzymes and cofactors. Operon Models. Types of RNA polymerase. Regulation of transcription in Eukaryotes. Promoters, enhancers, silencers, activators

UNIT IV

15-18L

RNA processing: splicing, capping and polyadenylation, rRNA and tRNA processing, RNA Editing, RNAi: miRNAs and siRNA, post-transcriptional gene regulation. Ribozymes.

Translation: Mechanisms of translation in prokaryotes and eukaryotes- initiation, elongation and termination. Post-translational modifications.

UNIT V

15-18L

Genetic Engineering: Principle and basic tools and application. Gene cloning vectors, DNA sequencing methods, Gene libraries, Human genome project, Genetic disorders. Genetically modified organisms, Transgenic Technology. Antisense technology.

Nanotechnology, DNA nanotechnology. Stem cell technology.

Text/Reference books:

1. Molecular Biology: D. Freifelder
2. Molecular biotechnology: Glick.
3. Gene VII: Lewin Benjamin (Oxford)
4. Molecular Cell Biology: J. Darnell, H. Lodhis & D. Baltimore (W.H. Freeman &Co.)
5. Genetics: From Genes to Genomes by Leland Hartwell, Leroy E. Hood, Michael L. Goldberg
6. Genetics: Analysis and Principles (3rd Edition): Brooker
7. Gene cloning: T.A. Brown
8. Genetic Engineering: Nicoll
9. Molecular Biology and Genetic Engineering: P.K. Gupta

M.Sc. Microbiology
Second Semester Examination
Paper 2.3- MIC -5203 Immunology and Immunotechnology

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination : 3 Hours	Continuous/Internal/Assessment	: 30 Marks
	Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT-I **15-18L**

Historical account and introduction to immune system. Innate and acquired immunity. Humoral and cell mediated immune responses. Cells and tissues of immune system – Structure, Functions and Properties of Immune Cells - Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT. Immuno-prophylaxis: Active and passive immunization, Vaccines: whole organism vaccine, subunit vaccine, vaccine, DNA vaccine, recombinant vaccine, subunit vaccines and anti-idiotypic vaccine.

UNIT-II **15-18L**

Antigens: Structure and properties, Types, haptens, adjuvants, antigen specificity, Epitopes (T & B cell epitopes); T-dependent and T-independent antigens; Immunoglobulins- structure, heterogeneity, types and properties. Molecular mechanism of antibody diversity and class switching. Antigen processing and presentation. Cytokines: profile and functions. Complement system: components, activation pathways, regulation of activation pathways.

UNIT-III **15-18L**

Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response (Self MHC restriction, T cell activation, Co- stimulatory signals); Killing Mechanisms by CTL and NK cells, Introduction to tolerance. Antibody: Mediated-type I. Anaphylaxis; Type II. Antibody dependent cell cytotoxicity; Type III immune complex mediated reactions; Type IV Cell mediated hypersensitivity reactions.

UNIT-IV **15-18L**

Major histocompatibility complex: organization of MHC genes, types and function of MHC molecules, antigen presentation. Transplantation immunology: immunologic basis of graft rejection, HLA typing methods. Autoimmunity–mechanism and diseases. Tumor immunology: cancer, oncogenes, tumor antigens, immune

response to tumors, tumor evasion of the immune system, immune-diagnosis. Immuno-deficiencies: congenital and acquired. Immune response to SARS-Cov-2.

UNIT-V

15-18L

Antigen- Antibody interaction - Agglutination, Precipitation, Immunofluorescence, ELISA, Radio-immunoassays; Immuno-blotting, Immunofluorescence, Flow cytometry, Protein microarrays, *In vivo* methods: skin test and their applications. Epitope mapping, Detection of immune complex. Hybridoma Technology: Monoclonal antibodies production. Antibody engineering: Chimeric and Humanized monoclonal antibodies.

Text/Reference books:

1. Essentials of Immunology, Author- Roitt, I.M., ELBS. Blackwell Scientific Publishers, London.
2. Immunology II Edition, Author- Kuby, J. WH., Freeman and Company, New York.
3. Immune Response Activation and Immunomodulation. Edit by R.K. Tyagi & P.S. Bisen, 2019. Intechopen .com
4. Immunology. Author- Klaus D. Elgert, Wiley-Liss. NY.
5. Text Book on Principles of Bacteriology, Virology and Immunology, IX Edition (5 volumes). Topley and Wilson's, Edward Arnold, London.
6. The Experimental Foundations of Modern Immunology. Authors- Clark, V.R., John Willey and Sons, Incl.
7. Fundamental Immunology. Author – W.E. Paul, Raven Press, New York.
8. Fundamentals of Immunology. Authors – R.M. Coleman, M.F. Lombord and R.E. Sicard 2nded. C. Brown publishers.
9. Immunology. Authors -D.M. Weir and J. Steward 7th Ed. (1993).
10. Immunology: Shailendra Sharma.
11. Immunology: C.V. Rao.

M.Sc. Microbiology
Second Semester Examination
Paper 2.4: MIC 5204-Tools and Techniques in Microbiology

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous/Internal/Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT- I **15-18L**
Microscopy: Microscopes types, use of techniques of preparing specimens, resolving power, optical microscope- Basic idea of light microscopy, Types- bright field, dark field, ultra-violet, fluorescence and phase-contrast microscopes, confocal microscopy Electron microscope. TEM, SEM.

UNIT – II **15-18L**
Centrifugation techniques: - Differential, gradient, zonal or band and isopycnic density gradient centrifugation. Chromatography: Basic principles and applications: adsorption, exclusion, ion-exchange, partition and affinity chromatography; GLC, HPLC, fast protein liquid chromatography and gas-liquid ion-exchange chromatography.

UNIT – III **15-18L**
Electrophoresis: principle, types and applications. Pulse field GE, denaturing gradient GE, Temperature gradient GE, SDS-PAGE electrophoresis, Iso- electric focusing and 2D gel electrophoresis.
Nucleic acid hybridizations Technique: colony, plaque, dot blot, southern, northern and western blotting, *In situ* hybridization, Microarray technology.

UNIT- IV **15-18L**
DNA sequencing techniques: Sanger-Coulson method, Maxam Gilbert method and next generation sequencing. Polymerase Chain Reaction: PCR -steps, Types of PCR and its applications.

UNIT-V **15-18L**
Spectroscopy: Principles, instrumentation and applications: Colorimetry, UV-visible spectroscopy, Infrared Spectroscopy, fluorescence Spectroscopy.
Characterization and Methods: FTIR, NMR, ESR, Mass Spectroscopy (types of ion source, analyzers and detectors), GC-MS, MALDI-TOF. X Ray Microanalysis, Techniques with radioisotopes: GM counter, Scintillation counter, Autoradiography.

Text/Reference books:

1. Introduction to Instrumentation in Life Sciences. P.S. Bisen & Anjana Sharma. 2013. CRC Press.

- Taylor & Francis group
2. Wilson K. and Walker J. (2008). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
 3. Molecular Diagnostics: Promises & Possibilities 2010. Mousuni Dabnath, G.B.K.S. Prasad P.S. Bisen.
 4. Nelson D and Cox MM. (2009). Principles of Biochemistry. W.H. Freeman and Company, NewYork.
 5. Voet D and Voet JG. (2003). Biochemistry. John Wiley and sons NewYork.
 6. Zubay G (2000). Biochemistry. W. C. Brown, NewYork.
 7. Life Science in tools and Techniques: P.S. Bisen and Shruti Mathur, S. Chand Publication
 8. Berg J, Tymoczko J, Stryer L (2001). Biochemistry. W. H. Freeman, NewYork.
 9. Nuclear Magnetic Resonance: Williams
 10. A Biologist Guide to Principle and Techniques: Willson K. and Gounding K.H.
 11. Biochemical Techniques theory and practice: WhiteR.
 12. Molecular biotechnology-Glick
 13. An Introduction to Practical Biochemistry: Plummer D.T.

M.Sc. Microbiology
Second Semester Practical Examination
Paper 2.5 MIC – 5205 Lab Course III

1. Isolation cultivation and morphological studies of Actinomycetes.
2. Isolation cultivation and morphological studies of fungi.
3. Study of *Rhizopus*, *Penicillium*, *Aspergillus*, *Saccharomyces* using temporary mounts.
4. Study of *Spirogyra* and *Chlamydomonas*, *Volvox* using temporary mounts.
5. Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Entamoeba*, *Paramecium* and *Plasmodium*.
6. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample.
7. Physicochemical analysis of sewage water: BOD, COD, DO.
8. To isolate genomic DNA from bacteria.
9. DNA: a) Isolation of DNA (nuclear and Mt)
b) Agarose gel electrophoresis
c) Demonstration of DNA modifications
d) Restriction endonuclease digestions and separation of fragments by gel chromatography
10. Isolation of total cellular RNA from suitable organisms (**bacteria**, yeast, plant, animal cells)
11. Isolation of total m RNA from suitable organisms.
12. Thermal melting of DNA
13. To perform SDS-PAGE for separation of proteins in given sample.
14. Blotting Techniques (**Southern and Northern**).
15. Fragment separation by restriction endonuclease enzyme.
16. Isolation of plasmid DNA -i) miniprep ii) large scale isolation.
17. DNA ligation, transformation of *E. coli*.
18. Culture of *E. coli* cells & plasmid isolation
19. Preparation of competent cells.
20. Calcium chloride mediated transformation.
21. Primer designing using Prime 3.

M.Sc. Microbiology
Second Semester Practical Examination
Paper 2.6 MIC – 5206 Lab Course IV

1. To prepare soluble antigen by different methods.
2. To demonstrate various routes of immunization in mice.
3. To prepare serum and plasma from blood.
4. To precipitate immunoglobulins by ammonium sulphate and to determine total protein contents.
5. To determine Blood group and Rh factor by slide agglutination test
6. Estimation of haemoglobin content.
7. To determine Total Leukocyte Count (TLC) for given blood sample
8. To determine Differential Leukocyte Count (DLC) for given blood sample using Leishman's stain.
9. To perform Widal agglutination test (slide and tube) for diagnosis of typhoid.
10. To perform Ouchterlony double diffusion test for detection of antigen and antibody reaction and to demonstrate relationship between antigens.
11. To perform Radial immuno-diffusion test for detection of antigen and antibody reaction and for quantification of antigens.
12. To perform immuno-electrophoresis for separation of antigens and for detection of antigen and antibody reaction
13. To perform Rocket immuno-electrophoresis for detection of antigen and antibody reaction
14. To perform ELISA for assay of antibodies in serum sample against given antigen.
15. To perform DOT ELISA.
16. Study of Laboratory Instruments
17. Ion exchange and gel filtration chromatography.
18. Separation of subcellular organelles by differential centrifugation.
19. Separation of blood cells by density gradient centrifugation.
20. Polyacrylamide gel electrophoresis of proteins.
21. To perform PCR for amplification of target DNA segment (or gene).
22. Electrophoretic separation of DNA in agarose gel.
23. Demonstration of DNA fingerprinting (RAPD and RFLP).
24. Gel documentation of DNA, RNA and proteins.

M.Sc. Microbiology
Third Semester Examination
Paper 3.1 MIC-6301– Microbial Ecology and Environment Microbiology

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination: 3 Hours	Continuous/Internal/Assessment	: 30 Marks
	Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT I **15-18L**

Soil: Soil Profile, Microorganism, Fertility, Rhizosphere & Phyllosphere. Biogeochemical cycles, Biological nitrogen fixation.

Microbial ecology: Concept of habitat and niche. Concept of population and community.

Development of microbial communities & diversity analysis. Microbial growth curve representing r and k reproductive strategies. Planktonic growth and Biofilm formation. Concept of plant probiotics.

UNIT II **15-18L**

Microbial interactions. Microbiology of extremophiles (Stress microbiology): Stress sequestration in halophiles, osmophiles, thermophiles, xerophiles, barophiles. Heavy metal detoxificants.

Quantitative microbial ecology: Modern and conventional methods used to study microorganism, (sampling procedure, microbial enumeration, biomass determination).

UNIT III **15-18L**

Biofertilizers: Definition, types- Nitrogen fixing, Phosphate solubilizing and cellulolytic microbes, mass production of bacterial inoculants (*Rhizobium*, *Azotobacter*, *Azospirillum*, *cyanobacteria*) mode of action, advantages and limitations.

Biopesticides: Bacterial, viral, fungal and protozoan, mode of action, factors influencing, genes involved in production technology. Mycorrhiza: Types and their application. Lichen.

UNIT IV **15-18L**

Introduction of environmental microbiology. Applications of microbes in solving environmental pollution problems.

Bioaccumulation of metals and detoxification, biosorption, scavenging.

Bioaugmentation: Pollution, wastes, their types and characterization. Methods of treatment-Physical, chemical, biological (Oxidation ponds, HRABP, ASP, Trickling Filter, Fluidized Bed Reactor, Biogas, Rotating contactor). Nanotechnology: Concept, scope and their role in pollution abatement. Biosensors for environment monitoring

UNIT V

15-18L

Bioremediation techniques: *In situ* and *ex-situ*. Use of GEMs in bioremediation.

Biodeterioration: Role of microbes in wood, pulp and paper.

Biodegradation: Xenobiotics, hydrocarbons, pesticides and plastics.

Biomonitoring: Microorganisms as bioindicators and applications of bioindicators. Role of *Dianococcus radiodurans* in disposal of radioactive waste material and its future in environmental biotechnology.

Recommended Books:

1. Soil Microbiology by Prof. N.S. Subba Rao, Fourth edition, Oxford and IBH Publishing CO. PVT., LTD., New Delhi
2. P.D. Sharma. 2006. Plant pathology. Alpha Science International.19.
3. Modern Soil Microbiology, Dirk J, Elsas V, Trevors JT, Wellington, EMH (1997) Marcel Dekker INC, New York.
4. Robert, S. Burlage Ronald Maltus, 1998. Techniques in Microbial Ecology. ASM Press.
5. Larry Barton, Diana E. Northup, 2011. Microbial Ecology. John Publisher, Academic Press.
6. Environmental microbiology: principles and applications by Patrick K. Jemba. Science publisher, 2004.
7. Environmental microbiology by P. D. Sharma, Alpha Sciences international, 2005.
8. Environmental microbiology, second edition, by Ralph, Ji Doug Gu, Wiley.
9. Atlas R M and Bartha, 1993. Microbial Ecology, Bejaminn Cummings Publishing Co. Redwood City CA
10. Environmental microbiology by Ian Papper and Charles Gerba, Elsevier Press.
11. Environmental microbiology by Rose Vol III-IV, 1999
12. Practical microbiology, third edition, by Dubey, D K. Maheswari, S. Chand publishers, 2012
13. Advances in applied Bioremediation, Springer.
14. Alexander M 1971. Microbial Ecology. John Wiley & Sons Inc., New York.
15. Eldowney Ec S., Hardman DJ. and Waite S 1993. Pollution: Ecology and biotreatment. Longman Scientific Technical.
16. Baker KH and Herson DS 1994. Bioremediation. Mc Graw Hill Inc., New York.

M.Sc. Microbiology
Third Semester Examination
Paper 3.2 MIC -6302–Fermentation Technology & Bioinformatics

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination : 3 Hours	Continuous/Internal/Assessment	: 30 Marks
	Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT- I **15-18L**
Introduction to fermentation technology: History, Scope and Development of Fermentation technology. Microbial culture selection for fermentation processes. Strain improvement: Mutant Selection, Recombination and Recombinant DNA technology.
Preservation and maintenance of industrially important microbes.

UNIT –II **15-18L**
Inoculum development for industrial fermentation & Microbial Kinetics: Introduction, Criteria for transfer of inoculum, development of inoculum for microbial processes. Inoculum development for plant fermenter, aseptic method of inoculation, achievement, and maintenance of aseptic conditions. Fermentation Material and Energy balance, Microbial growth kinetics: Microbial growth cycle, measurement of growth, Batch culture, continuous culture, fed-batch culture, applications, and examples. Design of fermenter/ bioreactors- Design aspects of flask, stirred tank reactor, Air-lift fermenter, Tower fermenter, Kinetics of operation of bioreactors, Batch, Fed-batch, Continuous processes, Design and operation of immobilized cell reactors.

UNIT III **15-18L**
Fermentation media Natural and Synthetic media; Basic components of a media (Carbon sources; Nitrogen sources; Vitamins; Minerals; Anti-foaming agents); Role of buffers in media. Media formulation and process optimization. Process of aeration, and agitation. Aeration-Theory of oxygen transfer in bubble aeration, Oxygen transfer kinetics, determination of K_{La}, Agitation-Design of impellers and their hydrodynamics, Fermentation broth rheology and power requirements for agitation-Concept of Newtonian and non-Newtonian fluids, effect of broth rheology on heat, nutrient and oxygen transfer, Reynolds number, power number, aeration number.

UNIT-IV **15-18L**
Bioinformatics: An overview, introduction and scope of bioinformatics. Databases: Characteristics, categories and types (Genome database, Literature database, Disease database, Sequence database, Structure database, PDB). Information retrieval system (Entrez, SRS). Data mining tools: Modelling tools (Rasmol, SPDV, HyperChem), Data submission tools (Bankit, Sequin, Webin, Sukura, Spin, AutoDep).

UNIT-V

15-18L

Algorithms: Classification of algorithms. Sequence Comparison algorithms. Submission metrics algorithms, Tools for sequence alignment. Gene Prediction: Methods, Gene mapping: DNA sequencing, Sequence alignment optimal algorithms. Tools for Genome analysis. Phylogenetic analysis: Phylogenetic trees. Methods of phylogenetic evaluation. Prediction tools Proteomics: Proteome analysis, Tools for Protein sequence analysis and proteomics, structure analysis. Molecular descriptors in QSAR studies, small molecule force field parameters (charges), potentials, Active site identification, ligand docking, Drug stability, synthesizability and drug delivery. Steps and software of drug designing.

Books/ References

1. Whitaker; Stanbury, Peter F; Hall, S.; Whitaker, A. Principles of Fermentation Technology, Second Edition (9780750645010) by Robert W. Hutkins. Microbiology and Technology of Fermented Foods.
2. D. W. Mount; Bioinformatics-Sequence and genome analysis; Cold Spring Harbour Lab press. 2001.
3. B.N. Mishra; Bioinformatics: Concept and application, Pearson Education (in press) 2020.
4. O' Reilly; Developing Bioinformatics computer skills-1st Indian edition, SPD publication. 2001.
5. Anthony J.F. Griffiths et al; An introduction to genetic analysis, 1st Ed 1976.
6. Michael Starkey and Ramnath Elaswarapu; Genomics protocols, Humana press.
7. Peter F Stanbury, Allan Whitaker, Stephen J Hall. Principles of Fermentation Technology. (2016) Butterworth-Heinemann Press. UK.
8. H. J. Peppler, D. Perlman. Microbial Technology: Fermentation Technology. (2014). Academic Press.
9. T. El-Mansi, C. Bryce, Arnold L. Demain, A.R. Allman. Fermentation Microbiology and Biotechnology. Second Edition. (2006). CRC Press, USA.
10. Hongzhang Chen. Modern Solid-State Fermentation: Theory and Practice. (2013). Springer Press, Germany.
11. John E. Smith. Biotechnology. (2009). Cambridge University Press. UK.
12. Celeste M. Todaro, Henry C. Vogel. Fermentation and Biochemical Engineering Handbook. (2014). William Andrew Press. Norwich, NY.
13. G. Lancini, R. Lorenzetti. Biotechnology of Antibiotics and other Bio.

M.Sc. Microbiology
Third Semester Examination
Paper3.3 MIC -6303(1)– Biofuel and Bioenergy

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination : 3 Hours	Continuous/Internal/Assessment	: 30 Marks
	Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT I

15-18L

Current energy consumption, overview of biofuel/bioenergy and biorefinery concepts. Fundamental concepts in understanding biofuel/bioenergy production. Biomass preprocessing: drying, size reduction, and densification. Microbes as a source of bioenergy.

Biomass for energy. Calorific value and its estimation. Co-generation of energy. Various biofuels/bioenergy from biomass. Biomass conversion to heat and power: thermal gasification of biomass, anaerobic digestion.

UNIT II

15-18L

Biomass conversion to biofuel: thermochemical conversion, syngas fermentation. Environmental impacts of biofuel production. Alternatives as biofuels: Alkanes, Biobutanol, bioethanol, biomethanol, biodiesel, biogas, hydrogen, syngas/synfuels and other energy dense molecules and their comparisons.

Biochemical conversion to ethanol: biomass pretreatment, Starch to sucrose conversion and Sucrose to ethanol fermentation. Different enzymes, enzyme hydrolysis, and their applications in ethanol production. Distillation and Quantification of ethanol.

UNIT III

15-18L

Lignocellulosic hydrolysis, Fermentation of pentoses and other issues in bioethanol production from lignocelluloses. Biobutanol production, Estimation of biobutanol.

Microbes and biogas production: Biogas and methane estimation. Bio gas Bottling Plant Technology, Application of Bio gas slurry in agriculture. Design of Biogas for cold climates.

UNIT IV

15-18L

Global biodiesel scenario. Oil crops. Microbes and Biodiesel: Production and feed stock. Techniques of lipid extraction and conversion to biodiesel (lipid transesterification), Biodiesel quality and its assessment.

Strategies of genetic engineering of organisms for biofuel production.

Wastewater remediation and biomass generation for biofuel purposes. Microbial Fuel Cells.

UNIT V

15-18L

Food vs Fuel debate. Carbon sequestration and its necessity. Carbon credits. Biorefinery, Thermochemical Conversion Processes (Gasification: Biofuels from Synthesis Gas and Pyrolysis) Biochemical Conversion Processes, Photobiological conversion: Biohydrogen production. Commercialized microalgae (*Spirulina*, *Dunaliella*, *Hematococcus*, *Chlorella* and others) and their production. Economics of microalgae production. Cultivation of seaweeds.

Reference Books:

1. Balachandran P. (2010); Engineering Fluid Mechanics, Prentice Hall India
2. Dessler A. (2011); Introduction to Modern Climate Change, Cambridge University Press.
3. Bioenergy (Biomass to Biofuel) 1st Edition 2014 Academic Press Editor: Anju Dahiya.
4. Biorenewable Resources: Engineering New Products from Agriculture. Robert C. Brown. Wiley-Blackwell Publishing (2003).
5. Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. Samir K. Khanal. Wiley-Blackwell Publishing (2008).
6. Kothari D. P. and Nagrath I. (2009); Basic Electrical Engineering, Third Edition, McGraw Hill, India
7. Zemansky M. and Dittman R. (2011); Heat and Thermodynamics, McGraw Hill, India
8. Wadhwa C. L. (2012); Generation, Distribution and Utilization of Electrical Energy, Third Edition, New Age International.

M.Sc. Microbiology
Third Semester Examination
Paper3.3 MIC -6303(2)– Pharmaceutical Microbiology

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT I **15-18L**

Antibiotics and synthetic antimicrobial agents: Antibiotics and synthetic antimicrobial agents: (Aminoglycosides, β lactams, tetracyclines, Ansamycins, macrolid antibiotics), Antifungal antibiotics, antitumor substances. Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolones antimicrobial agents. Chemical disinfectants, antiseptics and preservatives. Antimicrobial Testing Systems: Introduction, Antimicrobial agents, broad types, therapeutic ratio, MIC and MBC. Antimicrobial Susceptibility Testing.

UNIT II **15-18L**

Mechanism of action of antibiotics: 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 quinolones. Bacterial resistance to quinolone. Mode of action of non – antibiotic antimicrobial agents. Penetrating defenses- How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion).

UNIT III **15-18L**

Microbial production and Spoilage of pharmaceutical Products: Microbial contamination and spoilage of pharmaceutical products (sterile injectables, non-injectables, ophthalmic preparations and implants) and their sterilization. Manufacturing procedures and in process control of pharmaceuticals. Other pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase).

UNIT IV **15-18L**

Regulatory practices, biosensors and applications in Pharmaceuticals: Financing R&D capital and market outlook. IP, BP, USP. Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective. Rational drug design. Immobilization procedures for pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers. Biosensors in pharmaceuticals. Application of microbial enzymes in pharmaceuticals.

UNIT V **15-18L**

Quality Assurance and Validation: Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry. Regulatory aspects of quality control. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization) Chemical and biological indicators. Design and layout of sterile product manufacturing unit, Designing of Microbiology laboratory.

References

1. K. Park (2009), 20th Edition Park's Textbook of Preventive and Social Medicine
2. Konrad J. Karczewski, Roxana Daneshjou, Russ B. Altman, 2012 Chapter 7. Pharmacogenomics PLOS
3. Franklin T.J. and Snow G.A., 1975, Biochemistry of Antimicrobial Action, Chapman and Hall, London
4. Gale E.F., Cundliffe E., Reynolds P.E., Richmond M.H. and Waring M.J., 1972, The molecular basis of antibiotic action, John Wiley and Sons, London
5. Goldstein A., Aronow L. and Kalman S.M. 1969, Principles of Drug Action, The Basis of Pharmacology, Harper International Edition, New York
6. Mannfred A. Holliger, 2008, Introduction to Pharmacology, 3rd Edition, CRC Press
7. Kokate C. K., Purohit A.P., Gokhale A.B. 2000, Pharmacology, 4th Edition, Nirali Prakashan

M.Sc. Microbiology
Third Semester Examination

Paper 3.4 MIC -6304(1)– Antimicrobial Resistance

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT I

15-18L

Definition, phenomenon of antibiotics, concept of secondary metabolites. Discovery and History of antibiotics, importance of antibiotics, Different classes of antimicrobials (bacterial, Viral & fungal) and their mode of action. Role of antibiotics in the producer organism. Importance of optimizing antimicrobial usage for maintaining cost-effective therapies.

UNIT II

15-18L

Biochemical modes of action of antibiotics acting as inhibitors of ribosomal function (as for example aminoglycosides, tetracyclines, puromycin, chloramphenicol, macrolides etc.), inhibitors of nucleic acid metabolism (actinomycin D, mitomycin C etc.), inhibitors of cell wall biosynthesis (penicillin, bacitracin etc.) and inhibitors of membrane function (polyenes, tunicamycin, ionophores etc.) and other mode of actions.

UNIT III

15-18L

Phenomenon of antibiotic resistance. Emergence and spread of resistance; Microbial resistance – a global issue. Reservoirs of antibiotic resistance, Molecular mechanisms of Resistance; Different biochemical mechanisms of resistance development, multiple-drug resistance and XDR, their genetics and chemical significance. Bacterial Biofilms.

UNIT IV

15-18L

Assay of antibiotics: chemical versus microbiological assay system, different methods of antibiotic assays (serial dilution, photometric and agar-diffusion methods) - theory and practice; Chemical and biochemical modification of antibiotic structures: development of antibiotics (Different generations of antibiotics) taking penicillin and chloramphenicol's as parent compounds.

UNIT V

15-18L

Antimicrobial susceptibility tests; methods for detecting antimicrobial resistance; Obtaining good results; interpretation of antimicrobial susceptibility results; genomic analysis tools to detect resistance genes. Alternative therapies to antibiotics – phage therapy, probiotics, vaccines, etc. Roles and responsibilities of different

stakeholders in antimicrobial stewardship (including physician, pharmacist, microbiologist, hospital administrators); Case studies - Antimicrobial stewardship strategies by WHO, ICMR etc.

Books/References:

1. Kateryna Kon and Mahendra Rai “Antibiotic Resistance: Mechanisms and New Antimicrobial Approaches” Academic press 2016
2. CARD - Comprehensive Antibiotic Resistance Database (<https://card.mcmaster.ca/>) site for information on publicly available resistance genes and related information.
3. Research papers and Reports provided as per the course content.

M.Sc. Microbiology

Third Semester Examination

Paper 3.4 MIC -6304(2)– Microbial Nanotechnology

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT I

15-18L

Introduction to Nanotechnology: Characteristic scale for quantum phenomena, nanoparticles, nano-clusters, nanocomposite, nanotubes, nanowires and emergence of bio-nanotechnology.

Characterization of nanoparticles – UV-Vis. spectroscopy, FTIR, Electron Microscopy – HRTEM, SEM, AFM, EDS, XRD.

UNIT II

15-18L

Microbial nanotechnology-Microbial synthesis of Nanoparticles. Synthesis of nanodrugs-metal nanoparticles and drug delivery vehicles- Nanoshells- Tectodentrimers. Nanoparticle drug systems – Diagnostic applications of nanotechnology. Drug delivery- protein mediated and nanoparticle mediated.

UNIT III

15-18L

Preparation of nano-biomaterials – Polymeric scaffolds collagen, Elastins: Mucopolysaccharides, proteoglycans, cellulose and derivatives; Dextran, Alginates, Pectins, Chitin. Nanoparticles-types, functions- Silver, Gold and Titanium. Physical and chemical properties of nanoparticles.

UNIT IV

15-18L

Nanoscale applications in biology and medicine: Nanotechnologies for biology and medicine - Micro- and nano-fluidics - Scanning probe microscopy in biology and medicine- Self-assembly of biological molecules. Nanobiotics, Application of Nanoparticles in theragnostic. Hybrid conjugates of gold nanoparticles- DNA oligomers - use of DNA molecules in nano-mechanics and Computing. Nanoparticles as carrier for genetic material. Genetically Modified Organisms (GMO) and applications.

UNIT V

15-18L

Implications of nanotechnology: Health and safety implications from nanoparticles: Health issues- Environmental issues- Need for regulation- Societal implications: Possible military applications - Potential benefits and risks for developing countries - Intellectual property issues - Criticism of Nanotechnology - Studies on the implications of Nanotechnology.

Recommended Text Books:

1. Pradeep T. (2012). Textbook of Nanoscience and Nanotechnology. McGraw Hill Education (India) Private Limited.
2. Murty B.S., Shankar P., Baldev Raj, Rath B. B., James Murday. (2013). Textbook of Nanoscience and Nanotechnology. Springer, Berlin, Heidelberg.
3. Risal Singh, Shipra Mital Gupta. (2016). Introduction to Nanotechnology: Understanding the Essentials, 1st edition. Oxford University Press.
4. Rakesh K. Tekade. (2019). Biomaterials and Bio-Nanotechnology, 1st edition. Academic Press.
5. David E. Reisner. (2011). Bio-nanotechnology II: Global Prospects. CRC Press.
6. Yubing Xie. (2017). The Nanobiotechnology Handbook, 1st edition. CRC Press.

M.Sc. Microbiology
Third Semester Examination
Paper 3.5 MIC 6305 Lab Course V

Practical Exercises

1. To study the micro-flora of air (indoor and outdoor).
2. Analysis of soil: Texture, pH, moisture content, water holding capacity, percolation, and capillary action.
3. Isolation and study of microbes (bacteria and fungi) from Rhizosphere and Phyllosphere.
4. Isolation of *Rhizobium* from root modules of legumes (*Trigonella* / *Cicer* / *Soybean*)
5. Isolation of free nitrogen fixers (*Azotobacter*, *Azospirillum*) from soil.
6. Isolation of Phosphate solubilizing bacteria from soil.
7. To study the bacterial ecology in freshwater environment.
8. To study the microbial ecology of the rhizosphere and determination of Rhizospheric effect.
9. To study the effect of various salt concentrations on bacterial fungal growth.
10. To study the effect of osmotic pressure on bacterial fungal growth.
11. To determine the microbial biomass from different natural habitats.
12. Demonstration of biological treatment.
13. Determination of alkalinity
14. Determination of chlorine in water.
15. Demonstration of VAM.
16. Production of Biofertilizers: *Rhizobium* / *Azotobacter* sp.
17. Production of Single cell protein
18. Demonstrate the Mushroom cultivation.
19. Bioremediation of polluted soils by plants/ microbes.
20. Laboratory demonstration of vermi-composting.
21. Determination of BOD, COD and DO of water samples.
22. Field visit to recycling industries.
23. To study the Fermenter, Its Design and Working mechanism.
24. Determine the growth patterns and specific growth rate of *E. coli*
25. Determine the effect of peptone concentration on *E. coli* growth
26. Isolation of antibiotic and enzyme producing microorganisms from soil
27. Isolation of organic acid producing microorganisms from soil
28. Retrieving sequence data from Entrez
29. Locating the chromosome of a Gene
30. Retrieve gene expression data from GEO
31. Finding ORF of a Given Sequence
32. Retrieving structural data of a protein using PDB database
33. To access scientific data from Literature data bases (PUBMED, LITDB, Medline)
34. To access nucleic acid databases for retrieval of gene sequence.
35. To access protein databases for retrieval of amino acid sequence of target protein.
36. To perform multiple sequence alignment using BLAST and CLUSTAL-W
37. To prepare Phylogenetic tree and Cladogram using CLUSTAL-W

M.Sc. Microbiology
Third Semester Examination
Paper 3.6 MIC 6306 Lab Course VI (Based on elective papers)

Practical Exercises based on Biofuel and Bioenergy

1. Qualitative and Quantitative estimation of solid waste from different sites.
2. Liquid bio-fuel production and characterization.
3. Biogas production by anaerobic digestion and analysis.
4. Production of energy from microbes (microbial fuel cell)
5. Production of Biodiesel from nonedible oil.
6. Biogas production and application.
7. Bioethanol production.
8. Cultivation of seaweeds.

Practical Exercises based on Pharmaceutical Microbiology

1. Spectrophotometric / Microbiological methods for the determination of Griseofulvin.
2. Bioassay of chloramphenicol by plate assay method or turbidimetric Assay method.
3. Treatment of bacterial cells with cetrimide, phenol and detection of Leaky substances such as potassium ions, amino acids, purines, Pyrimidines and pentoses due to cytoplasmic membrane damage.
4. To determine MIC, LD 50 of Beta-lactam/aminoglycoside/ tetracycline/annamycin's.
5. Sterility testing by *Bacillus stearothermophilus*
6. Sampling of pharmaceuticals for microbial contamination and load (syrops, suspensions, creams).
7. Determination of D value, Z value for heat sterilization in pharmaceuticals.
8. Determination of antimicrobial activity of a chemical compound (Phenol, resorcinol, thymol, formaldehyde) to that of phenol under Standardized experimental conditions.
9. Microbiological assay of antibiotics by cup plate method and other methods
10. Extraction of bioactive ingredients from plant and its activity fraction.
11. Estimation of antimicrobial activity using CLSI.
12. Determination of microbial load of non-sterile products – ointments, capsules.
13. Determination of drug sensitivity of *Streptococcus mutans*.

Practical Exercises based on Antimicrobial Resistance

1. Antimicrobial Susceptibility Testing: Agar disk-diffusion method
2. Antimicrobial gradient method (E test)
3. Agar well diffusion method
4. Poisoned food method
5. Agar overlay bioassay
6. Broth dilution method
7. Agar dilution method
8. Time-Kill test (time-kill curve)

Practical Exercises based on Microbial Nanotechnology

1. Synthesis of Nanoparticles from plant materials: Green Synthesis.
2. Synthesis of nanoparticles from microbiological sources
3. Affinity purification of immunoglobulins & quantification
4. Demonstration of Imaging techniques: SEM/TEM/Bio-AFM (Natural Sample sources)
5. Bioconjugation of nanoparticles with proteins/antibodies/DNA
6. Antimicrobial activity of Biosynthesized Nanoparticles.
7. Antioxidant assay of Nanoparticles.
8. Synthesis of Metal Oxide Nanoparticle using different techniques.
9. Synthesis of TiO₂, Cu and ZnO nano particles by Laboratory method
10. Biogenesis of Iron nano-particles for development of Microbial Emulsion.
11. To demonstrate Characterizations using UV visible spectrophotometer, FTIR, X-ray Analysis.
12. Synthesis of Polymeric Nanocomposite.
13. Demonstration of Drug Delivery by drug delivery Vehicles: Tectodentrimers and nanoparticles.
14. Effect of pH, temperature and salt concentration on Nanoparticle Synthesis.
15. Stability analysis of nanoparticles (Long term storage, pH sensitivity and UV exposure).

M.Sc. Microbiology
Fourth Semester Examination

The students have to select one of the following specializations that shall be taught in fourth semesters:

Paper 4.1 MIC -6401– Industrial Microbiology **or** Paper 4.2 MIC -6402– Medical Microbiology.

Paper 4.1 MIC -6401– Industrial Microbiology

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination : 3 Hours	Continuous/Internal/Assessment	: 30 Marks
	Semester Assessment	: 70 Marks

***Note:** The syllabus is divided into five independent units and question paper will be divided into two sections.*

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

***Note:** Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.*

UNIT-I **15-18L**
Novel microbes for future industry. Historical account of microbes in industrial microbiology. Industrial microorganisms: Sources and characters of industrially potent microbes (bacteria, fungi and actinomycetes). Industrial sterilization process for media, air and equipment. Fermentations technology: Principles of fermentation, Types of fermentations: Solid substrate fermentation (SSF) - Principles and application, Submerged Fermentation. Aerobic and anaerobic fermentation, Components of fermentation process.

UNIT-II **15-18L**
Downstream processing: Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration methods.
Extraction: Solvent, two phase, liquid extraction, supercritical fluid extraction, whole broth, aqueous multiphase extraction. Product Purification: precipitation, Crystallization, chromatographic methods, ultra-filtration, reverse osmosis. Drying devices.

UNIT-III **15-18L**

Industrial production of antibiotics: Streptomycin, Penicillin. Industrial production of: Vitamin B12, Riboflavin, Citric acid, Lactic acid, Vinegar; Glutamic acid, L – lysine; Acetone, glycerol, alcohol. Steroid biotransformation. Production of alcoholic beverages. Microbial Enzymes: Tannases, Proteases, Amylases, Production of biopharmaceuticals through GEMs: Insulin, Interferons, Tissue plasminogen activator, Streptokinase. Immobilization of enzymes and cells: Types & applications.

UNIT- IV

15-18L

Microbiology of food: sources and types of microorganisms in food, food borne pathogens, microbiological examination of food, spoilage of food, food preservation. Starter cultures their biochemical activities, production and preservation of the following fermented foods: Soy sauce fermentation by Moulds, Fermented vegetables – Sauerkraut, Fermented Meat – Sausages. Production and application of Baker's Yeast. Role of microorganisms in beverages – tea and coffee fermentations. Genetically modified foods. Biosensors in food.

UNIT- V

15-18L

Dairy microbiology: sources and types of microorganisms in milk, microbial examination of milk, pasteurization and phosphatase test, sterilization of milk, grades of milk, Microbiology of fermented milk products (acidophilus milk, yoghurt), butter & cheese. Applications of microbial enzymes in dairy industry (Protease, Lipases). Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, ISI.

Reference Books:

1. Microbiology an Introduction by Gerard J Tortora, Berdell R Funke and Christine L Case. Pearson Publisher (11th Edition) 2016.
2. Basic and Industrial Microbiology by S. M. Reddy.
3. Microbes: Concepts & Applications- P.S. Bisen, Mousumi Debnath, Godavarthi B.K.S. Prasad, John Wiley & Sons Publication 2012.
4. Industrial Microbiology by David B. Wilson, Hermann Sahm, Klaus-Peter Stahmann, Mattheos Koffas. Wiley Publisher 2019.
5. Reed G (2004). Industrial Microbiology. CBS Publishers (AVI Publishing Co.)
6. Stanbury PF, Whittakar A. and Hall (2006). Principles of Fermentation Technology. Pergaman. McNeul and Harvey.
7. Creuger and Creuger (2004). Biotechnology- A textbook of Industrial Microbiology, Sinaeur Associates.
8. Casida LE (2001). Industrial Microbiology, Wiley Eastern.
9. Manual of Industrial Microbiology and Biotechnology, Demain & Davies, 2nd ed.
10. Microbial Biotechnology A. N. Glazer and H. Nikaido
11. Biotechnology An Introduction Susan R. Barnum
12. Topics in Enzyme & Fermentation Biotechnology by Wisemen
13. S.N. Jogdand. Medical Biotechnology
14. S.N. Jogdand. Biopharmaceuticals

M.Sc. Microbiology
Fourth Semester Examination
Paper 4.2 MIC -6402– Medical Microbiology

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination : 3 Hours	Continuous/Internal/Assessment	: 30 Marks
	Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

UNIT-I

15-18L

Human microbiome & its significance. Probiotics: Gut microbiota, Gut brain interaction. Infection: types, sources, reservoirs and vehicles of infection, predisposing factors. Host-parasite relationship governing the infection and establishment of disease, factors affecting virulence. Mode of spread of infection.

Emerging epidemics, Re-emerging epidemics. Epidemics fundamentals: Types of epidemics, investigation, management and control. Biosafety: components, laboratory safety management. Management of biomedical waste. Biosafety levels. Introduction of center for Disease Control (CDC) and National center for disease control (NCDC).

UNIT-II

15-18L

Study of diseases caused by pathogenic bacteria: Pathogenicity, laboratory diagnosis, epidemiology and control measures– *Streptococcus*, *Staphylococcus*, *Neisseria*, *Salmonella*, *E. coli*, *Klebsiella*, *Proteus*, *Pseudomonas*, *Shigella*, *Corynebacterium*, *Vibrio*, *Corynebacterium*, *Bacillus*, *Clostridium*, *Vibrio*, *Mycobacterium*, *Spirochetes*, *Chlamydiae*, *Rickettsia*, *Mycoplasma*.

UNIT-III

15-18L

Morphology, pathogenesis, immune response, diagnosis and prevention of Pox viruses, Herpes, Picorna viruses (Enteroviruses and Polioviruses). Paramyxo viruses, Orthomyxoviruses, Hepatitis viruses, Rhabdo viruses (Rabies virus), Oncogenic viruses, HIV virus, Prion infection. Introduction to emerging diseases- Swine flu, chikungunya, Ebola, SARS-CoV-2.

UNIT-IV

15-18L

Fungal diseases: Aetiology, clinical symptoms, laboratory diagnosis and treatment of Human mycotic infections caused by Dermatophytes, Histoplasma, Cryptococcus, Candida, opportunistic mycoses. Mycotoxins. Important protozoal diseases: Route of entry, Life Cycles, Immunity, diagnosis & prophylaxis of *Plasmodium*, *Entamoeba*, *Leishmania*, *Giardia*, *Taenia*.

UNIT-V

15-18L

Antimicrobial resistance: Drug resistance organisms, mechanisms and development of multidrug resistance.

Mechanism of drug action: Antibacterial, Antifungal and Antivirals. Methods of testing drug sensitivity.

Preclinical development: Safety profile of drugs, Toxicological evaluation of drug, Mutagenicity and Carcinogenicity. Clinical studies.

Recent advances in medical microbiology-antiretroviral therapy, Plasma therapy. Probiotics as therapeutic agents, Aptamers, nanotechnology in medicines, Interferons.

Reference Books:

1. Emerging epidemics: Management and control P.S. Bisen and E. Raghuvanshi 2013. Wilay & Sons publication New Jersey
2. Molecular Diagnostics: Promises & Possibilities 2010. Mousuni Dabnath, G.B.K.S. Prasad P.S. Bisen. Principles of Therapeutics, Burn J. H., Blackwell Scientific Pub. O. Ltd. Oxford.
3. Medical Microbiology, McGraw Hill Publication 2019, by Stefan Riedel, Stephen A. Morse, Timothy A. Mietzner, Steve Miller
4. Role of Novel Drug Delivery Vehicles in Nanomedicine Edited by R.K. Tyagi, N. Garg, R. Shukla & P.S. Bisen 2020.
5. Ananthanarayan and Jayaram Paniker. Textbook of Microbiology, 4th ed. Orient Longman, 2000.
6. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication.
7. Tille P (2013) Bailey's and Scott's Diagnostic Microbiology, 13th edition, Mosby.
8. Medical Microbiology-David Green wood
9. Jawetz-Medical Microbiology-Geo F. Brooks, Janet S Butel.
10. Microbiology: An introduction, G.J. Tortora, B.R. Funke and C.L. Funke.
11. Virology; Renato Dulbecco and Harold S. Ginsberg, Fourth edition, J.B. Lippincott Company, USA
12. An Introduction to viruses, S. B. Biswas and Amita Biswas. Fourth edition, Vikas Publishing House PVT LTD New Delhi.
13. Medical Bacteriology, Medical Mycology and AIDS; N.C. Dey, T.K. Dey and D. Sinha, New Central Book Agency (P) Ltd.

M.Sc. Microbiology
Fourth Semester Examination
Paper 4.2 MIC -6402– Biostatistics and IPR

Contact Hours / Week : 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination : 3 Hours	Continuous/Internal/Assessment Semester Assessment	: 30 Marks : 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into two sections.

- **Section-A** will carry 20 marks with one compulsory question comprising ten short answer type questions taking two questions from each unit. Each question shall be of two marks.
- **Section-B** will carry 50 marks with equally divided into five long answer type questions (answer about in 400 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

Unit-I

15-18L

Introduction to statistics: Aim and Scope of statistics, Sample size & Sampling. Tabulation and graphics representation. Measure of central tendency, Measure of dispersion, Range, Standard deviation, Lorenz curve. Skewness and kurtosis: Definition, Types and measures of skewness. Kurtosis.

Unit-II

15-18L

Correlation analysis: Definition, Types of Methods of correlation- scatter diagram, Karl Pearson's coefficient, Rank correlation. Regression analysis: Regression Line, regression equations. Multiple regression. Basics of Statistical Software (SPSS, GraphPad prism and excel). Probability theory: Concept, rules, types and Theorems. Theoretical distributions: Binomial, Poisson and Normal distribution.

UNIT-III

15-18L

Hypothesis Testing: population and sample, Steps in tests of hypothesis. Sampling techniques and Sampling and non-sampling error. Test of significance for attributes. Test for number of success and proportion of success. Test of significance for variables (Large samples)- tests of differences between means of two samples and between two standard deviations. Tests of significance for variables (Small samples)- Students t-distribution, F-Test. Chi-square, ANOVA. Applications of probability in biology and research.

UNIT IV

15-18L

Intellectual Property Rights (IPR): Introduction to Intellectual Property & IPR, patent, copyrights, trademarks, trade secret, geographical indications, Industrial designs. Patent laws, Legislations covering IPR's in India, Patenting of living organisms, procedure involved in patenting, patent infringement, patent filing and international patent law, PCT, provisional and complete specification, patentable and non-patentable materials, product planning and development.

UNIT-V

15-18L

International Treaties and conventions: WTO, TRIPS, WIPO (World Intellectual property organization), GATT, Budapest Treaty, UPOV (International union for the protection of New varieties of plants). Biopiracy and Bioprospecting, Traditional knowledge and TKDL. Ethical issues in IPR, Role of IPR in entrepreneurship and start-ups.

Reference Book:

1. B.L. Wadera, Patents, trademarks, copyright, Designs and Geographical Judications.
2. D.P. Mittal (Taxman Publication), Indian Patents Law and Procedure
3. David W. Mount. 2003. Bioinformatics: Sequence & Genome Analysis. CBS Publishers and Distributors. New Delhi.
4. Fundamentals of Statistics, Goon, Gupta and Dasgupta –World Press, Kolkata
5. Guide to Research Methodology and Biostatistics. Edited by KMK Masthan 2017 CBS Publisher.
6. Hilarry Pearson and Clifford Miller, Commercial Exploitation of Intellectual Property.
7. N.S. Gopalakrishnan & T.G. Agitha, Principles of Intellectual Property (2009), Eastern Book Company, Lucknow
8. P. Narayanan (Eastern Law House), Intellectual Property Law
9. Statistical Methods, Gupta SP. Sultan chand & Sons.

M.Sc. Microbiology
Fourth Semester Examination

Paper 4.3 MIC -6403–Scientific Skills and Research Ethics

Unit I

Foundations of Scientific Inquiry and Methodology: Research Methodology: Introduction-Basic research, applied research, need based research. Identification of the problem, defining the problem. Research Project planning. Literature search-information sources, library resources-books, abstracts hand books, procedure manuals, encyclopedias, annual report, data banks, CDROMS, online literature search- internet access, websites, directories of information resources. Progress of research- evaluation of results, statistical approach, comparison with existing methodologies, validation of findings.

Unit II

Scientific Communication and Data Presentation: Structure of Scientific Articles: IMRaD format – Introduction, Methods, Results, Discussion, Writing Abstracts and Proposals: Characteristics of a good abstract and research synopsis, Visual Communication: Graphs, tables, flowcharts, and images using Excel, R, or GraphPad, Poster and Oral Presentation Skills: Layout design, delivery, visual aids, research paper/research work presentation in a conference/seminar/workshop Digital Writing Tools: LaTeX, Grammarly, Zotero/Mendeley, Managing References: Citation styles (APA, Vancouver, MLA), inline citations, DOI linking, Author Profiles and IDs: ORCID, Google Scholar, ResearchGate, impact factor of journals.

Unit III

Ethics in Research and Scientific Misconduct: Research Misconduct: Definitions and real examples of fabrication, falsification, plagiarism, Forms of Plagiarism: Self-plagiarism, paraphrasing, mosaic plagiarism, Detection Tools: Introduction to Turnitin, URKUND, plagiarism reports, Ethical Publishing: Authorship criteria (ICMJE), corresponding vs. contributing authors, Predatory Journals & Publishing Scams: Identification and avoidance, Retractions and Corrections: Process and consequences, Case Studies.

Unit IV

Bioethics and Regulatory Frameworks: Introduction to Ethics, Bioethics and Biosafety. History of Bioethics, Personal ethics: Profession and professionalism, Moral Reasoning, Ethical theories, ethics in microbiology and biotechnology, benefits and risks of genetic engineering, ethical aspects of genetic testing, Stem Cell and Gene Editing Ethics, genetic engineering and biowarfare. Ethical implications of cloning. Ethical, legal and socio-economic aspects of gene therapy, Human genome project and ELSI of human genome project. Ethical issues in genetically modified food and crops. Ethical Review Bodies.

Unit V

Responsible Science in Society and Soft Skills: Open Science and Citizen Science: Data sharing, FAIR principles (Findable, Accessible, Interoperable, Reusable), Science Communication: Importance, writing for non-experts,

social media ethics, Teamwork and Collaboration: Conflict resolution, accountability, international partnerships, Authorship Ethics in Collaborative Research: Order of authors, corresponding author roles, Inclusion and Equity in Science: Gender issues, cultural context, universal access, Time and Project Management Tools: Gantt charts, Trello, Notion, digital planning, Social Responsibility of Scientists: Science in policy making, public trust in science.

Reference Books & Resources.

1. C.R. Kothari & Gaurav Garg – *Research Methodology: Methods and Techniques*. 4th Revised Edition (2019), New Age International Publishers. ISBN: 978-9386649225.
2. Wayne C. Booth et al. – *The Craft of Research*. 4th Edition (2016), University of Chicago Press. ISBN: 978-0226239736
3. Michael Alley – *The Craft of Scientific Writing*. 4th Edition (2018), Springer. 978-1441982872.
4. Robert A. Day & Barbara Gastel – *How to Write and Publish a Scientific Paper*. 9th Edition (2019), Cambridge University Press. ISBN: 978-1108490399.
5. Tom L. Beauchamp, James F. Childress– *Principles of Biomedical Ethics*. 7th Edition (2013), Oxford University Press. ISBN: 978-0199924585.
6. Nicholas H. Steneck – *Introduction to the Responsible Conduct of Research*. 2nd Edition (2007), Office of Research Integrity (U.S. Department of Health & Human Services).Free Public Domain Document (Available online).
7. Committee on Science, Engineering, and Public Policy – *On Being a Scientist: A Guide to Responsible Conduct in Research*. National Academies of Sciences, Engineering, and Medicine (USA), 3rd Edition (2009). 978-0309119702.
8. Dr. Mahendra Rai -*Ethics in Science: Ethical Misconduct in Scientific Research*. 1st Edition (2016), CRC Press. ISBN: 978-1498709785.
9. David Koepsell-The Ethics of Scientific Research. 1st Edition (2006), Routledge. ISBN: 978-0415976734.
10. ICMR & DBT Guidelines on Bioethics and Biosafety, Indian Council of Medical Research (ICMR) & Department of Biotechnology (DBT), Govt. of India Latest editions (freely available online as PDFs).

M.Sc. Microbiology

Fourth Semester Examination Paper 4.4 MIC 6404 Lab Course VII

Practical Exercises based on Paper 4.1 MIC -6401-Industrial Microbiology

1. Components and Operation of a Bioreactor
2. Batch fermentation in conical flask
3. Solid state fermentation
4. Optimization of conditions for optimal production of enzyme: - Media composition, Incubation temperature, Aeration, Incubation time.
5. Purification of antimicrobial metabolites from a microbe.
6. Production of amylase and cellulase by SmF and SSF.
7. Production of antibiotics by SmF technology
8. Immobilization of cells and enzymes.
9. Instrumentation of fermenter. Design of various types of fermenters & bioreactors
10. Production of ethanol & wine from grapes.
11. DSP for microbial enzymes/antibiotics/organic acids.
12. Determination of TDT of microbes.
13. Determination of TDP of microbes.
14. Production and estimation of lactic acid by *Lactobacillus* Sp. or *Streptococcus* Sp.
15. Sauerkraut fermentation
16. Isolation of food poisoning bacteria from contaminated foods,
17. Production of Dairy products: yoghurt, cheese.
18. Extraction and detection of aflatoxin for infected foods.
19. Preservation of potato/onion by UV radiation
20. Production of fermented milk by *Lactobacillus acidophilus*.
21. Rapid analytical techniques in food quality control using microbial Biosensors.

Practical Exercises based on Paper 4.2 MIC -6402- Medical Microbiology

1. To prepare various basic, selective, enrichment and enriched media used for isolation of medically important bacteria from clinical samples.
2. To perform various biochemical tests (IMVC, oxidase, catalase, urea utilization test, sugar utilization and H₂S production on TSI agar slant) used for identification.
3. To perform sugar fermentation tests used for identification of medically important bacteria.
4. Preparation of transport media for different clinical samples.
5. Demonstration normal microbial flora of skin, mouth and throat.
6. Isolation and identification of *Staphylococcal* species using suitable media, staining techniques and biochemical tests.

7. Identification of bacterial species belonging to *Enterobacteriaceae* family using suitable biochemical tests (*E. coli*, *Proteus*, *Pseudomonas*, *Klebsiella*)
8. Isolation and identification of enteric fever causing bacteria (*Salmonella typhi*) using suitable media and biochemical tests.
9. Isolation and identification of *Bacillus* species using suitable media, staining techniques and biochemical tests.
10. Microbiological analysis of urine specimens.
11. Microbiological analysis of sputum specimens
12. Isolation dermatophytes and their identification based on colony morphology and microscopic characteristics.
13. To determine antibiotic sensitivity for Gram negative and Gram-positive bacteria by disc diffusion method
14. To determine Minimal Inhibitory Concentration (MIC) and Minimal Bactericidal concentration of an antibiotic for test bacteria.
15. Identification of human blood groups.
16. Estimation of blood haemoglobin.
17. Perform Total Leukocyte Count of the given blood sample.
18. Perform Differential Leukocyte Count of the given blood sample
19. Separate serum from the blood sample.

Practical Exercises based on Paper 4.2 MB-642-Research Methodology, IPR & Bioethics

1. Representation of statistical data by
 - a. Histogram
 2. O give curves
 3. Pie diagrams
2. Collection of data using different sampling methods
3. Determination of Averages or Central tendencies (Mean, Mode, Median)
4. Determination of measures of dispersion (Mean deviation, Standard deviation and Coefficient of variation, Quartile deviation)
5. Application of Tests of significance (Chi-Square test, student t-test, Standard error)
6. Applications of computers in biology using MS-office (MS-Word, Excel, Power point)
7. Searching of India Patent databases
8. Drafting and filing of Indian Patent databases
9. Searching of International Patent application
10. Drafting and filing of International Patent application

M.Sc. Microbiology
Fourth Semester Examination
Paper 4.5 MIC -6405–Dissertation

A dissertation shall be initiated at the end of the Semester III and continued during Semester IV. A dissertation may be undertaken in any related research laboratories/industries/university department. Project work for the dissertation will involve experimental work and the student will have to complete this in stipulated time i.e., 3 months. The final evaluation of the project work will be through a Panel involving internal and external supervisors and examiners. The students shall compulsorily submit the certificate of completion and report to the Department during the practical examination.

This process includes: Conceptualization of the independent research, Collection, analysis, and interpretation of data, Thesis writing, Oral presentation of findings and Viva-Voce.

The marks will be awarded by the external examiner on the day of the practical examination on the basis of the experimental, presentation and viva-voce. The distribution of marks for project work will be:

Project work : 200 Marks

- | | |
|-------------------------------|------|
| 1. Experimental Work & Thesis | :100 |
| 2. Research work presentation | :50 |
| 3. Viva-voce | :50 |

