RADHA GOVIND UNIVERSITY

RAMGARH, JHARKHAND

Department of Microbiology

Under Faculty of Science

Choice Based Credit System Curriculum for

Master of Science in Microbiology

(Effective from Academic Session 2019-21)

RADHA GOVIND UNIVERSITY, RAMGARH, JHARKHAND

DEPARTMENT OF MICROBIOLOGY

Vision & Mission

Vision

To contribute to nation building by transforming people through quality education, creating knowledge, to make the invisible world more visible and inculcate scientific temper and provide platform research.

Mission

To create an ideal department keeping students at the centre of its aspirations and endeavours while manifesting wholehearted commitment.

To encourage research by providing state of the art facilities and with committed standards.

To cultivate a healthy and hygienic environment, to be a good citizen of future India and no to extinction of Mankind.

Competence, discipline, dedication and contribution to society.

PROGRAM EDUCATION OBJECTIVE (PEO)

PEO 1: Have a successful career in Microbiology and related disciplines.

PEO 2: Excel in research career in microbiology and inter-disciplinary fields and actively contribute to science and society.

PEO 3: Possess technical and professional competency to address growing demands of society and industrial needs ethically.

PEO 4: Demonstrate life-long independent and reflective skills in their career.

PEO 5: Apply research and entrepreneurial skills augmented with a rich set of communication, teamwork and leadership skills to excel in their profession.

PEO 6: Show continuous improvement in their professional career and appreciate human values and ethics.

PROGRAMME SPECIFIC OUTCOME (PSO)

The students of M.Sc. Microbiology should be able to:

PSO1: To emphasize the distribution, morphology and physiology of microorganisms and demonstrate the skills in aseptic handling of microbes including isolation, identification and maintenance.

PSO2: Demonstrate the ability to identify significant microbiological research questions, develop research protocols, and analyse research outcomes as per the scientific methods to improve the employment skills.

PSO3: Enhance analytical and quantitative skills and demonstrate an understanding of basic computational and statistical techniques in the field of microbiology.

PROGRAME OUTCOME (PO)

PO 1: Basic and applied knowledge:gathers in-depth knowledge of basic and applied areas of microbiology.

PO 2: Core microbiology laboratory skills: understands various methods of safe handling, culturing and storage of microorganisms in the laboratory.

PO 3: Critical Thinking:develops scientific logic and approaches a problem with critical reasoning.

PO 4: Effective Communication: Develops effective communication skills through oral presentations of ongoing developments in the field and the compiling of information in the form of reports.

PO 5: Social Interaction: Elicit views of others, mediate disagreements and help reach conclusions in group settings.

PO 6: Global perspective: becomes acquainted with standard international practices and emerging technologies used to study microbes.

PO 7: Modern Microbiology usage: Develop new technologies, protocols, resources, using modern microbiological techniques and therapeutics and apply it to solve complex human health problems and conserve biodiversity.

PO 8: Effective Citizenship: Demonstrate empathetic social concern and equity centered national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

PO 9: Ethics: Acquires an awareness of work ethics and ethical issues in scientific research as well as plagiarism policies.

PO 10: Research related skills: Will develop ability to identify problems, give justifications for solutions by lab investigations & critical analysis by using appropriate research related biological skills.

PO 11: Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

PO 12: Self-directed and Life-long Learning: Develops self-discipline, planning and organization skills, and time management skills.

THE BROCHURE OF THE PROGRAMME OF STUDY IN MICROBIOLOGY IS BROADLY DIVIDED INTO THREE PARTS -

(A) General Information

(B) Scheme of Examination and

(C) Course of Study

(A) General Information

1. Duration of the Course: The M.Sc. Microbiology programme offered by Radha Govind University is of two years' duration and is divided into four semesters. The first part of the course shall be called M.Sc. previous consisting of 1st and 2nd semesters and second part as M.Sc. final, consisting of 3rd and 4th semesters. At the end of each Semester/Academic year, there shall be a university examination. The various courses of the programme are designed to include classroom teaching and lectures, laboratory work, project work, viva, seminars, assignments and field trips.

2.Eligibility for admission: The student shall be eligible for admission to a Master's Degree Program in Microbiology after he/she has successfully completed a three year undergraduate degree or earned prescribed number of credits through the examinations conducted by University as equivalent to an undergraduate degree.

B.Sc. (General) or B.Sc. (Hons.) or an equivalent Undergraduate Degree in any branch of Life Sciences/ Medical Sciences/ any branch of Biology.

Method of Admission:

The admission to the 1st Semester of Master's Course will be made in general on the basis of a merit list of the application prepared on the basis of marks obtained in the last qualifying examination or on the basis of the written entrance test conducted by the university for the purpose.

Reservation and Weightage:

(i)The reservation rules of the Jharkhand state government framed for the purpose of admission shall be applicable to different caste categories of the candidates provided that 15% of the total seat of the department shall be reserved for students passing outside the Jharkhand state, out of which 5% seats will be reserved for NRI categories. In case candidates of a particular category are not available adequately, the vacant seats will be treated as general seats.

(ii)The following categories of candidates will be provided with a weightage of marks obtained against each category for preparing the merit list.

Category: - Weightage (percent of marks to be added in the relevant Marks obtained by the candidate in the subject concerned for preparing merit list)

(i) Girl Student	3%
(ii) Department of Ex Serviceman	2%
a. Ward of Teaching and Non-teaching	
Staff of the University/College under	7%
Privilege of the University	
(iv) N.C.C	
(a) N.C.C. Cadet having camp certificate	1%
(b) N.C.C. Cadet having state comp certificate	2%
(c) N.C.C. CADET having National camp Certificate	3%
(d) N.C.C. C- Certificate	5%
(e) N.C.C. B-Certificate	4%
(v) N.S.S	
(a) N.S.S. Special Camp Certificate (unit level)	1%
(b) N.S.S. Zonal Level	2%

(c) PRD- Camp N.S.S National Level Camp	3%
(d) R.D.Parade/National award	5%
(vi) Sports/Cultural Activities/Fine Art and Music/Drama	
(a) International Level Representation	
(i) Olmpic or Equivalent	20%
(ii) Asian Level	15%
(b) National Level	10%
(c) Representation of the college at State/Zonal Level	5%

Provided that no candidate shall be allowed two benefits at the same time.

The Total number of seats allotted to the University Department shall be fixed by the Syndicate on the recommendation of the Academic Council.

Provided that if the Academic Council does not ratify the increase in the number of seats, the increase will be reverted back only in the next academic session.

3.Course Fee per Semester: This course will be totally operated under self –Finance Scheme of the University. Candidates admitted to this course will pay for his/her seats semester fees along with other fees of the University every semester. Fee may be increased as and when required after due consideration.

4.Scope of students (Structure of Programme): There will be four theory papers along with two practical in each semester. Every student of fourth semester will submit a dissertation. The course of studies in different papers and in practical will be as per syllabus prescribed by the Board of Studies in Microbiology, Radha Govind University.

Course Structure

The Course structure of Semester I-1V shall be as under.

(Total Credits: 96)

FIRST SEMESTER **(24 credits)**

Paper	No. of Credits per week	Teaching (in hours) per week	Minimum Teaching required in Hrs
I	4(4x1=4)	4	60
II	4(4x1=4)	4	60
III	4(4x1=4)	4	60
IV	4(4x1=4)	4	60
V	4(4x1=4)	4	60
VI	4(4x1=4)	4	60/120

SECOND SEMESTER **(24 credits)**

Paper	No. of Credits per week	Teaching (in hours) per week	Minimum Teaching required in Hrs
VII	4(4x1=4)	4	60
VIII	4(4x1=4)	4	60

IX	**4(4x1=4)**	**4**	**60**
X	**4(4x1=4)**	**4**	**60**
XI	**4(4x1=4)**	**4**	**60**
XII	**4(4x1=4)**	**4**	**60/120**

THIRD SEMESTER **(24 credits)**

Paper	**No. of Credits per week**	**Teaching (in hours) per week**	**Minimum Teaching required in Hrs**
XIII	**4(4x1=4)**	**4**	**60**
XIV	**4(4x1=4)**	**4**	**60**
XV	**4(4x1=4)**	**4**	**60**
XVI	**4(4x1=4)**	**4**	**60**
XVII	**4(4x1=4)**	**4**	**60**
XVIII	**4(4x1=4)**	**4**	**60/120**

FOURTH SEMESTER (24 credits)

Paper	No. of Credits per week	Teaching (in hours) per week	Minimum Teaching required in Hrs
XIX	**4(4x1=4)**	**4**	**60**
XX	**4(4x1=4)**	**4**	**60**
XXI	**4(4x1=4)**	**4**	**60**
XXII	**4(4x1=4)**	**4**	**60**
XXIII	**4(4x1=4)**	**4**	**60**
XXIV	**4(4x1=4)**	**4**	**60/120**

5.Internal (Continuous) Assessment: Apart from the semester (term) examination, every student of first, second and third semesters will be assessed in (i) Written tests (ii) Assignments. (iii) Seminars (iv) Attendance

(i) Written tests: In I, II, III and IV semesters, every student will have to appear in two written test at least.

(a) The assessment (sessional) in theory courses shall comprise a class test of 1.5 hour duration for 20 marks and 10 marks for regularity/viva/quiz/ or any other similar test.

The 30 marks of sessional for courses of laboratory exercises shall be based on completion of the laboratory exercise in due course of time/keeping up of practical record book / punctuality in class/viva to the practical/ any other relevant judgment.

(b) At the discretion of the concerned Head, a student who could not appear in the internal test(s) already conducted on account of some cogent reasons, such as late admission, illness, etc., may be allowed to appear in the internal assignment/test held for such a student.

(c) The class tests shall be conducted by the teacher (or group of teachers) teaching the course and the marks shall be displayed on the Notice Board and the student must be allowed to see their evaluated answer books based on their desire.

(d) Head of The Department shall ensure that all internal assessment marks of the sessional are sent to Controller of Examination prior to the commencement of End Semester Examination.

(e) Sessional marks of a course shall be carried over for failed students in the course.

(ii) Assignments: Regular assignments will be given to each student during 1st, 2nd and 3rd semester in each course. Assignments should be relevant to course content. Credit for assignments in each semester shall be included along with internal assessment marks.

(iii) Seminars: Students in I, II and III semesters will be required to deliver one seminar of 30 minute duration followed by discussion. The performance of the student will be judged by two teachers of the department. The credit for seminar in each semester shall be included along with internal assessment exam marks.

(iv) Attendance: - Each student shall attend at least 75% of the classes (Theory / Practical/ Library/ Seminar) held in the department, failing which He/ She shall be debarred from filling up the University Examination form/appearing at the University Examination. Internal evalutions will also be done for the above.

Absence during the Semester-

(a) A student must inform the HOD concerned immediately of any instance of continuous absence from classes.

(b) A student who is absent due to illness should approach the teachers concerned for make-up test immediately on return to class. The request should be supported with a medical certificate issued by a registered medical practitioner.

(c) In case of period of absence on medical grounds is more than 20 days during the Semester a student may apply for withdrawal from the semester. Such application must be made as early as possible. No applications for semester withdrawal will be considered after External examination have commenced. Partial withdrawn in a semester is not allowed.

(d) If a student is continuously absent from the institute for more than four weeks without permission of the Head of the Department concerned, his/her name will be removed from institute rolls.

6. Eligibility for taking examination: Students Participation in the Course (Attendance):

No student admitted to M.Sc. course in Microbiology, shall be considered to have completed the course and be eligible for taking the concerned examination unless he/she has attended at least 75% of lectures and practicals and has completed his/her project work. The H.O.D. concerned/Principal can act at his/her discretion to exempt 5% attendance under special condition only on production of medical certificate. The student(s) **will be declared failed in that subject/course/semester.**

7. Term (Semester) Examination: There shall be term (semester) examination at the end of each semester. The semester examination will be held every year normally in the month of December and June or on dates declared in the academic calendar of the Department/University. A student seeking admission to a semester examination will submit through the Head of the Department his/her application on prescribed form along with required examination fee, etc to the Registrar of the University. Every student will appear in four respective theory papers and two combined practical examination of 3 hour duration in every semester. In the fourth semester, every student will be allotted dissertation work. Also the students have to study four theory paper and two practical paper and appear in exam. Allotment of dissertation will be done by a committee comprising of the Head of the Department of Microbiology and other faculties of the Department, preferably in a National Laboratory/ Institute etc. However if it is not arranged in these institutions, the students however may be permitted to pursue their dissertation work in the department or other Universities/ Private Universities or to a government recognized Laboratory or any institution duly recognized by a statutory body.

The dissertation evaluation will be evaluated by the external examiner(s) who has expertise in the concerned subject. For the purpose of holding viva-voce external examiners will be appointed so. The scheme of marks for evaluating the various components of dissertation will be followed as given in the syllabus. **The dissertation evaluation will be purely external in nature.**

8. Condition for Pass: For passing the examination in each semester, a candidate must have secured a minimum of 45% marks in aggregate in theory, practical, dissertation and internal assessment separately. The students who do not pass a semester examination shall get an opportunity in the subsequent examination of that semester in the papers in which they have failed in the next academic session. Provided any student who fails in two consecutive semesters will not be given privileges of this clause.

Eligibility criteria for taking admission in 2nd/3rd/4th Semester:

All Candidates who have passed or promoted in the previous semester may take admission in next semester.

9. **Result:** The result of the candidate will be declared on the basis of aggregate marks obtained by him/her in all semester examination taken together. The division shall be awarded on the following basis *viz.*

(i) First Division:	60% and above
(ii)Second Division:	45% and above but less than 60%
(iii)Failed:	Less than 45%

The result of an examination shall be published as per the provisions of the concerned Ordinance.

Examination:

There shall be the following four examinations comprising the course.

1st Examination: On completion of the courses for the period prescribed therein in November/December

2nd Examination: On completion of the courses for the period prescribed therein in April/May/June.

(B). Scheme of Examination of a Semester:

The examination of each paper shall have two components- written examination at the end of each semester carrying 70% marks to be conducted by the University and Sessional work of 30% to be evaluated by the Departmental Council. Sessional work shall comprise the written component Seminars/Cultural Activities/NCC/NSS/Sports and day to day assessment. The written component shall carry 20% marks of a paper Seminars/Cultural Activities/Sports/NCC/NSS be 5% and day to day assessment 5% of a paper. The sessional work shall be evaluated which will comprise the candidate by the Departmental Council on the basis of his/her performance in various extra-curricular activities, general behavior, performance at seminar, etc.

(i). Scheme of Examination:

As and when required, the Board of Studies in Microbiology, Radha Govind University will be empowered to change the scheme of examination.

(ii). Others: Moderation of Results, Award of Degrees and other provisions not covered under the present regulation shall be governed by the regulation for Masters examination in Arts, Science and Commerce of Radha Govind University, and may, if needed be reviewed.

(C). Course of Study: The courses of the studies in different papers and in practicals will be as per syllabus prescribed by the Board of Studies in Microbiology, Radha Govind University. The syllabus of M.Sc. Microbiology shall be demarcated in to well defined units/areas of content along with a topic wise break up in each paper as per UGC/ Microbiology guidelines. The syllabus may be revised as per discretion of the university.

There shall be twenty-four papers, all the papers will be of 100 marks each. Dissertation paper in 4th semester will be of 100 marks. The duration of test of theory papers will be of 3 hours and that of practical papers will be of 6 hours.

Teaching in Microbiology subject shall follow the Semester pattern with a minimum of 90 days covered in 15-16 weeks per semester as provided in the relevant summary chart.

Invited lectures from eminent Researchers, Industrialists and others, on recent issues related to Biodiversity, Ethics, Biosafety, Intellectual Property Rights and Patent Issues, and Good Laboratory and Manufacturing practices shall be organized.

Note: The Departmental council shall be responsible for conduct of sessional examination. Normally the test of a portion shall be conducted by the teacher who had imparted the teaching of the relevant portion and shall evaluate the answer paper and submit the result to the HOD within a week of the test conducted.

The following are the detailed schemes of examination of a semester.

Structure of M.Sc. Microbiology under CBCS

Semester	Paper number	Name of the Paper	Mid Sem	End Sem	Full Marks	Pass Marks
Semester I	Paper I	General Microbiology	30	70	100	45
	Paper II	Diversity of Prokaryotic and Eukaryotic Microbes	30	70	100	45
	Paper III	Microbial Physiology and Metabolism	30	70	100	45
	Paper IV	Virology	30	70	100	45
	Paper V	Practical based on Paper I and Paper II	30	70	100	45
	Paper VI	Practical based on Paper III and Paper IV	30	70	100	45
Semester II	Paper VII	Cell Biology and Analytical techniques	30	70	100	45
	Paper VIII	Bio-Molecules and Enzymes	30	70	100	45
	Paper IX	Environmental Microbiology	30	70	100	45
	Paper X	Microbial Genetics	30	70	100	45
	Paper XI	Practical based on Paper VII and Paper VIII	30	70	100	45
	Paper XII	Practical based on Paper IX and Paper X	30	70	100	45

Semester III	Paper XIII	Molecular Biology	30	70	100	45
	Paper XIV	Recombinant DNA Technology	30	70	100	45
	Paper XV	Medical Microbiology	30	70	100	45
	Paper XVI	Agricultural Microbiology	30	70	100	45
	Paper XVII	Practical based on Paper XIII and Paper XIV	30	70	100	45
	Paper XVIII	Practical based on Paper XV and Paper XVI	30	70	100	45
Semester IV	Paper XIX	Industrial Microbiology and Bioprocess Engineering	30	70	100	45
	Paper XX	Bioinformatics	30	70	100	45
	Paper XXI	Immunology	30	70	100	45
	Paper XXII	Food And Dairy Microbiology	30	70	100	45
	Paper XXIII	Practical based Paper XIX, Paper XX, Paper XXI and Paper XII	30	70	100	45
	Paper XXIV	DISSERTATION	-	100	100	45
		Total Marks			2400	

Programme Structure:

The M.Sc. Microbiology programme is a two-year course divided into four-semesters. A student is required to complete ninety-six credits for the completion of course and the award of degree. A student has to accumulate twenty-four credits in each of the four semesters. Part – I First Year Semester I Semester II Part – II Second Year Semester III Semester I.

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

Course Credit Scheme

Semester	Core Course			Elective Course			Open Elective Course			Total Credits
	No. of Papers	Credits (L+T/P)	Total Credits	No. of Papers	Credits (L+T/P)	Total Credits	No. of Papers	Credits (L+T/P)	Total Credits	
I	6	16+8	24	-	-	-	-	-	-	24
II	6	16+8	24	-	-	-	-	-	-	24
III	6	16+8	24	-	-	-	-	-	-	24
IV	6	16+8	24	-	-	-	-	-	-	24
Total Credits				-			-			96

Duration of examination of a four credit course shall be 3 hours.

Duration of examination of a laboratory course will be ‘8 hours + 8 hours’ or ‘4 hours + 4 hours’ over two consecutive days, for eight credit or four credit courses respectively

Semester wise Course Curriculum and Credit distribution Total credits:

Semester-I (Total credits - 24)

Course code	Paper no.	Course title	L	P	Credit
MMBCC	I	General Microbiology	4	0	4
MMBCC	II	Diversity of Prokaryotic and Eukaryotic Microbes	4	0	4
MMBCC	III	Microbial Physiology and Metabolism	4	0	4
MMBCC	IV	Virology	4	0	4
MMBCC	V	Practical based on Paper I and Paper II	0	4	4
MMBCC	VI	Practical based on Paper III and Paper IV	0	4	4
Total Credits in Course					24

Semester-II (Total credits - 24)

Course code	Paper no.	Course title	L	P	Credit
MMBCC	VII	Cell Biology and Analytical techniques	4	0	4
MMBCC	VIII	Bio-Molecules and Enzymes	4	0	4
MMBEC	IX	Environmental Microbiology	4	0	4

MMBCC	X	Microbial Genetics	4	0	4
MMBCC	XI	Practical based on Paper VII and Paper VIII	0	4	4
MMBCC	XII	Practical based on Paper IX and Paper X	0	4	4
Total Credits in Course					24

Semester-III (Total credits - 24)

Course code	Paper no.	Course title	L	P	Credit
MMBCC	XIII	Molecular Biology	4	0	4
MMBCC	XIV	Recombinant DNA Technology	4	0	4
MMBEC	XV	Medical Microbiology	4	0	4
MMBCC	XVI	Agricultural Microbiology	4	0	4
MMBCC	XVII	Practical based on Paper XIII and Paper XIV	0	4	4
MMBCC	XVIII	Practical based on Paper XV and Paper XVI	0	4	4
Total Credits in Course					24

Semester-IV (Total credits - 24)

Course code	Paper no.	Course title	L	P	Credit
MMBCC	XIX	Industrial Microbiology and Bioprocess Engineering	4	0	4
MMBCC	XX	Bioinformatics	4	0	4
MMBCC	XXI	Immunology	4	0	4
MMBCC	XXII	Food And Dairy Microbiology	4	0	4
MMBCC	XXIII	Practical based Paper XIX, Paper XX, Paper XXI and Paper XII	0	4	4
MMBCC	XXIV	DISSERTATION	0	4	4
Total Credits in Course					24

M.Sc. Microbiology Semester I

Paper I: General Microbiology

Course Objectives:

The objective of this course is to introduce the field of microbiology with particular emphasis on history, morphology, growth and nutrition; methods of controlling bacteria.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Identify the main types of microorganisms and analyze bacterial taxonomy, diversity and prevalence.
CO 2	Identify and demonstrate how to control microbial growth.
CO 3	Identify and demonstrate the nutrition and growth of bacteria
CO 4	Insights into Bacterial Reproduction and Structural Diversity
CO 5	Mastery of Sterilization Techniques and Pure Culture Methods
CO 6	Proficiency in Media and Culture Preservation

UNIT – I: History and scope of Microbiology. Recent trends and developments in modern microbiology. Identification, characterization and classification of microorganisms- Principles of bacterial taxonomy and classification: - Bergey's manual and its importance, Concepts, nomenclature and taxonomic ranks: general properties of bacterial groups. Major characteristics used in Taxonomy- morphological, physiological and metabolic, ecological, numerical taxonomy, genetic and molecular classification systems; the kingdoms of organisms and phylogenetic trees. Distinguishing characteristics between prokaryotic and eukaryotic cells Structure and function of Cell wall of bacteria, cell membranes, flagella, pili, capsule, gas vesicles, carboxysomes, magnetosomes and phycobilisomes.

UNIT- II: Methods of sterilization: Physical methods – Dry heat, moist heat, radiation methods, filtration methods, chemical methods and their application. Concept of containment facility, sterilization at industrial level. Microbial cultures: Concept of pure culture,Methods of pure culture

isolation, Enrichment culturing techniques, single cell isolation, and pure culture development. Microscopic identification characteristics, staining methods – simple staining, differential staining, structural staining and special staining methods.

UNIT -III: Microbiological media-Natural and synthetic; autotrophic, heterotrophic and phototrophic media: basal, defined, complex, enrichment, selective, differential, maintenance and transport media Preservation and Maintenance of Microbial cultures: Repeated subculturing, preservation at low temperature, sterile soil preservation, mineral oil preservation, deep freezing and liquid nitrogen preservation, drying, glycerol cultures, freeze- drying (lyophilization).

UNIT -IV:Bacterial nutrition and growth kinetics- synchronous, stock, batch and continuous cultures. Growth measurement methods –Metabolic diversity, measurements of NAD, ATP, DNA, and Protein, CO_2 liberated O_2 consumed, extracellular enzymes. Cultivation of aerobes and anaerobes.
Reproduction and spore formation in bacteria. Morphology, Ultrastructure and chemical composition of bacteria, actinomycetes, spirochetes, rickettsiae, mycoplasma, Chlamydiae.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2,4	3	-	2	-	-	1	3	-	3	2	3	3	3	3	-
CO2	1,2,2	3	2	2	-	2	1	3	-	2	2	1	3	3	1	-
CO3	1,2	3	1	2	-	-	2	2	-	-	3	2	3	1	2	1
CO4	1,2,4	3	1	1	-	-	1	-	2	-		-	2	1	-	2
CO5	2,3	3	3	1	-	-	2	1	-	-	2	-	2	2	1	2
CO6	2,3,6	3	3	2	-	-	2	3	-	-	3	-	2	2	-	1

H (3)-High, M (2)- Moderate, L (1)- Low, '-' for No correlation

Recommended Books: -

1. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's microbiology. McGraw-Hill, New York.

2. Black, J.G. Microbiology: Principles and exploration. John Wiley and Sons, New Jersey.

3. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.

4. Pommerville, J.C. Alcamo's fundamentals of microbiology. Jones and Bartlett Learning, Sudbury.

5. Wheelis, M. Principles of modern microbiology. Jones and Bartlett Learning, Sudbury

Paper II: Diversity of Prokaryotic and Eukaryotic Microbes

Course Objective:

The objective of this course is to convey knowledge about the different groups of microorganisms and help students become aware of the importance of each.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Understand the diversity of the microbial world and its implications.
CO 2	Understand the characteristics and significance of different groups of microorganisms.
CO 3	Knowledge of other groups of microorganisms.
CO 4	Advanced Understanding of Bacterial Systematics and Applications
CO 5	Appreciation of Algal Diversity and Environmental Importance
CO 6	Comprehensive Insight into Fungal Diversity and Functional Roles

UNIT I. Archaea: Systematics, and occurrence, diversity, characteristic features, significance and potential applications (eg., biochips, methane generation, ultrafiltration membranes, production of PHB and PHA, desulphurization of coal and crude oil, bioleaching of metals, enzymes, compatible solutes and others) of different groups of archaebacteria (Crenarchaeota, Euarchaeota, Korarchaeota, Nanoarchaeota).

UNIT II. Bacteria: Conventional and molecular systematics, and general discussion on the occurrence, diversity, characteristic features, significance and potential applications of various groups of bacteria according to Bergey's Manual of Systematic Bacteriology.

UNIT III. Fungal Systematics and diversity: Implications of molecular and biochemical methods including rDNA analysis, RFLP, RAPD. Endophytic fungi, colonization and adaptation of endophytes. Endophytes as latent pathogens and biocontrol agents.

Mycorrhizal fungi: Diversity of endo and ectomycorrhizal fungi. Biology of arbuscular mycorrhizal fungi: signaling, penetration and colonization inside roots, culturing and benefits, recent advances in the field of mycorrhiza. Agriculturally important toxigenic fungi: Biodiversity, Chemical and biological characterization of toxic metabolites, toxigenic fungi in sustainable agriculture with special emphasis on biopesticides.

UNIT IV. Biotechnological applications of yeasts: Yeasts as producers of bioactive molecules such as pigments, lipids, organic acids and EPS, yeasts as probiotics, yeasts in bioremediation, yeasts in alcoholic fermentations.

UNIT V. Algal diversity from morphology to molecules: Importance of algae in production of algal pigments, biofuels, hydrogen production, important bioactive molecules, role of algae in sustainable environment.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2, 3	3	2	2	-	-	3	2	-	-	2	2	3	3	2	1
CO2	2,3	3	2	3	-	-	1	3	-	-	-	-	1	2	2	-
CO3	1,2	1	-	-	-	-	-	2	-	-	-	-	1	2	-	-
CO4	1,2	2	2	1	-	-	1	2	-	-	-	-	1	1	2	-
CO5	2,5	2	2	1	-	-	1	2	-	-	-	-	2	-	-	-
CO6	2,5	2	1	1	-	-	1	2	-	-	-	-	1	1	-	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

Recommended Books: -

1. The Prokaryotes. A handbook on the biology of bacteria: ecophysiology, isolation, identification, applications. Volumes I-IV by Balows, A., Trüper, H. G., Dworkin, M., Harder, W., Schleifer, K. H. Springer-Verlag, New York; 1992

2. Bacterial Systematics, by Logan, A., Niall A. Logan, Wiley-blackwell; 1994

3. Principles of Microbiology by R.M. Atlas , Mosby publishers, St. Louis; 1995

4. Brock Biology of Microorganisms (12th edition) by Madigan and John M. Martinko, Paul V. Dunlap, David P. Clark Benjamin Cummings; 2008.

5. Microbiology : An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case Benjamin-Cummings Publishing Company ; 2008.

Paper III: Microbial Physiology and Metabolism

Course Objective:

The objective of this course is to study description of metabolic and physiological diversity in prokaryotes and knowledge of the metabolic cycle of prokaryotes.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Learn the principles of microbial catabolism and anabolic pathways.
CO 2	Understand transport systems and energy conservation mechanisms in microbial metabolism.
CO 3	Identify different physiological groups of bacteria with their characteristics and understand the biosynthesis of basic biomolecules.
CO 4	Understanding Nucleotide Metabolism and Its Regulation
CO 5	Proficiency in Central Metabolic Pathways
CO 6	Comprehension of Physiological Adaptations and Cell Signaling

UNIT I. Growth and cell division: Measurement of growth,growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth.

UNIT II. Solute Transport: Primary and Secondary transport: Introduction, Kinetics,ABC transporters, Phosphotransferase system, Drug export systems, amino acid transport.

UNIT III. Central Metabolic Pathways and Regulation: Glycolysis, PPP, ED pathway, Citric acid cycle: Branched TCA andReverse TCA, glyoxylate cycle.

UNIT IV. Protein and Nitrogen metabolism: Metabolism of amino acids: Amino acid biosynthesis and utilisation. Catabolism of amino acids, transamination, decarboxylation and oxidative deamination.

UNIT V. Metabolism of lipids and hydrocarbons: Lipid composition of microorganisms,biosynthesis and degradation of lipids.

UNIT VI. Metabolism of nucleotides: Purine and pyrimidine biosynthesis, regulation of purine and pyrimidine biosynthesis,inhibitors of nucleotide synthesis.

UNIT VII. Physiological Adaptations and Intercellular signaling: Introduction to two component system, regulatory systems during aerobic- anaerobic shifts: Arc, Fnr, Nar, Fhl Aregulon, response to phosphate supply: The Pho regulon. Quorum sensing: A and C signaling system, sporulation in *Bacillus subtilis*, control of competence in *Bacillus subtilis.* Heat-Shock responses, pH homeostasis, osmotic homeostasis.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,4, 5	3	-	2	-	-	-	-	-	-	-	-	1	2	1	-
CO2	2,5	3	-	1	-	-	-	1	-	-	1	2	1	3	1	-
CO3	1,2, 4	1	2	-	-	-	2	1	-	-	2	-	2	3	2	-
CO4	1,2	2	1	1	-	-	1	1	-	-	-	-	1	2	-	1
CO5	3,5	2	1	2	-	-	-	1	-	-	1	-	2	-	1	1
CO6	2,5	2	1	1	-	-	-	1	-	-	1	-	1	-	-	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

Recommended Books: -

1. Biochemistry by Geoffrey L. Zubay. Fourth Edition, Addison-Wesley educational publishers Inc.,2008

2. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox. Fifth Edition, W.H. Freeman and Company; 2008.

3. Microbial lipids edited by C. Ratledge and SG Wilkinson, second edition, Academic Press; 1988.

4. Microbial Physiology by Albert G. Moat and John W. Foster. Third edition, John Wiley and Sons; 2002

5. The Physiology and Biochemistry of Prokaryotes by David White. Second Edition, Oxford University Press; 2000.

Paper IV: VIROLOGY

Course Objective:

The objective of this course is to convey advanced understanding and applied knowledge of viruses and familiarize students with the pathogenesis of viruses.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Identify and demonstrate the main viruses, their properties, and their ability to replicate.
CO 2	Knowledge of virus transmission and pathogenesis.
CO 3	Describethe physiology and virology of unusual viral outbreaks.
CO 4	In-depth Knowledge of Animal Viruses
CO 5	Proficiency in Plant and Microbial Virus Propagation and Assay Techniques
CO 6	Understanding of Plant Virus Diseases and Control

UNIT I. Animal Viruses: Classification, Morphology and Chemistry of Viruses: Virus evolution and classification, properties of viruses, virus structure. Techniques for visualization and enumeration of viral particles, measuring biological activity of viruses, characterization of viral products expressed in infected cells, Diagnostic virology, Physical and chemical manipulation of viruses.

UNIT II. Virus replication Strategies: Principal events involved in replication: Adsorption, penetration, uncoating nucleic acid and protein synthesis, intracellular trafficking, assembly, maturation and release, viral- host interaction, Host response to viral infection. Replicative strategies employed by animal DNA viruses. Replicative strategies employed by animal RNA viruses. Identification of virus prototypes associated with different virus replication schemes; Details on important viruses namely Herpes virus, Poliovirus, Influenza virus, VSV, SV40 and Adeno Virus, Poxviruses, Hepatitis Viruses, coronaviruses, Retroviruses. Subviral pathogens: HDV, Prions, Viroid.

UNIT III. Pathogenesis of viral infection and control of viral diseases: Stages of infection, Patterns of some viral diseases- epidemiology, transmission, infection, symptoms, risk, transformation and oncogenesis, emerging viruses. Host specific and nonspecific defense mechanisms involved in resistance to and recovery from virus infections. Role of interferon in viral infections. Viral Chemotherapy: Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitors, History of vaccines especially smallpox and polio. New methods: subunit vaccines, anti- idiotype and DNA vaccines.

UNIT IV. Plant and microbial viruses: General methods of propagation of plant viruses; purification of plant viruses using centrifugation, chromatography and electrophoresis techniques, their assay and comparison of the sensitivity of assay methods; methods employed in identification of plant viruses and structural and functional genomics.

UNIT V. Symptoms of plant virus diseases, transmission of plant viruses, viral and viroid diseases and their control: General discussion on symptoms caused by viruses and viroids in diseased economically important trees and agricultural crops, and their control including development of virus disease resistant transgenic.

UNIT VI. Microbial viruses: Diversity, classification, characteristics and applications of bacteriophages, and general account on algal, fungal and protozoan viruses.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2, 4	3	3	2	-	-	1	1	-	-	2	2	3	3	2	1
CO2	2,4, 5	3	2	-	-	-	-	-	-	-	-	-	3	2	3	1
CO3	1,2, 3	3	3	2	-	-	1	-	-	-	-	-	3	2	-	-
CO4	2,3	1	2	2	-	-	1	1	-	-	-	-	2	2	-	-
CO5	3,5	1	2	2	-	-	2	1	-	-	2	-	3	1	-	-
CO6	1,2, 3	1	2	1	-	-	1	1	-	-	-	-	2	1	1	1

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

Recommended Books: -

1. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses by S.J. Flint, L.W. Enquist, V.R. Racaniello, and A.M. Skalka 2nd edition, ASM Press, Washington, DC, 2004.

2. Introduction to Modern Virology EPZ by Nigel Dimmock, Andrew Easton and Keith Leppard, 5th edition, Blackwell Publishing, 2005

3. Basic Virology by Edward K. Wanger, Martinez Hewiett, David Bloom and David Camerini, 3rd edition, Blackwell Publishing, 2007.

4. Principles of Molecular Virology by Alan J. Cann, 3rd edition, Elsevier Academic Press, 2001.

5. Plant Virology by Roger Hull, 4th edition, Academic press, 2002.

PAPER V: Practical based on Paper I and Paper II

Course Objective:

The objective of this laboratory course is to provide practical skills on basic microbiological techniques.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Know the basic organization of a microbiology laboratory.
CO 2	Isolation,characterization and identification of common microorganisms.
CO 3	Preservation of microbial culture.
CO 4	Quantitative Measurement of Microbial Growth
CO 5	Bacterial Systematics and Application
CO 6	Identification of microbial Diversity

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO 11	PO1 2	PSO 1	PSO 2	PSO 3
CO1	2,3, 4	2	3	3	-	-	2	3	-	-	2	-	3	-	1	2
CO2	2,4, 6	2	3	3	-	-	3	3	-	-	-	-	2	-	3	1
CO3	2,5, 6	1	3	3	-	-	3	3	-	-	-	-	2	-	3	-
CO4	3,5	1	3	3	-	-	2	3	-	-	1	-	2	1	-	-
CO5	1,2	1	3	3	-	-	2	3	-	-	1	-	2	-	-	-
CO6	2,5	1	3	3	-	-	3	3	-	-	1	-	2	-	-	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

PAPER VI: Practical based on Paper III and Paper IV

Course Objective:

The objective of this laboratory course is to provide practical skills on biochemical estimation and understanding on viral disease and diagnosis

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Prepare biochemical solutions.
CO 2	Demonstrate quantification of different biomolecules.
CO 3	Tests to diagnose viral diseases by different techniques.
CO 4	Investigation of Metabolic Pathways
CO 5	Virus Replication and Host Interaction Analysis
CO 6	Study of Microbial Viruses and Bacteriophages

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2,3, 6	-	-	-	-	-	2	2	-	-	2	-	-	-	3	-
CO2	2,5, 6	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2
CO3	3,5, 6	1	3	3	-	-	-	3	-	-	-	-	-	-	3	2
CO4	4,6	1	-	2	-	-	-	-	-	-	2	-	-	-	2	-
CO5	4,5, 6	2	2	-	-	-	-	2	-	-	2	-	-	-	2	-
CO6	2,5	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

M.Sc. Microbiology Semester II

PAPER VII: CELL BIOLOGY AND ANALYTICAL TECHNIQUES

Course Objective:

The objective of this course is to study the details of cell structure and function. To understand the fundamentals of the various techniques used in biological experiments and impart technical skills in the use of advanced equipment.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Understand cellular organization and understand cell-to-cell communication mechanisms.
CO 2	To demonstrate the principles of various basic and advanced techniques used in biology experiments.
CO 3	Critically analyze and interpret the results obtained from biological experiments.
CO 4	Students will learn about key signal transduction pathways, including protein kinases, phosphorylation cascades, the Ras and MAP kinase pathways, and the roles of cyclic nucleotides and G proteins.
CO 5	Introduces the use of radioisotopes as tracers, covering methodologies, radiometric analysis, stable and radioactive isotopes, and kinetics of radioactive decay.
CO 6	Learn sample preparation methods, such as fixing, blocking, and staining biological samples.

UNIT I. Organellar Biology: structure, function and biogenesis of chloroplast and mitochondria, mesosomes, lysosomes and cytoskeletal system. Photosynthesis in bacteria and plants, oxygenic

and anoxygenic photosynthesis, PSI and PSII, electron transport, CO_2 fixation, purple green and halo bacteria photosynthesis. Physicochemical properties of bacteria- intracellular osmotic pressure, permeability of bacterial cell, nutrient transport- simple diffusion, active, passive and facilitated diffusion.

UNIT II. Signal transduction in eukaryotes: Protein kinases, phosphorylation cascades, Ras pathway, MAP kinase pathway, cyclic nucleotides, G proteins.

UNIT III. Microscopy- Basic principles and application of light, phase contrast microscopy, fluorescent and electron microscope- scanning and transmission. Microtome and sample preparations- fixing of specimens, preparation of blocks, staining of biological samples. Principles of cytometry and flow cytometry.

UNIT V. Analytical Techniques: Principles of centrifugation, techniques, preparative and analytical methods, density gradient centrifugation. General principle and application of chromatography-paper, column, thin layer, Gas, Ion Exchange, affinity chromatography, HPLC and Gel filtration. Electrophoresis- moving boundary, zone electrophoresis, immunoelectrophoresis, immunoblotting, isoelectric focussing, 2-D electrophoresis.

UNIT VI. Principles, laws of absorption and radiation. Visible, ultraviolet, infrared and mass spectrophotometry. Absorption spectra, flame photometry,NMR, ESR, principles of colorimetry, turbidometry, viscometry. Determination of size, shape and molecular weight of macromolecule-light scattering, diffusion, sedimentation, optical rotatory dispersion and X-ray diffraction.

UNIT VII. Radio isotopic tracers- methodology, radiometric analysis, stable and radioactive isotopes, preparation, labelling, detection and measurement of isotopes. RIA, Kinetics of radioactive disintegration, manometric techniques, freeze drying and its application in biological systems.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2, 4	3	-	2	-	-	-	1	-	-	-	-	3	3	-	1
CO2	2,3	-	-	2	-	-	3	3	-	-	2	-	-	2	3	1
CO3	2,3, 4	3	-	3	-	-	3	3	-	-	3	-	-	2	2	2
CO4	1,2	2	-	2	-	-	2	2	-	-	3	-	-	1	2	1
CO5	2	-	-	1	-	-	2	2	-	-	3	-	-	1	1	1
CO6	1,2	2	-	1	-	-	1	3	-	-	2	-	-	2	2	1

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

Recommended Books: -

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. Molecular biology of the cell. Garland Science, New York.

2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P. Molecular cell biology. W.H. Freeman and Company, New York.

3. Cooper, G.M. and Hausman, R.E. Cell: Molecular approach. ASM Press, Washington, D.C.

4. de Robertis, E. D. P. and de Robertis, E.M.F. Cellular and molecular biology. Saunders, Philadelphia.

PAPER VIII: BIOMOLECULES AND ENZYMES

Course Objective:

The objective of this course is to provide students with an understanding of biomolecules, the structural unit of living organisms. To introduce students to the principles & role of enzymes, their specificity, kinetics, regulations, and applications in industry

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Know the chemical and molecular structure of biomolecules and be able to determine the importance and role of biomolecules.
CO 2	Gain basic knowledge of enzymes and their specificity.
CO 3	Understand the kinetics of enzymes, enzymes regulations and applications.
CO 4	Students will explore amino acid and protein classification, structure, and function, including peptide bonds, Ramachandran's plot, and the four structural levels of proteins (primary to quaternary).
CO 5	Covers the structure, function, and properties of nucleic acids (DNA and RNA) and their structural polymorphisms.
CO 6	By studying enzyme characteristics, activation energy, active sites, and factors affecting catalytic efficiency

UNIT I. Major Biomolecules: Carbohydrates – Classification, chemistry, properties, and function –. Conjugated polysaccharides– lycoproteins, muriens and lipopolysaccharides.

UNIT II. Lipids – classification, chemistry, properties and function –Conjugated lipids – lipoproteins. Major steroids of biological importance – prostaglandins.

UNIT III. Amino acids and proteins: classification, structure and function. Peptide structure. Ramachandran's plot.. Structural levels of proteins – primary, secondary, tertiary and quaternary, denaturation of proteins. Hydrolysis of proteins, Protein sequencing using various methods.

UNIT IV. Nucleic acids –Structure, function and their properties. Structural polymorphism of DNA, RNA. Structural characteristics of RNA.Sources,.

UNIT V. Enzymology- Introduction, General characteristics of enzymes, Activation energy, Coupled reactions, active site and its importance, Factors influencing catalytic efficiency. Enzyme kinetics, Rapid Equilibrium, Henry-Nucgaekkus-Menten's equations, Steady State approach, significance of Km, Haldane equation, Velocity vital Substrate concentration curves. Methods of plotting enzyme kinetics data-Lineweaver-Burk. Equilibrium dialysis, Effect of pH and temperature on enzyme stability and activity, Arrhenius equation.

UNIT VI. Regulation of enzyme activity: Feedback inhibition, reversible covalent modification, irreversible covalent modification, allosteric concept, Aspartate transcarbamylalse, ligand-protein interaction, scatchard plot, Hill plot, cooperativity index, Models for allostery (MWC, KNF), Half site reactivity. Enzyme Inhibition, Models and types of inhibition.

UNIT VII. Applied enzymology: Application of enzymes in analytical labs. (clinical and industrial), enzymes as industrial catalysts, Immobilized enzymes, enzyme electrodes, assay of enzyme activities for diagnostic purposes, abzymes, recent developments.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2, 3	3	-	2	-	-	2	1	-	-	3	-	3	3	3	1
CO2	1,2, 5	-	-	2	-	-	-	1	-	-	-	-	-	3	-	-
CO3	2,4, 5	3	-	3	-	-	2	1	-	-	1	-	3	3	-	2
CO4	1,2	-	-	2	-	-	2	1	-	-	-	-	-	2	-	1
CO5	2,3	-	-	2	-	-	-	1	-	-	1	-	-	2	-	-
CO6	2,4	3	-	2	-	-	-	1	-	-	-	-	-	1	-	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

Recommended Books: -

1. Atkins, P. and Paula, J.D. Atkins' physical chemistry. Oxford University Press, Oxford.

2. Segel, I.H. Biochemical calculations. John Wiley and Sons, New York.

3. Nelson D.L. and Cox, M.M. Lehninger principles of biochemistry. W.H. Freeman and Company, New York.

4. Berg, J.M., Tymoczko, J.L. and Stryer, L. Biochemistry. W.H. Freeman and Company, New York.

5. Garrett, R.H. and Grisham, C.M. Biochemistry. Cole Publishing Company, California.

PAPER IX: ENVIRONMENTAL MICROBIOLOGY

Course Objective:

The objective of this course is to understand the role of microorganisms in environmental processes and learn principles and applications of microbiology in bioremediation of pollutants and wastewater treatment.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Know-how of the effect of environmental conditions on microbes.
CO 2	Understand the interactions between microorganisms and their environment.
CO 3	Understand applications of microorganisms in solving environmental problems.
CO 4	Students will gain knowledge about the history, evolution, and key contributions in microbial ecology.
CO 5	Students will examine the causes and effects of eutrophication on aquatic systems, including factors affecting eutrophic conditions, the role of algal blooms, and methods for controlling eutrophication.
CO 6	Students will learn about the factors influencing the biodegradation of pesticides and other toxic chemicals, mechanisms involved, and the role of specific microorganisms.

Unit 1 Brief history and development of environmental microbiology: History and development of microbial ecology highlighting significant contributions of microbiologists and emergence of environmental microbiology, and significant applications of microbes in solving environmental pollution problems.

Unit – 2 Environment and Ecosystems

Definitions, biotic and abiotic environment. Environmental segments. Composition and structure of environment. Concept of biosphere, communities and ecosystems. Ecosystem characteristics, structure and function. Food chains, food webs and trophic structures. Ecological pyramids.

Unit – 3 Eutrophication

Water pollution and its control,, Eutrophication, causes of eutrophication, effects of eutrophication on the quality of water environment, factors influencing eutrophication. Qualitative characteristics and properties of eutrophic lakes. Algae in eutrophication, algal blooms, their effects and toxicity, coloured waters, red tides, and cultural eutrophication. Physico-chemical and biological measures to control eutrophication

Unit –4 Effluent treatment techniques

Microbiology of wastewater and solid waste treatment: - Waste-types-solid and liquid waste Characterization, physical, chemical, biological, aerobic, anaerobic, primary, secondary and Tertiary treatments. Anaerobic processes: Anaerobic digestion, anaerobic filters, and up flow anaerobic sludge. Treatment schemes for effluents of dairy, distillery, tannery, sugar and antibiotic industries. Bioconversion of Solid Waste and utilization as fertilizer. Bioaccumulation of heavy metal ions from industrial effluents.

Unit 5 Biodegradation

Factors affecting biodegradation, effects of pesticides, biodegradation of pesticides, mechanism of biodegradation, microorganisms involved, biodegradation of other toxic chemicals. Bioplastics.

Unit – 6 Bioremediation of Xenobiotics

Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behaviour, bioaccumulation and biomagnification, oil pollution, surfactants and pesticides. Genetically Modified Organisms released and its environmental impact assessment and ethical issues. Bioremediation of Petroleum hydrocarbons.

Unit – 7 Global environmental problems

Ozone depletion, UV-B, global warming and its impact, ozone layer-formation and depletion, greenhouse effect and acid rain, their impact and biotechnological approaches for management.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2, 5	3	3	3	-	-	-	-	-	-	2	3	2	3	2	2
CO2	2,5	3	-	2	-	-	-	1	-	-	-	3	3	3	2	2
CO3	2,3	3	3	2	-	-	2	2	-	-	3	3	3	3	2	3
CO4	1,2	2	1	2	-	-	1	1	-	-	-	3	2	3	2	2
CO5	2,4	2	-	2	-	-	-	-	-	-	-	3	2	3	1	1
CO6	1,2	1	-	2	-	-	-	1	-	-	1	3	3	3	2	2

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

Recommended Books: -

1. Microbial Ecology By Atlas R.M., Bartha R., Benjamin Cummings Publishing Co, Redwood City, CA., 1993.
2. Environmental Microbiology by A.H. Varnam& M.G. Evans, Manson Publishing Ltd., 2000.
3. Manual of Environmental Microbiology by Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, ASM Press, 2007.
4. Environmental Microbiology by W.D. Grant & P.E. Long, Kluwer Academic Publishers, 1981.
5. Environmental Microbiology by R. Mitchel (2nd edition), Wiley-Blackwell, 2009.
6. Microbiology: An environmental Perspective by P. Edmonds, Macmillan, New York, 1978.
7. Environmental Microbiology by Raina Maier, Ian Pepper, & Charles Gerba, Academic Press, 2008.
8. Environmental Microbiology: Principles And Applications by Patrick K. Jjemba, Science Publishing Inc., 2004.

PAPER X: MICROBIAL GENETICS

Course Objective:

The objective of this course is to understand a comprehensive detail on microbial genomes and impart thorough knowledge on gene regulation and transfer mechanisms.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Understand the structure and functions of genomes of different microbial groups
CO 2	Understand the processes behind mutations and other genetic changes.
CO 3	Identify and distinguish genetic regulatory mechanisms at different levels and bacterial genomics.
CO 4	Students will gain knowledge about natural and artificial transformation, the mechanisms underlying DNA uptake in bacteria, and the importance of competence systems.
CO 5	Covers the discovery, classes, and mechanisms of bacterial transposons, along with their genetic and regulatory roles.
CO 6	By studying the mechanisms of gene regulation, including positive and negative control and attenuation in operons (e.g., lac, gal, and trp), students learn how bacteria control gene expression in response to environmental changes.

UNIT I. Genetic analysis of bacteria: Importance and uses of mutation analysis. Inheritance in bacteria, types of mutations, spontaneous and induced mutagenesis, isolating mutants, selecting mutants, mutant enrichment. Reversions versus suppression. Complementation tests, recombination tests and gene replacements. Cloning genes by complementation. Cloning genes by markerrescue.

UNIT II. Gene transfer and mapping by conjugation: Basis of fertility in bacteria. Self-transmissible and mobilizable plasmids. Molecular mechanism of gene transfer by conjugation – genes and proteins involved. Regulation of gene transfer by conjugation. Hfr strains. Mapping

bacterial genomes using Hfr strains. Chromosomal DNA transfer by plasmids – by integrated plasmids, by chromosome mobilization and by creation of prime factors. Ti plasmid transfer system and its application in creating transgenics.

UNIT III. Lytic bacteriophages: Lytic development cycle using phages T4 andT7 as models. Regulation of expression of genes in phageT4 – transcriptional activators, anti-termination, a new sigma factor and replication-coupled transcription. Regulation of gene expression in phage T7 – a phage-encoded RNA polymerase. Replication of T4 versus T7 phages – recent advances. Replication and packaging of filamentous phages M13 and f1 – recent advances. Genetic analysis of phages – complementation and recombination tests with phages.

UNIT IV. Lysogenic phages: Lambda phage – gene and promoter organization. Lambda lytic cycle– regulation of gene expression – very early, early and late genes. Establishment and maintenance of lysogeny. Regulation of gene expression in lysogenic phase - role of cI, cIIand cIII proteins. Lambda immunity region and immunity to superinfection. Events leading to induction – role of cI and crore pressors in regulating the events. Other lysogenic phages – P2 and P4.

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

UNIT VI. Transposons: Discovery of transposition. Classes of bacterial transposons. Regulation of transposition activity. Effects of transposition in bacteria. Genetic requirements for transposition. Molecular mechanisms of transposition – genetic evidence supporting the mechanisms. Conjugative transposons. Transposon mutagenesis. Cloning out genes by transposon mutagenesis. Mutransposon, Mu*d* transposons and gene fusions, mini-Mu elements and their use in *in vivo* cloning. YeastTy-1transposon.

UNIT VII. Gene regulation: Control of gene expression. Positive gene regulation, negative gene regulation and attenuation, using the *lac*, *gal*, *trp*

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2, 5	2	-	3	-	-	-	-	-	-	-	-	3	3	1	-
CO2	2,3	3	-	3	-	-	2	-	-	-	-	-	3	3	2	-
CO3	3,4	3	3	3	-	-	3	-	-	-	3	-	3	3	1	3
CO4	2,4	2	2	3	-	-	2	-	-	-	-	-	3	3	1	-
CO5	3,5	3	2	3	-	-	2	-	-	-	-	-	3	3	1	-
CO6	2,5	3	-	3	-	-	-	-	-	-	1	-	3	3	1	-

H-High, M- Moderate, L- Low, '-' for No correlation

Recommended Books: -

1. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.

2. Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.

3. Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.

4. Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987.

PAPER XI: Practical based on Paper VII and PaperVIII

Course Objective:

The objective of this course is to deliver hands-on experience of various biomolecules determination techniques and operating of advanced instruments.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Demonstrate qualitative and quantitative identification of different biomolecules.
CO 2	Develop capability to quantify enzymes and determine kinetic parameters
CO 3	Understand the SOPs and handling of equipment.
CO 4	Hands-on experience in studying eukaryotic signal transduction pathways, including protein kinases and G-protein-mediated pathways.
CO 5	Students will master the principles and applications of various microscopy techniques.
CO 6	Through hands-on experiments with enzyme kinetics and stability (using Lineweaver-Burk plots, pH/temperature studies).

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3,4, 6	2	-	-	-	-	2	3	-	-	3	-	2	1	3	3
CO 2	3,4, 5	2	2	3	-	-	2	3	-	-	3	-	3	-	3	3
CO 3	2,4	2	2	3	-	-	3	3	-	-	3	-	3	3	-	2
CO 4	3,6	2	2	3	-	-	2	3	-	-	3	-	3	-	-	1
CO 5	1,3	2	2	-	-	-	-	3	-	-	3	-	3	-	2	2
CO 6	3,5	2	2	-	-	-	1	3	-	-	3	-	2	2	-	-

H-High, M- Moderate, L- Low, '-' for No correlation

PAPER XII: Practical based on Paper IX and Paper X

Course Objective:

The objective of this course is to give basic understanding of interaction of microbes with their surrounding and microbial genetic manipulations with special emphasis on conjugation, transformation.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Analyse diversity of different microbes in different ecological niches
CO 2	Skill development in analysis of soil microorganisms
CO 3	Understand the concepts of bacterial genetics.
CO 4	Through practical work in ecosystem modelling and analysis of biotic and abiotic factors, students will learn to classify ecological components, interpret food chains and trophic structures, and evaluate ecosystem functionality
CO 5	Through hands-on study of lambda phage cycles, students will learn about lysogeny, immunity regions, and superinfection prevention.
CO 6	Through lab exercises on gene regulation, students will study control mechanisms (positive and negative regulation) using models like the lac and trp operons, gaining insight into attenuation, feedback inhibition, and allosteric control.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2, 4	-	3	3	-	-	3	-	-	-	2	3	3	3	-	1
CO2	3,4, 6	-	3	2	-	-	3	-	-	-	3	3	3	2	3	2
CO3	1,2	-	2	2	-	-	3	-	-	-	-	-	3	3	-	-
CO4	3,6	-	-	-	-	-	3	-	-	-	-	-	3	3	2	
CO5	3,5, 6	-	2	2	-	-	3	-	-	-	-	-	3	2	-	-
CO6	6	-	3	2	-	-	3	-	-	-	-	-	3	2	-	-

H-High, M- Moderate, L- Low, '-' for No correlation

M.Sc. Microbiology Semester III

Paper XIII: MOLECULAR BIOLOGY

Course Objective:

The objective of this course is to understand the molecular concepts in prokaryotic, eukaryotic and study the central dogma of molecular biology (replication, transcription, and translation).

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Describe the structure of DNA and RNA, organization of prokaryotic and eukaryotic genomes.
CO 2	Explain central dogma of molecular biology (replication, transcription, and translation)
CO 3	Articulate applications of molecular biology in the modern world.
CO 4	Explain the transcription machinery in prokaryotes and eukaryotes, including RNA polymerase roles, promoter, enhancer, silencer elements, and transcription regulation influenced by chromatin structure.
CO 5	Understand RNA processing mechanisms such as splicing, capping, polyadenylation, and editing.
CO 6	Gain insight into molecular signalling pathways, mechanisms underlying cancer and oncogenesis, genetic disorders, aging, and mitochondrial inheritance.

UNIT I. The nature of Genetic material: The structure of DNA and RNA; Melting of DNA, Superhelicity, Organization of Microbial Genomes, Organization of Eukaryotic Genomes, Chromatin arrangement, nucleosome formation.

UNIT II. DNA replication: Arrangement of replicons in a genome, Various modes of replication, specific features of replication inProkaryotes and Eukaryotes, action of topoisomerases, Telomere

maintenance and Chromatin Assembly, Single stranded DNA replication. DNA repair and recombination, DNA Mismatch Repair, Double Strand Break Repair, Recombination as a molecular biology tool.

UNIT II. Transcription: Transcription machinery of prokaryotes, eukaryotes, various forms of RNA polymerase promoters, enhancers, silencers, activators, effect of chromatin structure, regulation of transcription.

UNIT III. Post-transcriptional processes: RNA processing, splicing, capping and polyadenylation, rRNA and tRNA processing, RNA Editing; RNAi and miRNAs, Antisense RNA, Post-transcriptional gene regulation.

UNIT IV. Translation: The genetic code and protein structure, Mechanisms of translation in prokaryotes, Mechanisms of translation in eukaryotes, *in vitro* translation systems, polycistronic/ monocistronic synthesis, Regulation of translation, RNA instability, inhibitors of translation, stringent response in bacteria. Post-translational processes: Protein modification, folding, chaperones, transportation; The Signal Hypothesis, protein degradation.

UNIT V. Molecular basis of cell physiology: Signals and cascades in organism development Molecular mechanisms of Oncogenesis and cancer, genetic disorders, aging, mitochondrial inheritance. Implications of genome organization, Genes and behavior, Genome analysis, DNA typing, Genomics and beyond.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2, 4	-	3	2	-	-	-	-	-	-	2	-	3	3	3	-
CO2	1,2, 3	3	3	2	-	-	-	-	-	-	3	-	3	3	2	2
CO3	3,6	-	2	1	-	-	1	1	-	-	-	-	3	3	2	-
CO4	2,3	-	2	1	-	-	-	-	-	-	-	-	3	3	2	-
CO5	1,2	2	3	3	-	-	-	-	-	-	-	-	3	3	2	-
CO6	1,2, 3	-	3	3	-	-	-	-	-	-	-	-	3	3	2	-

H-High, M- Moderate, L- Low, '-' for No correlation

Recommended Books: -

1. Gene IX by Benjamin Lewin, Jones and Bartlett Publishers, Sudbury, Massachusetts, 2007.

2. Molecular Biology by R.F. Weaver , 4th edition, McGraw Hill. New York. USA, 2007.

3. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick, 6th edition, Benjamin Cummings, San Francisco, USA, 2007..

4. Biochemistry (5th edition) by J.M. Berg, J.L. Tymoczko, L. Stryer, W.H. Freeman and Company, New York, USA, 2008.

5. Current Protocols in Molecular Biology Edited by: Fred M. Ausubel; Roger Brent; Robert E. Kingston; David D. Moore; John A. Smith; Kevin Struhl, John Wiley and Sons, Inc. 2007.

PAPER XIV: RECOMBINANT DNA TECHNOLOGY

Course Objective:

The objective of this course is to learn about the concept of recombinant DNA technology and cloning of a gene.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Explain about the core technique of rDNA technology and enzymes required for it.
CO 2	Demonstrate the tools and techniques used in rDNA technology.
CO 3	Cognizant about various rDNA products in various fields.
CO 4	Design primers and perform various types of PCR such as Gradient, Touchdown, RT-PCR, qPCR, and Multiplex PCR, along with advanced PCR techniques (e.g., RAPD and differential display) for specific applications in genetic analysis and molecular diagnostics.
CO 5	Build and screen cDNA and genomic DNA libraries using methods like colony hybridization and PCR, and apply techniques for clone enrichment through positive selection and subtractive hybridization.
CO 6	Implement systems for recombinant protein overexpression in E. coli, B. subtilis, yeast (S. cerevisiae and S. pombe), baculovirus systems, and mammalian cells, including the use of various promoters for regulation of expression.

UNIT I. Basics of DNA cloning: Simple cloning and cloning using linkers and adaptors. Cloning vectors – plasmids, phages lambda and M13, phagemids, cosmids, P1 phage, PACs, BACs and YACs. Selection and screening of clones.

UNIT II. Methods of DNA and protein analysis: Isolation and purification of DNA. Agarose, polyacrylamide and pulsed field gel electrophoresis of DNA. Southern and Northern Blotting. Radiolabelling probes. RFLP analysis. DNA fingerprinting and its application. Native PAGE SDS-PAGE and two-dimensional PAGE analysis of proteins. Western Blotting analysis.

UNIT III Polymerase Chain Reaction: Concept of PCR and various thermophilic enzymes used in PCR. Gradient PCR versus Touchdown PCR. Designing primers. Long PCR, Inverse PCR, RT-PCR, 5' and 3' RACE, qPCR, Real Time PCR using SYBR Green, Scorpion primers and TaqMan probes, MOPAC, Multiplex PCR, Differential Display PCR, RAPD fingerprinting ofmicro-organisms.

UNIT IV. Construction of cDNAand genomic DNA libraries: Vectorsused in the construction of cDNAversus genomic DNA libraries. Screening libraries by colony hybridization and colony PCR. Enriching for clones in Cdna libraries by positive selection and subtractive hybridization.

UNIT V. Genome sequencing: DNA sequencing by Sanger's method – traditional and cycle sequencing. Physical mapping by restriction fragment fingerprinting of BAC clones. Whole genome shotgun sequencing. Clone-by-clone shotgun sequencing of genome – preparation of BAC/YAC library, map construction, random shotgun phase, finishing phase and sequence authentication. Genome annotation at the nucleotide level, protein level and process level. Comparative genome sequencing of microorganisms to identify and categorize SNPs. Array CGH.

UNIT VI. Transcriptional analysis of gene expression and transcriptomics: Gene expression analysis by Northern Blotting, RT-PCR, EST analysis and the use of reporter genes. Transcriptome analysis by DD-PCR and EST analysis, DNA microarrays (cDNAarrays and oligo arrays), Serial Analysis of Gene Expresion (SAGE).

UNIT VII. Overexpression of recombinant proteins: Overexpression and tagging of recombinant proteins in *E.coli,* driven by lac, T7 and Tet-regulatable promoters, Expression in *B. subtilis*. Overexpression systems in *S.cerevisiae*, *S.pombe*. Baculovirus overexpression system. Mammalian cell overexpression system.

UNIT VIII.Analysis of protein-DNA and protein-protein interactions: Gel retardation assay, DNA footprinting by DNase I and chemical methods, yeast one-hybrid assay, ChIP- chips. Yeast two hybrids, three-hybrids, split hybrids and reverse hybrids. Co- immunoprecipitations, pull-downs and Far-Westerns. GFP and FRET. Phage display.

UNIT VIII. Pharmaceutical products of DNA technology: Human protein replacements – insulin, hGH and Factor VIII. Human therapies – TPA, interferon, antisense molecules.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2, 3	3	3	3	-	-	3	3	-	-	3	-	3	3	3	-
CO2	2,3	-	-	2	-	-	3	3	-	-	3	-	3	3	2	-
CO3	1,5	2	2	2	-	-	3	3	-	-	-	-	3	2	2	3
CO4	3,5	-	2	3	-	-	3	3	-	-	-	-	3	3	2	3
CO5	3,6	2	2	2	-	-	3	3	-	-	3	-	3	2	2	-
CO6	3,4	2	-	2	-	-	3	3	-	-	2	-	3	2	2	-

H-High, M- Moderate, L- Low, '-' for No correlation

Recommended Books: -

1. Brown, T.A. Gene cloning and DNA analysis: An introduction. Wiley-Blackwell, New Jersey.

2. Primrose, S.B. and Twyman, R. Principles of gene manipulation and genomics. WileyBlackwell, New Jersey.

3. Nicholl, D.S.T. An introduction to genetic engineering. Cambridge University Press, Cambridge.

4. Glick, B.R., Pasternak, J.J. and Patten, C.L. Molecular biotechnology: Principles and applications of recombinant DNA. ASM Press, Washington, D.C.

5. Hartwell, L. Genetics: From genes to genome. McGraw-Hill, New York.

6. Old, R.W. and Primrose, S.B. Principles of gene manipulations. Blackwell Science, Oxford.

PAPER XV: MEDICAL MICROBIOLOGY

Course Objectives:

The objective of this course is to gain theoretical knowledge of various diseased conditions generated due to pathogenic bacteria, pathogenic protozoa & fungi and pathogenic viruses.

Course Learning outcome:

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

CO	COURSE OUTCOMES
CO 1	Will acquire a good understanding of infection process, common diseases caused by bacteria, viruses and other microbes.
CO 2	Knows about pathogenesis, laboratory diagnosis and rapid methods of pathogenic bacteria, pathogenic fungi and viruses
CO 3	Describe disease prevention and control measures for emerging and re-emerging diseases.
CO 4	Discuss key fungal diseases, distinguishing between superficial, subcutaneous, systemic, and opportunistic mycoses.
CO 5	Gain knowledge in quality control practices within a laboratory setting, including total quality management, quality control planning, assessment, and improvement in microbiology labs.
CO 6	Classify and describe basic haematological disorders, including types of anemia and coagulation disorders.

UNIT I. General topics on medical microbiology: History and development, Koch's postulates, classification of medically important bacteria. Infection: source, modes of transmission, portal of entry into susceptible hosts and prevention. Bacterial pathogenicity, identification of bacteria: staining methods, culture method, biochemical tests and other recent methods. Sterilization and disinfection. Normal microbial flora, antimicrobial agents, drug resistance and drug sensitivity test.

UNIT II. Systematic Microbiology: Diseases caused by Gram positive cocci-sore throat, pneumonia etc., Diseases caused by Gram negative cocci- meningitis, gonorrhoea etc. Diseases caused by Gram positive bacilli- Tuberculosis, Diphtheria, Tetanus, Gas gangrene etc, Diseases caused by Gram negative bacilli of Enterobacteriaceae- Enteric fever, Bacillary dysentery,UTI
Diseases caused by Gram negative bacilli- Cholera, plague, Whooping cough, Wound infection, Septicaemia. Sexually transmitted diseases. Disease caused by mycoplasma, Chlamydia, Rickettsia.

UNIT III. Overview of medical Mycology: Important fungal diseases- Superficial, Subcutaneous, Systemic and opportunistic Mycosis. Overview of Medical Parasitology, Important Protozoan Diseases- Ascaris, Ankylostomiasis, Filariasis, Taeniasis, Echinococcosis etc. Overview of Medical Virology, Important Viral Diseases- Herpesvirus, Poliovirus, Rabies Virus, Arboviruses, Hepatitis, HIV etc. Opportunistic Microbial Infection, Water, Milk and Food borne Diseases, Microbial Vaccine.

UNIT IV. Quality Control: Introduction, Total Quality Management, Framework, Laboratory Processes, Assurance and Assessment, Quality control Planning and Improvement.

UNIT V. Haematology: Basic Haematological Disorders- Classification of Anemia, Iron Deficiency anemia, Megaloblastic Anemia, Haemolytic Anemia, Basic Haematological Techniques- Collection of Blood Specimens, Haemolysis of Blood, Separation of Serum and Plasma, Maintenance and Transport of Specimen, Coagulation and Bleeding Disorders (in brief).

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2	3	2	2	-	-	2	2	-	-	2	-	3	2	1	-
CO2	2,4, 6	3	3	3	-	-	3	3	-	-	2	-	3	3	3	1
CO3	1,3, 4	3	2	3	-	-	3	2	-	-	2	3	3	1	1	3
CO4	1,2	3	2	2	-	-	2	2	-	-	2	3	3	1	1	1
CO5	2,3	3	2	2	-	-	3	2	-	-	2	-	3	2	1	-
CO6	1,4	3	2	3	-	-	3	1	-	-	2	-	3	1	1	1

H-High, M- Moderate, L- Low, '-' for No correlation

Recommended Books: -

1. Murrey, P.R., Rosenthal, K.S., Kobayashi, G.S. and Pfaller, M.A. Medical microbiology. Saunders, Philadelphia.
2. Baron, E.J., Peterson, L.R. and Finegold, S.M. Bailey and Scott's diagnostic microbiology. Mosby, St. Louis.
3. Dockrell, H., Zuckerman, M., Roitt, I.M. and Chiodini, P.L. Mim's medical microbiology. Elsevier, London.
4. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. Mackie and McCartney practical medical microbiology. Churchill Livingstone, London.
5. Ananthanarayanan, R. and Panicker, C.K.J. Text book of microbiology. Orient Longman, Hyderabad.

PAPER XVI: AGRICULTURAL MICROBIOLOGY

Course Objectives:

The objective of this course is to understand the students about the role of soil microbes in the biogeochemical cycle of nutrients and organic matter degradation.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Understanding the role of microorganisms in the biogeochemical cycles of nutrients
CO 2	Understanding the role of microbes in degradation of solid organic waste and other organic pollutants.
CO 3	Understanding the different types of interactions between plants and microbes
CO 4	Investigate the biodegradation pathways of herbicides and pesticides, and evaluate the role of soil microorganisms in the detoxification of these chemicals.
CO 5	Discuss the principles and methods for the mass cultivation of microbial inoculants used as biofertilizers.
CO 6	Identify the roles of plant growth-promoting rhizobacteria (PGPR) and mycorrhizal fungi in promoting plant health and growth.

UNIT I. Soil Microorganism in agro ecosystem: Types of microbial communities: soil microbial diversity: significance and conservation; effect of agricultural practices on soil organisms.

UNIT II. Biological Nitrogen fixation: The range of nitrogen fixing organisms; mechanism of nitrogen fixation (biochemistry of nitrogenase); genetics of nitrogen fixation.

Rhizobiunm Legume Association; Symplasmids, N2 fixation by non leguminous plants.

UNIT III. Chemical transformation of microbes: Organic matter decomposition, nutrient mineralization and immobilization; transformation of carbon and carbon compounds.

UNIT IV. Biodegradation of herbicides and pesticides

UNIT V. Biofertilizers: Mass cultivation of microbial inoculants; green manuring; algalization; *Azolla.*

UNIT VI. Microbial products and plant health: Plant growth promoting rhizobacteria (PGPR); significance of mycorrhizae, Microbial herbicides, biological control.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2	3	2	3	-	-	2	1	-	-	1	3	2	2	3	-
CO2	2,3, 5	3	2	3	-	-	3	3	-	-	1	1	2	-	3	3
CO3	1,2, 4	3	2	3	-	-	-	1	-	-	1	3	3	2	1	2
CO4	2,3	3	2	3	-	-	-	1	-	-	1	2	3	2	1	2
CO5	1,2	3	2	3	-	-	-	-	-	-	1	1	3	-	3	1
CO6	3,4	3	2	3	-	-	-	-	-	-	1	2	2	2	3	1

H-High, M- Moderate, L- Low, '-' for No correlation

Recommended Books: -

1. Subba Rao, N.S. Soil microorganisms and plant growth. Oxford and IBH Publishing Company, New Delhi.

2. Alexander, M. Introduction to soil microbiology. John Wiley and Sons, New York.

3. Kononova, M.M. Soil organic matter: Nature, its role in soil formation and in soil fertility. Pergamon, Oxford.

4. Burges, A. and Raw, F. Soil biology. Academic Press, London.

5. Rangasami G. and Bagyarai, D.J. Agricultural microbiology. Prentice-Hall, New Delhi.

6. Agrios, G.N. Plant pathology. Academic Press, San Diego.

7. Mathews, R.E. Functionals of plant virology. Academic Press, San Diego.

PAPER XVII: Practical based on Paper XIII and Paper XIV

Course Objective:

The objective of this course is to provide idea about DNA, protein purification from samples and quantification and basic techniques used in recombinant DNA technology.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Capable of performing basic techniques of Molecular biology techniques.
CO 2	Capable of performing several RDT techniques.
CO 3	Capable of performing several techniques used during development of Recombinant DNA.
CO 4	Identify replicons in genomes through experimental techniques and study different modes of DNA replication.
CO 5	Study the regulation of translation and factors affecting RNA stability.
CO 6	Experimentally analyse transcription machinery and various forms of RNA polymerase activity

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2,3, 6	3	3	3	-	-	3	2	-	-	2	-	2	-	3	2
CO2	1,3, 6	2	3	3	-	-	2	2	-	-	2	-	-	-	3	3
CO3	3,6	3	2	3	-	-	3	2	-	-	3	-	3	-	3	3
CO4	2,3	2	2	3	-	-	2	2	-	-	2	-	-	-	3	2
CO5	1,2	3	2	3	-	-	3	2	-	-	2	-	2	-	3	3
CO6	3,4	2	3	3	-	-	3	2	-	-	2	-	2	-	3	3

H-High, M- Moderate, L- Low, '-' for No correlation

PAPER XVIII: Practical based on Paper XV and Paper XVI

Course Objective:

The objective of this course is to develop students‟ understanding of medical microbiology with hand on experience in the isolation of the bacteria from different clinical and agriculture sources.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Explain the aseptic techniques and sterilization techniques for the isolation of pure cultures of microorganisms.
CO 2	Able to analyze diversity of different microbes in different ecological niches
CO 3	Learning methods for antimicrobial susceptibility testing.
CO 4	Use staining methods (such as Gram staining), culture techniques, and biochemical assays to identify bacterial pathogens in clinical samples.
CO 5	Practice haematological techniques for the classification of anaemia’s and other blood disorders.
CO 6	Gain skills in the mass production and application of bio fertilizers, including microbial inoculants, green manures, and Azolla.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2	2	3	3	-	-	3	2	-	-	3	3	-	-	3	2
CO2	2,4, 5	2	3	3	-	-	3	2	-	-	3	3	1	-	3	-
CO3	1,2	2	3	3	-	-	3	2	-	-	3	3	1	-	-	3
CO4	3,6	2	3	3	-	-	3	2	-	-	3	3	1	-	-	2
CO5	2,3, 6	2	3	3	-	-	3	2	-	-	3	3	-	-	-	-
CO6	5,6	2	3	3	-	-	3	2	-	-	3	3	-	-	-	1

H-High, M- Moderate, L- Low, '-' for No correlation

PAPER XIX: INDUSTRIAL MICROBIOLOGY AND BIOPROCESS ENGINEERING

Course Objective:

The objective of this course is to impart theoretical knowledge of role of microbes in industrial production of different bio- chemicals/bio-molecules.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Learning of different fermentation techniques, bioreactor design, inoculum development for industrial fermentations, Microbial growth and product formation kinetics, media formulation and sterilization, isolation, preservation and improvement of industrially important microorganisms.
CO 2	Understanding of industrial production and purification of organic acids, alcohols, wine and vinegar with help of different microbes.
CO 3	Understanding of industrial production and purification of antibiotics, enzymes, amino acids and steroids.
CO 4	Recognize sources of industrially relevant microorganisms, understand strain development processes, and optimize fermentation conditions.
CO 5	Understand batch, continuous, and fed-batch culture processes and their industrial applications.
CO 6	Acquire knowledge of media formulation, including water, carbon, nitrogen, and mineral sources, and techniques for nutrient recycling and sterilization.

UNIT I. Introduction to industrial microbiology: Sources of industrially important microbes, strain development, types of fermentation and fermenters, process optimization, and recent developments in fermentation technology.

UNIT II. Downstream processing of microbial products: Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilisation and spray drying), and crystallization.

UNIT III. Fermentation economics: Basic objective for successful economically viable fermentation process, cost breakdown for well-established fermentation processes, market potential of the products, cost aspects of various stages in the processes development including effluent treatment.

UNIT IV. Production aspects: Microbial strains, substrates, strain improvement, flow diagrams, product optimization, and applications of industrial alcohol (ethanol and butanol), amino acids (lysine, phenylalanine, tryptophan),antibiotics (cephalosporins, tetracyclines, polyenes), enzymes and immobilized enzymes, SCP, microbial polyesters, biosurfactants, and recombinant products (insulin, somatostatin, thaumatin).

UNIT V. Bioprocessing Technology and Bioengineering: An introduction to fermentation processes- range of fermentation processes, microbial biomass. Microbial growth kinetics- batch Culture, continuous culture, industrial application of continuous culture processes, fed- batch culture. The isolation, preservation and improvement of industrially important and useful microorganisms.

UNIT VI. Industrial fermentation-typical media, media formulation, water, energy and carbon sources, nitrogen sources, minerals. Vitamin sources, nutrient recycle, buffers, precursors and metabolic regulators, oxygen requirements. Media sterilization, sterilization of fermenter, sterilisation of the feed. Inocula for industrial fermentation-development of inocula for yeast, bacteria, fungi and actinomycetes, the inoculation of fermenters. Design of fermenter, basic functions, construction, aeration and agitation, oxygen requirements of industrial fermentation.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1, 2, 5	3	3	2	-	-	3	3	-	-	3	-	3	3	2	2
CO2	2, 3, 6	2	2	2	-	-	-	3	-	-	3	2	3	3	1	-
CO3	2, 3, 6	2	2	2	-	-	-	3	-	-	3	2	3	3	1	-
CO4	1, 2	2	2	2	-	-	-	3	-	-	3	2	3	3	1	-
CO5	2, 3	2	2	2	-	-	-	3	-	-	3	2	3	3	1	-
CO6	2, 3	2	2	2	-	-	-	3	-	-	3	2	3	3	1	-

H-High, M- Moderate, L- Low, '-' for No correlation

Recommended Books: -

1. Hershberger, C.L., Queener, S.W. and Hedemen, Q. Genetics and biotechnology of industrial microorganisms. ASM Press, Washington, D.C.

2. Crueger, W. and Crueger, A. Biotechnology: A textbook of industrial microbiology. Sinauer Associates, Sunderland.

3. Reed, G. Prescott and Dunn's industrial microbiology. Globe Book services, London.

4. Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.

PAPER XX: BIOINFORMATICS

Course Objective:

The objective of this course is to provide an overview of various bioinformatics tools, databases available and sequence analysis.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Grasp fundamental concepts in bioinformatics and computer operations, including types of operating systems, networking, remote login, and basic Unix commands.
CO 2	Acquire an understanding of various biological databases and their formats (such as GenBank, EMBL, DDBJ, PDB), data storage modes, and search methods.
CO 3	Retrieve the information from available databases and use them for microbial identifications.
CO 4	Gain ability to modify gene and protein structures in simulated systems.
CO 5	Predict the significance of the biological phenomenon on the basis of available bioinformatics data set
CO 6	Explore prediction techniques for nucleic acids and protein structures, including RNA secondary and tertiary structure modelling.

UNIT I. Introduction to computers and bioinformatics- Types of operating systems, concepts of networking and remote login, basic fundamentals of working with unix.

UNIT II. Biological databases- Overview, modes of database search, mode of data storage (Flat file format, db-tables), flat file formats of GenBank, EMBL, DDBJ, PDB.

UNIT III. Sequence alignment –Concept of local and global sequence alignment, Pairwise sequence alignment, scoring an alignment, substitution matrices, multiple sequence alignment.

UNIT IV. Phylogenetic analysis- Basic concepts of phylogenetic analysis, rooted/uprooted trees, approaches for phylogenetic tree construction (UPGMA, Neighbour joining, Maximum parsimony, Maximum likelihood).

UNIT VI. Generation and analysis of high throughput sequence data- Assembly pipeline for clustering of HTGS data, format of ".ace" file, quality assessment of genomic assemblies, International norms for sequence data quality, Clustering of EST sequences, concept of Unigene. Annotation procedures for high through-put sequence data- Identification of various genomic elements (protein coding genes, repeat elements, strategies for annotation of whole genome, functional annotation of EST clusters, gene ontology (GO) consortium.

UNIT VII. Structure predictions for nucleic acids and proteins - Approaches for the prediction of RNA secondary and tertiary predictions, energy minimization and base covariance models, Basic approaches for protein structure predictions, comparative modeling, fold recognition/"threading" and *ab-initio* prediction.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2	2	2	3	-	-	3	-	1	-	2	-	2	3	-	3
CO2	1,4 6	2	2	3	-	-	3	-	1	-	2	-	2	1	3	3
CO3	2,3, 5	2	2	3	-	3	3	-	1	2	3	-	2	2	-	3
CO4	2,4	2	2	3	-	-	3	-	1	2	2	-	2	2	-	3
CO5	2,3	2	2	3	-	-	3	-	1	-	2	-	2	1	-	3
CO6	4,5	2	2	3	-	-	3	-	1	-	2	-	2	1	-	3

H-High, M- Moderate, L- Low, '-' for No correlation

Recommended Books: -

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins by Baxevanis A.D. and Ouellette, Third Edition. John Wiley and Son Inc., 2005.

2. Bioinformatics Sequence and Genome Analysis by Mount D.W., CSHL Press, 2004.

3. Introduction to Bioinformatics by Tramontano A., Chapman & Hall/CRC, 2007.

4. Understanding Bioinformatics by Zvelebil, M. and Baum, Chapman & Hall/CRC, 2008.

PAPER XXI: IMMUNOLOGY

Course Objective:

The objective of this course is to provide an overview of the immune system, antigen antibody structure and interactions and integrate immunology with health and enrich the knowledge for autoimmune disorders, hypersensitivity reactions.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Understand the immune system and the cells involved in it and the complement system as well as autoimmunity
CO 2	Describe innate and adaptive immunity as well as details about antigen and antibody together with their interaction.
CO 3	Theoretical understanding of various microbial diseased conditions generated due to interplay of immune system components and role of APCs and MHC molecules
CO 4	Understand recent advances in innate immunity, including NK-DC interactions, and analyze key cytokines and signaling pathways, such as MAP kinases and NF-κB, involved in immune regulation.
CO 5	Master techniques for detecting pathogens, such as ELISA, Western Blotting, and immunofluorescence, and apply these methods in immunodiagnostics.
CO 6	Understand the history, types, and effectiveness of vaccines, including Hepatitis B, AIDS, and DNA vaccines.

UNIT I. Immune System: Three fundamental concepts: Specificity, discrimination of self from non-self and memory. Lymphocytes, their sub population, properties and functions, lymphocyte trafficking.

UNIT II. Antigens and Immunoglobulins

Concept of haptens, determinants, conditions of antigenicity, antigens and immunogenicity, superantigen. Immunoglobulins: Structure and properties of immunoglobulin classes. Theories of

antibody formation, hybridoma technology for monoclonal antibodies and designer monoclonal antibodies. Multiple myelomas and structural basis of antibody diversity. Freund's adjuvants and their Significance.

UNIT III. Genetic organization: Organization of the genes for B and T cell receptors. Genetic organization of MHC-I and MHC-II complex (both HLA and H-2).Peptide loading and expression of MHC-I and MHC-II molecules.

UNIT IV. Immune response and signaling: Humoral and cell- mediated immune response; Innate immune response and pattern recognition; Recent advances in innate immune response especially NK-DC interactions; Major cytokines and their role in immune mechanisms: TNF, IFN, IL-1, IL-2, IL-4, 1L-6, 1L-10, 1L-12, IL-17, TGFβ; Cell signalling through MAP kinases and NF-κB.

UNIT V. Immunity and Immunoassays: Defense against bacteria, viruses, fungi and parasites. Immunodiagnostics and immunotherapy in virology – Serological methods for detection and quantitation of viruses including Hepatitis, Influenza, HIV and others. Immuno- assays: ELISA, ELISA-PCR, RIA, Western Blotting, Immunofluorescence and their application. Tolerance and autoimmunity: Central and peripheral tolerance, and their mechanism; Mechanisms of autoimmunity; Autoimmune components of diabetes mellitus (DM), multiple sclerosis (MS), experimental autoimmune encephalitis (EAE); Infections leading to autoimmune diseases.

UNIT VI. Immunological disorders and hypersensitivity: Deficiencies / defects of T cells, B cells, complement and phagocytic cells; immunodeficiency with special reference to AIDS, Comparative study of Type I-V hypersensitivities with examples. Mechanism and molecular events in mast cell degranulation by IgE, pharmacological mediators of type-1 reactions.

UNIT VII. Transplantation and tumor immunology: Alloreactive response; types of grafts, Graft rejection and GVHD; HLA-matching; mechanism and prevention of graft rejection. Transgenic animals for xenotransplantation; Tumor antigens, immune response to tumors and immunotherapy of tumors.

UNIT VIII. Vaccine: Vaccines – Introduction and History, Effectiveness and Adverse effect of Vaccines, Types of Vaccines, Production of Vaccines, Delivery system of Vaccines, Hepatitis B, AIDS, and DNA vaccines, DIVA Vaccines, Recent Advances in Vaccines, Vaccines for Cancer.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2	3	2	3	-	-	-	2	-	-	2	-	3	3	3	-
CO2	2,4, 5	2	2	3	-	-	-	-	-	-	2	-	3	3	-	-
CO3	1,2	3	3	3	-	-	3	2	-	-	1	-	3	3	-	1
CO4	2,3	2	2	3	-	-	-	2	-	-	2	-	3	3	-	-
CO5	3,5	3	2	3	-	-	3	2	-	-	1	-	3	3	-	-
CO6	1,2	3	3	3	-	-	3	-	-	-	1	-	3	3	-	-

H-High, M- Moderate, L- Low, '-' for No correlation

Recommended Books: -

1. Kindt, T.J., Goldsby, R.A., Osborne, B.A. and Kuby, J. Kuby immunology. W.H. Freeman and Company, New York.

2. Male, D.K. Immunology: An illustrated outline. Elsevier Health Sciences, Philadelphia.

3. Abbas, A.K., Lichtman, A.H.H. and Pillai, S. Cellular and molecular immunology. Saunders, Philadelphia.

4. Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M. Roitt's essential immunology. Wiley- Blackwell, New Jersey.

5. Playfair, J.H.L. Immunology at a glance. Blackwell Scientific Publications, Oxford.

6. Chapel, H., Haeney, M., Misbah, S. and Snowden, N. Essentials of clinical immunology. Wiley, New Jersey.

PAPER XXII: FOOD AND DAIRY MICROBIOLOGY

Course Objective:

The objective of this course is to provide the knowledge about food associated with microorganisms and microbial spoilage and preservation of foods and insights on producing dairy and non-dairy fermented foods, and role of probiotics and prebiotics in improving human health.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Understanding about the interactions between microorganisms and the food environment.
CO 2	Knowledge of the various food fermentations, and methods for preservation of foods.
CO 3	Understanding about the detection, preventive measures and sources of food infections and intoxications caused by various microorganisms.
CO 4	Analyze microbial presence in different food types, including vegetables, fruits, milk, fermented and non-fermented dairy products, meats, and non-dairy fermented foods, and evaluate the impact of microorganisms on food quality.
CO 5	Gain insights into the microbial processes involved in producing fermented dairy products (e.g., acidophilus milk, yogurt) and beverages like tea, coffee, and vinegar, appreciating the role of microorganisms in flavor and texture development.
CO 6	Understand the advancements in food microbiology, including genetically modified foods, biosensor applications, microbial enzyme uses in dairy (proteases, lipases), and sustainable management of dairy by-products like whey.

UNIT I. Microbiology of foods: Vegetables, fruits, milk, fermented and non- fermented milk products, fresh meats,poultry and non-dairy fermented foods.

UNIT II. Industrial Food fermentations: Starter cultures, their biochemical activities, production and preservation of the following fermented foods.

a. Soy sauce fermentation byMoulds, b. Fermented vegetables –Sauerkraut, c. Fermented Meat –Sausages, d. Production and application of Baker'sYeast, e. Application of microbial enzymes in food industry

UNIT III. Quality assurances in foods: Foodborne infections and intoxications; bacteria with examples of infective and toxic types – Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter, Listeria. Mycotoxins In food with reference to Aspergillus species.

UNIT IV. Quality assurance: Microbiological quality standards of food.Government regulatory practices and policies. FDA, EPA, HACCP, ISI.

UNIT V. Food preservation methods: Radiations - UV, Gamma and microwave Temperature Chemical and naturally occurring antimicrobials Biosensors in the food industry.

UNIT VI. Microbiology of cheese and beverage fermentation: Microbiology of fermented milk products (acidophilus milk, yoghurt).Role of microorganisms in beverages – tea and coffee fermentations. Vinegar Fermentation.

UNIT VII. Advanced Food Microbiology: Genetically modified foods. Biosensors in food, Applications of microbial enzymes in dairy industry [Protease, Lipases].Utilization and disposal of dairy by-product - whey.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	**BL**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1,2	2	1	2	-	-	-	2	-	-	-	-	2	3	-	-
CO2	1,2	2	1	1	-	-	2	1	-	-	-	-	1	3	-	-
CO3	2,3, 4	2	3	3	-	-	3	2	-	2	-	-	2	3	-	-
CO4	3,4	2	2	2	-	-	-	2	-	-	2	1	2	2	-	1

CO5	1,2	1	3	2	-	-	3	-	-	2	-	-	2	1	2	-
CO6	2,4	2	2	3	-	-	-	2	-	-	3	-	2	-	2	-

H-High, M- Moderate, L- Low, '-' for No correlation

Recommended Books: -

1. Adams, M.R., and Moss, M.O. Food microbiology. Royal Society of Chemistry Publication, Cambridge.

2. Frazier, W.C. and Westhoff, D.C. Food microbiology. Tata McGraw Hill, New Delhi.

3. Stanbuty, P.F. and Hall, S.J. Principles of fermentation technology. Pergamon Press, Oxford.

4. Banwart, G.J. Basic food microbiology. CBS Publishers and Distributors, New Delhi.

5. Robinson, R.K. Dairy microbiology. Elsevier Applied Sciences, London.

6. James M.J. Modern food microbiology. CBS Publishers and Distributors, New Delhi.

7. Wood, B.J. Microbiology of fermented foods. Elsevier Applied Sciences, London.

PAPER XXIII: PRACTICAL BASED PAPER XIX, PAPER XX, PAPER XXI AND PAPER XII

Course Objective:

The objective of this course is to impart hand-on experience and laboratory skills to students in area of bioprocess and bioinformatics tools. To provide hands-on experience to basic immunological techniques for determination of microorganisms in biological fluids and other samples.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Perform upstream and downstream processing and also able to determine the microbial quality of food products
CO 2	Quantify and amplify DNA/RNA and Cloning and confirmation of insert by phenotypic/molecular methods.
CO 3	Describe different types of antigen-antibody interaction with special methods in immunology.
CO 4	Measure and regulate essential fermentation parameters, including pH, oxygen levels, and temperature, ensuring optimal conditions for high-yield and quality production in bioprocesses.
CO 5	Demonstrate proficiency in bioinformatics software and Unix commands, managing files and directories, and navigating different operating systems to access computational resources for bioinformatics applications.
CO 6	Perform experiments related to transplantation immunology, including HLA matching, assessment of graft rejection mechanisms

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2,3	2	3	3	-	-	3	3	-	-	3	-	3	1	3	
CO2	2,3, 6	3	3	3	-	-	3	3	-	-	3	-	-	1	3	2
CO3	1,3, 5	2	3	3	-	-	3	3	-	-	3	-	-	2	-	1
CO4	2,6	2	2	1	-	-	-	2	-	-	2	1	2	-	2	2
CO5	2,3	3	1	1	-	-	-	2	-	1	2	-	2	1	1	1
CO6	3,4, 6	2	1	1	-	-	-	2	-	-	2	-	2	1	2	1

H-High, M- Moderate, L- Low, '-' for No correlation

PAPER XXIV: DISSERTATION

Course Objective:

The objective of this course is to develop research skills involved execution of microbiological proposal.

Course Learning Outcomes:

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

CO	COURSE OUTCOMES
CO 1	Have research skills involved execution of microbiological proposal
CO 2	Make use of appropriate microbiological methods and lab equipment
CO 3	Create document and report on experimental protocols, results, and conclusions.
CO 4	Contribute original findings to the field of microbiology, demonstrating the ability to generate new knowledge or insights that advance the understanding of microbial processes or applications.
CO 5	Understand and apply ethical principles related to microbiological research, including biosafety, bioethics, and responsible conduct in research.
CO 6	Cultivate an attitude of continuous learning and professional development, recognizing the importance of staying current with advancements in microbiology and related disciplines.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2,3, 6	3	3	3	-	-	3	3	-	-	3	-	3	2	3	3
CO2	1,3, 4	3	3	3	-	-	3	3	-	-	3	-	3	2	3	3
CO3	3,4, 6	3	2	3	3	3	3	2	-	3	3	-	3	2	3	3
CO4	2,3	2	1	2	-	-	2	2	-	-	2	-	2	2	2	2
CO5	2,3	1	2	2	-	-	3	1	-	3	3	-	3	2	2	2
CO6	3,4, 6	3	2	2	-	-	3	2	-	2	2	-	2	2	3	2

H-High, M- Moderate, L- Low, '-' for No correlation