Syllabus and Examination Scheme

for

M.Sc. MICROBIOLOGY

(SEMESTER I to IV)

Department of Microbiology

Chaudhary Bansi Lal University, Bhiwani

(A State University established under Haryana Act No. 25 of 2014)

(2019-20)

Chaudhary Bansi Lal University, Bhiwani
(A State University established under Haryana Act No. 25 of 2014)

Study & Evaluation Scheme
Of
M.Sc. Microbiology
Summary

Programme : M.Sc. Microbiology
Duration : Two years (Four Semesters)
Minimum Attendance Required : 75%
Total Credits : 106

Assessment/Evaluation of Theory examination:

Internal Marks	Major Test (End Semester Exam) Marks	Total Marks
20	80	100
10	40	50

Internal Evaluation:

Minor Test Marks	Attendance Marks	Assignment/ Quiz Marks	Total Marks
10	5	5	20
5	3	2	10

Duration of Examination:

Minor Test (Internal)	Major Test
1.5 hrs.	3 hrs.

To qualify the course, a student is required to secure a minimum of 40% marks in aggregate including the internal evaluation and Major Test (*End Semester Examination).* A candidate who secures less than 40% of marks in a course shall be deemed to have failed in the course. The student should have obtained at least 40% marks in aggregate to qualify the semester.

Note: The student should also be involved in extracurricular activities through Hobby Clubs (Non CGPA) such as photography, science club, drama Poetry etc. and will be awarded a grade. The criteria for hobby club are available on the University website.

Seminar/Review/Case Study **Max.Marks-50**

Objective: This course intends to create habits of reading books and journals to develop scientific temperament and communication skills in a manner of creativity and originality. The students present their ideas/words which they have learnt from their studies of books, journals, national and international dailies.

This course aims:

- To motivate the students for innovative research and experimentation
- To inculcate the habit of self-study and discussion
- To assess intensity of originality and creativity of the students
- To acquire knowledge about plagiarism and original scientific work

Proper guidance will be given to students through teachers/In-charge/Resource Person.

a) General Instructions for review study writing:

1. Selection of topic of interest
2. Selection of suitable title
3. You are expected to be creative and original in your approach.
4. Review article will be submitted in two typed copies of A4 size 5-6 pages (both sides in 1.5 line spaces in Times New Roman Font size 12).
5. Organize your review article in three broad steps:
   - **(a)** Introduction
   - **(b)** Main Body
   - **(c)** Conclusion
   - **(d)** References
6. Use headings and sub-headings
7. Use graphics wherever necessary
8. Give a list of books/references wherever cited

Distribution of Marks

The evaluation criteria is mentioned as below:	**25 Marks**
(i) Selection of Topic:	05 Marks
(ii) Organization of subject matter:	10 Marks
(iii) Conclusion:	05 Marks
(iv) References:	05 Marks

b) Seminar **25 Marks**

Every candidate will have to deliver a seminar of 30 min. duration on a topic (not from the syllabus) which will be chosen by him/her in consultation with the teacher of the department. The seminar will be delivered before the students and teachers of the department. A three-member committee (one coordinator and two teachers of the department of different branches) duly approved by the departmental council will be constituted to evaluate the seminar.

Distribution of marks will be as follows:

The following factors will be taken into consideration while evaluating the students' presentation.

1. Way of presentation: 10 marks
2. Knowledge of the subject: 10 marks
3. Answers to the questions: 05 marks

Examination scheme (Question Paper Structure)

1. The question paper shall consist of 9 questions. The weightage for each question shall be 16 marks. Out of which, first question shall be of short answer type and compulsory. Question no. 1, shall contain 8 parts representing all units of the syllabus and students shall have to answer all parts.

2. The remaining 8 questions shall have internal choice.

SEMESTER I **CREDTS:26** **MARKS: 550**

Sr. No	Paper Code	Subjects	Type of Course	Contact hours per week			Credits			Examination Scheme			
				Theory	Practical	Total	Theory	Practical	Total	Theory	Internal Assessments	Practical	**Total**
1	19MB101	General Microbiology	CC	04	-	04	04	-	04	80	20	-	100
2	19MB102	Fundamentals of Biochemistry	CC	04	-	04	04	-	04	80	20	-	100
3	19MB103	Microbial Genetics	CC	04	-	04	04	-	04	80	20	-	100
4	19MB104	Microbial physiology and metabolism	CC	04	-	04	04	-	04	80	20		100
5	19MB105	**Lab course I**	CC	-	04 X 2	08	-	02 X 2	04	-	-	50	50
6	19MB106	**Lab course II**	CC	-	04 X 2	08	-	02 X 2	04	-	-	50	50
7	19LS101	Communication Skills	A.E.C.C.	02		02	02		02	40	10	-	50
	TOTAL			**18**	**16**	**34**	**18**	**8**	**26**	**360**	**90**	**100**	**550**

C.C = Core Course **A.E.C.C.= Ability Enhancement Compulsory Course**

SEMESTER II **CREDTS: 28** **MARKS: 650**

Sr. No	Paper Code	Subjects	Type of Course	Contact hours per week			Credits			Examination Scheme			
				Theory	Practical	Total	Theory	Practical	Total	Theory	Internal Assessments	Practical	**Total**
1	19MB201	Bacteriology	CC	04	-	04	04	-	04	80	20	-	100
2	19MB202	Molecular Immunology	CC	04	-	04	04	-	04	80	20	-	100
3	19MB 203	Molecular Biology	CC	04	-	04	04	-	04	80	20	-	100
4	19MB 204	Biotechniques	CC	04	-	04	04	-	04	80	20		100
5	19MB 205	**Lab course I**	CC	-	04 X 2	08	-	02 X 2	04	-	-	50	50
6	19MB 206	**Lab course II**	CC	-	04 X 2	08	-	02 X 2	04	-	-	50	50
7		Open Elective I*	O.E.C.	02		02	02		02	80	20	-	100
8	19LS 201	Biostatistics	S.E.C.	02	--	02	02	--	02	40	10	--	50
	TOTAL			**20**	**16**	**36**	**20**	**8**	**28**	**440**	**110**	**100**	**650**

C.C. = Core Course **O.E.C. = Open Elective Course** **S.E.C. = Skill Enhancement Course**

***For Open Elective-I, Students will have to choose one course out of list of open electives courses offered by other departments of University.**

Note: The students may cover 8 credits from MOOC courses from the list comprising offered courses. These Swayam courses can be opted in place of DSE or OEC.

SEMESTER III **CREDTS: 26** **MARKS: 600**

Sr. No	Paper Code	Subjects	Type of Course	Contact hours per week			Credits			Examination Scheme			
				Theory	Practical	Total	Theory	Practical	Total	Theory	Internal Assessments	Practical	**Total**
1	19MB 301	Virology	CC	04	-	04	04	-	04	80	20	-	100
2	19MB 302	Soil and Agricultural Microbiology	CC	04	-	04	04	-	04	80	20	-	100
3	19MB 303	Industrial Microbiology	CC	04	-	04	04	-	04	80	20	-	100
4		Discipline Specific Elective #	DSE#	04	-	04	04	-	04	80	20		100
5	19MB 306	**Lab course I**	CC	-	04 X 2	08	-	02 X 2	04	-	-	50	50
6	19MB 307	**Lab course II**	CC+DSE	-	04 X 2	08	-	02 X 2	04	-	-	50	50
7		Open elective II*	O.E.C.	02		02	02		02	80	20	-	100
	TOTAL			**18**	**16**	**34**	**18**	**8**	**26**	**400**	**100**	**100**	**600**

C.C = Core Course **O.E.C. = Open Elective Course** **D.S.E. =Discipline Specific Elective**

***For Open Elective-II, Students will have to choose one course out of list of open electives courses offered by other departments of university and it should not be same course in both semesters.**

#The Discipline Specific Elective (DSE) course can be offered depending upon the availability of the resources and faculties. Students may select one out of two below given DSE courses.

List of Discipline Elective Courses: **(a) 19MB 304 Bioinformatics**

(b) 19MB 305 IPR and Biosafety

The students can opt for maximum 8 credit courses instead of open elective / discipline specific courses from SWAYAM courses list provided by department.

SEMESTER IV **CREDTS: 26** **MARKS: 550**

Sr. No	Paper Code	Subjects	Type of Course	Contact hours per week			Credits			Examination Scheme			Total
				Theory	Practical	Total	Theory	Practical	Theory	Theory	Internal Assessments	Practical	
1	19MB 401	Environmental Microbiology	CC	04	-	04	04	-	04	80	20	-	100
2	19MB 402	Food and Dairy Microbiology	CC	04	-	04	04	-	04	80	20	-	100
3	19MB 403	Medical Microbiology	CC	04	-	04	04	-	04	80	20	-	100
4		Discipline Specific Elective #	DSE#	04	-	04	04	-	04	80	20		100
5	19MB 406	**Lab course I**	CC	-	04 X 2	08		02 X 2	04	-	-	50	50
6	19MB 407	**Lab course II**	CC+DSE	-	04 X 2	08		02 X 2	04	-	-	50	50
7	19MB 408	Seminar/ Review/ Case Study	S.E.C	02		02	02		02			-	50
	TOTAL			**18**	**16**	**34**	**18**	**8**	**26**	**320**	**80**	**100**	**550**

CC = Core Course **S.E.C. = Skill Enhancement Course** **DSE=Discipline Specific Elective**

#The Discipline Specific Elective (DSE) course can be offered depending upon the availability of the resources and faculties. Student may select one out of two below given DSE courses

List of Discipline Specific Elective Courses: **(a) 19MB 404 Cell Biology**
(b) 19MB 405 Mycology and Phycology

Duration- 2 Years (4 Semesters) **Total Marks– 2350** **Total Credits - 106**

The students can opt for maximum 8 credit courses instead of open elective / discipline specific courses from SWAYAM courses list provided by department

M.Sc. Microbiology
Semester I

19MB 101
General Microbiology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: To teach the students about basics in development of microbiology, differences in prokaryotic and eukaryotic cell. The students will be covering the various structural, physiological characteristics and classification of bacteria.

Outcome: The students will gain the knowledge about various types of microscopy, different methods of staining, cultivation and preservation of bacteria.

Unit I

History and development of microbiology in 21st century; the spontaneous generation controversy; Germ theory of disease; Microbes and fermentation; Physical and Chemical methods of sterilization, Impact of microbes on human health; simple and compound Microscope.

Unit II

Binomial Nomenclature; Haeckel's three kingdom classification, Basic principles and techniques used in bacterial classification; Use of DNA and r-RNA sequencing in classification of microorganisms; Woese's three kingdom classification systems and their utility–Archaea, Eubacteria, Eukarya; Organization of prokaryotic and eukaryotic cell; Definition of Viruses and Viroid.

Unit III

General features of microorganisms- Bacteria, Algae, Fungi, Protozoa and Mycoplasmas. Classification of bacteria; Bacterial growth and metabolism; Microbes in Extreme Environment – Special features of the thermophilic, methanogenic and halophilic archaea; Photosynthetic bacteria, Cyanobacteria; microbes in other extreme conditions- Deep Ocean and space.

Unit IV

Microbial-interactions, mutualism, symbiosis, commensalisms, predation, parasitism, amensalism, competition, bioluminescence, biodegradation, biofilms. Cleaning oil spills, microbes in composting, biopesticides, biocontrol agents, bioremediation, bioleaching, SCP, microbial enzymes and fermented foods. Microbial diseases in Human (Cholera and Typhoid). Definition of aero microbiology, airborne pathogens and allergens.

Books Recommended:

1. Tortora, G.J., Funke, B.R., Case, C.L. Microbiology -An Introduction,Pearson
2. Madigan M.T., Martinko J.M. and Parker J. Brock Biology of Microorganisms, Pearson Education Ltd.
3. Kathleen, M. S., Dorothy, H. W.Prescott's microbiology, Tata McGraw Hill.
4. Brock T.D. Milestones in Microbiology, Infinity Books.
5. Pelczar MJ, Chan ECS, Kreig NR. Microbiology: Concepts and Application, Tata McGraw Hill.
6. Stainer RY, Ingraham JL, Wheelis ML & Painter PR. General Microbiology, MacMillan, New Jersey, USA.
7. Atlas R.M. Principles of Microbiology, Wm C. Brown Publishers, USA.
8. Vandenmark P.V. and Batzing B.L., The Microbes – An Introduction to their Nature and Importance. Benjamin-Cummings Pub Co.
9. Pratyoosh Shukla, Microbial Biotechnology: An Interdisciplinary Approach. Taylor and Francis Group. United States.

M.Sc. Microbiology
Semester I

19MB 102
Fundamentals of Biochemistry

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: To impart brief knowledge about macromolecules, classification of carbohydrates, lipids, proteins and catalytic role of enzymes.

Outcome: The students will have the knowledge of enzymes kinetics, bioenergetics, macromolecules and metabolism.

Unit 1

General Principles of Biochemistry and chemical composition of life, Classification, structure and function of carbohydrates, Metabolism of Carbohydrates: Glycolysis, Gluconeogenesis, Citric acid cycles its regulation and role as metabolic center, Cori Cycle, Pentose phosphate pathway and their regulation, interlinking between different pathways[1].

Unit II

Structure and Classifications of amino acids and proteins, Ramachandran plot, Classification and nomenclature of enzymes, coenzyme, isozymes, enzyme kinetics (Michaelis-Menten equation, Km, Vmax, Turnover number, Enzyme inhibition, allosteric enzymes, Immobilised enzymes, coenzymes, in-born abnormalities of metabolism.

Unit III

Saturated and unsaturated fatty acid and their metabolism, Structure and function of major lipid subclasses-Acyl glycerols, Phospholipids, glycolipids, Sphingolipids, Waxes, Terpenes and Sterols, Fatty acid biosynthesis, degradation and their regulations, Ketone bodies synthesis, biosynthesis of TAG, Phospholipids and Glycolipids, biosynthesis of cholesterol and its metabolism.

Unit IV

Structure and properties of nucleic acid bases, nucleosides and nucleotides. Chemistry, structure and properties of DNA and RNA. Biosynthesis and degradation of purines and pyrimidines, Salvage pathway. Conformation of nucleic acids (A, B, Z-DNA), t-RNA, micro-RNA. Structure and biochemical roles of vitamins.

Books Recommended:

1. Nelson, D.L. & Cox, M.M. Lehninger Principles of biochemistry. Freeman, W.H & Company.
2. Voet, D. and J.G. Voet. Biochemistry, John Wiley & Sons
3. Wilson, K. and Walker, J. Principles and Techniques of biochemistry and molecular Biology. Cambridge University Press
4. Rodwell, V.W. Harper's Illustrated Biochemistry. McGraw-Hill Education-Medical.
5. Jeremy, M. B. Lubert, S.,Tymoczko, J.L., Gatto, G.J., Biochemistry. Macmillan international higher education New York W.H. Freeman and Company.
6. Mathews C.K., VanHolde K.E. and Ahern K.G., Biochemistry, Benjamin Cummings.

M.Sc. Microbiology
Semester I

19MB 103
Microbial Genetics

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: The purpose of this paper is to familiarize the students about basic principles of genetics, concept of linkage, mutation, chromosomal structure, variations and their effects on biological system.

Outcome: The students are expected to have better understanding of basic principles of Mendelian inheritance, concept of linkage and mutagenesis. It also develops the understanding of management of inherited disease.

Unit I
Mendel's work on transmission of traits; Genetic Variation; Molecular basis of Genetic Information; Mitosis and Meiosis; Linkage and crossing over; Molecular mechanism of crossing over; Recombination and recombination frequency.

Unit II
Mutations-Induced versus Spontaneous mutations, Suppressor mutations, Molecular basis of Mutations, mutant enrichment; Complementation tests; recombination tests and gene replacements; Cloning genes by complementation and marker rescue; DNA repair mechanisms, Mutation and Microbial evolution.

Unit III
Molecular mechanism of gene transfer by conjugation, Regulation of gene transfer by conjugation. Mapping bacterial genomes using Hfr strains. Transfer systems in Gram positive bacteria. Ti plasmid and application; Transformation and transduction**:** Natural transformation and competence. Generalized versus specialized transduction. Positive and negative gene regulation and attenuation, using the *lac*, *gal*, *trp* and *ara* operons.

Unit IV
Lytic and lysogenic phages (M13, λ, T_2); Benzer's experiments to construct phage genetic linkage maps Transposons and gene regulation; Yeast Ty-1 transposon; Methods of gene cloning and sequencing; Genome transplantation.

Books Recommended:
1. Watson J.D., Hopkins NH, Roberts JW, Steitz JA, Weiner AM. Molecular Biology of the Gene, Benjamin Cummings, San Francisco.
2. Gardener, J.E., Simmons, M.J. Snustad, D.P. Principles of Genetics, John Wiley & Sons.
3. Snustad, P. D and M.J. Summons. Genetics, Wiley John & Sons.
4. Klug, W.S, Cummings, M.R., Concepts of Genetics. Pearson.
5. Snyder L, Chapness W. Molecular Genetics of Bacteria, ASM Press.
6. Hartl, D.L., Essential of Genetics: A Genomics perspective, Jones and Bartlett Publishers.
7. Miglani, G.S., Advanced Genetics, Alpha Science Intl Ltd.
8. Brown T.A, Gene Cloning and DNA Analysis. Blackwell Publishing.

M.Sc. Microbiology
Semester I

19MB 104
Microbial physiology and Metabolism

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: To make the students aware with various structures of bacterial cell and their functions, growth, reproduction, cultivation, energy generation and metabolic pathways.
Outcome: After the completion of the course, the students will learn about bacterial cell and its structural components, carbohydrate metabolism, bacterial fermentations, ATP generation.

Unit I
Nutritional Categories of microorganisms based on carbon and energy sources, Metabolite Transport**,** Primary and secondary active transport, Group translocation, symport, antiport, uniport, electrogenic, electro neutral transport, and transport of Iron. Microbial Growth**,** balanced and unbalanced growth, growth curve, the mathematics of growth, Generation time, specific growth rate, batch and continuous culture, synchronous growth, diauxic growth curve, effect of physical and chemical factors on growth.

Unit II
Brief account of photosynthetic and accessory pigments: chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobiliproteins. Carbohydrates, anabolism. Autotrophy, oxygenic, anoxygenic photosynthesis, autotrophic generation of ATP, fixation of CO_2, Calvin cycle, C3, C4 pathway. Chemolithotrophy: sulphur, iron, hydrogen, nitrogen oxidations, methanogenesis and luminescence.

Unit III
Respiratory metabolism, glyoxalate pathway, oxidative and substrate level phosphorylation, reverse TCA cycle, Pasteur effect; Fermentation of carbohydrates, homo and heterolactic fermentations. Halophiles and ATP synthesis.

Unit IV
Biosynthesis of peptidoglycan, polysaccharides, major amino acids, polyamines, Lipids, Nucleotides: Purines and Pyrimidines; Assimilation of nitrogen; Dormancy and germination; Microbial Differentiation, sporulation and morphogenesis, Cell division cycle in *E.coli* and Yeast and its regulation.

Books Recommended:

1. Caldwell, D.R. Microbial Physiology and Metabolism, Brown Publishers.
2. Gottschalk G. Bacterial Metabolism, Springer Verlag, New York.
3. Moat, A.G. Microbial Physiology, John Wiley & Sons, New York, USA.
4. Moat, AG, Foster J W, Spector M P. Microbial Physiology, Wiley India Pvt Ltd, Country.
5. Sokatch, J.R. Bacterial Physiology and Metabolism, Academic Press, USA.
6. Srivastava, B. Microbial Physiology and Metabolism, LAP Lambert Academic Publishing, USA

M.Sc. Microbiology
Semester I

19LS101
Communications skills

Total Marks: 50
Time: 4 hours

Note*: There shall be nine questions in all. Question no. I shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Objective and scope: To enable the students to achieve professional and scientific expertise with the help of improved communication skills including writing, speaking, presenting and grooming.

Internal Assessment will be a continuous evaluation process on the basis of the students' expression of effective communication skills through participation in activities like presentations, group-discussions, mock-interviews, etc.

Internal Assessment	Attendance Marks	Assignment, Quiz etc. Marks	Total Marks
	3	7	10

Unit I

Human communication; verbal and nonverbal communication; barriers to communication; the seven C's of effective communication; preparation for an interview; preparing CV/Biodata.

Unit II

Public speaking skills (preparation, body language and voice modulation); oral presentation; debates; elocution and extempore; delivering a presentation; greeting and introducing, making requests, giving instructions and directions.

Unit III

Personality development skills: Personal grooming; assertiveness; improving self-esteem; significance of critical thinking; confidence building; SWOC analysis; recognizing and managing emotions and situations; stress and anger management; positive thinking; developing sense of humour[2].

Unit IV

Science/scientific writing (theory and practice): Goals and objectives; ethics in writing structure of documents; language and grammar; illustrations and aids; writing proposals and instructions; making presentations; formatting documents; drafts and revisions; editing and writing popular science/journal article; writing scientific reports.

Books Recommended:

1. Kumar, Sanjay and Pushp Lata. English for Effective Communication. OUP, 2016.
2. Mohan, Krishna and Meera Banerji. Developing Communication Skills 2nd ed. Trinity Press, 2013.
3. Dutt, P. Kirammai and Geetha Rajeevan et al., A Course in Communication Skills, Foundation Books, CUP, 2016.

M.Sc. Microbiology
Semester I

Lab course I
19MB 105 **Total Marks: 50**
Time: 4 hours

Evaluation scheme in examination:

Practical Performance & Evaluation	**Viva-voce Practical**	**Record/File**
35	**10**	**05**

Course contents:

1. Good microbiological laboratory practices: sterilization, gloves, lab coat etc.
2. Working of compound microscope and understanding the principles of different samples at different magnification
3. Microscopic examination of bacteria, actinomycetes, algae, fungi and protozoa.
4. Different sterilization methods: Principles and Operations.
5. Preparation of microbiological media: NAM, LB media, *etc*.
6. Differential and Structural staining methods
7. Study the shape and arrangement of bacterial cell.
8. Sampling and quantification of microorganisms in air, soil and water.
9. Isolation of thermophiles from compost.
10. Preparation of standard and buffer solutions: maintaining pH.
11. Use of simple techniques in laboratory (Spectrophotometry-verification of Beer- Lambert's law, relation between O.D. and percentage transmission, centrifugation).
12. Sugar/Lactose estimation.
13. Protein estimation by Bradford method.
14. Determination of enzyme activity and study of enzyme kinetics.
15. Separation techniques - Centrifugation, Chromatography (Gel permeation, Ion exchange, TLC and Electrophoresis.

M.Sc. Microbiology
Semester I

Lab course II
19MB 106 **Total Marks: 50**
Time: 4 hours

Evaluation scheme in examination:

Practical Performance & Evaluation	**Viva-voce Practical**	**Record/File**
35	**10**	**05**

Course contents:

1. Production, isolation and characterization of mutants.
2. Determination of mutation rate.
3. Isolation and characterization of plasmids.
4. Preparation of competent cells, Transformation of *E.coli*. using plasmid DNA
5. Tetrad and random spore analysis.
6. Determination of viable number of bacterial cells in a given sample
7. Determination of bacterial growth by turbidity measurements (Bacterial growth curve)
8. To study the types of growth (synchronous, diauxic, batch) in bacteria.
9. To study the effect of incubation temperature on the growth of microorganisms
10. To study the lethal effect of temperature on the growth of microorganisms
11. To study the effect of pH on the growth of microorganisms
12. To study the bacterial growth under aerobic, microaerophilic and anaerobic conditions
13. To study the effect of salt concentration on the growth of microorganisms;
14. Preparation of selective and differential media for the growth of microorganisms
15. To study the fermentation of different carbohydrates.
16. Morphological, Physiological and Biochemical tests for selected bacterial cultures.
17. Field Visit/Project report/presentation by the students.

M.Sc. Microbiology
Semester II

19MB 201
Bacteriology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: The students will be covering the various physiological characteristics and classification of bacteria and archaea.

Outcome: The students will be having the knowledge about various methods of staining and groups of bacteria. Also thus acquired knowledge will be used for cultivation and preservation of bacteria through various methods.

Unit I

Bacterial Classification**,** Basis of Bacterial classification; conventional; molecular and recent approaches to polyphasic bacterial taxonomy; evolutionary chronometers; rRNA oligonucleotide sequencing; signature sequences; and protein sequences**.** Differences between eubacteria and archaebacteria**.**

Unit II

Organization of Bacterial Cell**,** Structure and function of Cell Wall; Cell Membrane; Cytoplasm; Flagella; Endoflagella; Fimbriae; Glycocalyx; Capsule; Endospore; Growth and Nutrition**,** Cultivation of aerobic; anaerobic and accessing non-cultureable bacteria**.** Maintenance and preservation of bacterial cultures; Components of media and different types of culture media**.** Bacterial nutrition**,** Transport of nutrients; Salient features of bacterial growth curve**.**

Unit III

Important archaeal groups**,** Brock's 2009 and Bergey's Manual of Systematic Bacteriology**.** Archaebacteria**,** General characteristics; phylogenetic overview; genera belonging to Nanoarchaeota **(***Nanoarchaeum***)**; Crenarchaeota **(**Sulfolobus, Thermoproteus**)** and Euryarchaeota, Methanogens **(**Methanobacterium, Methanocaldococcus**)**; thermophiles **(***Thermococcus, Pyrococcus, Thermoplasma***)** and Halophiles **(***Halobacterium, Halococcus***).**

Unit IV

Eubacteria**,** Non Proteobacteria and Proteobacteria**:** Morphology, metabolism, ecological significance and economic importance of following groups: Gram Negative- Non proteobacteria *(Aquifex, Thermotoga, Deinococcus, Thermus, Chlorobium, Chloroflexus, Chlamydiae, Spirochaete)*, Alpha proteobacteria *(Rickettsia, Coxiella, Caulobacter, Rhizobium, Hyphomicrobium, Agrobacterium)*,Beta proteobacteria **(***Neisseria, Burkholderia, Thiobacillus)*, Gamma proteobacteria **(***Enterobacteriaceae* family, Purple sulphur bacteria, *Pseudomonas, Vibrio, Beggiatoa, Methylococcus, Haemophilus)*, Delta proteobacteria **(***Bdellovibrio, Myxococcus)*, Epsilon proteobacteria **(***Helicobacter, Campylobacter*). Gram Positive-Low G+C or Firmicutes **(**Mycoplasmas,*Clostridium, Heliobacterium, Lactobacillus, Lactococcus, Staphylococcus, Streptococcus, Leuconostoc, Bacillus)*, High G+C or Actinobacteria **(***Arthrobacter, Bifidobacterium, Corynebacterium, Frankia, Mycobacterium, Nocardia, Streptomyces, Thermomonospora, Propionibacterium Cyanobacteria*).

Books Recommended:

1. Atlas, R.M. Principles of Microbiology, Wm C Brown Publishers, USA.
2. Madigan, M.T., Martinko, J. M., Parker, J. Brock Biology of Microorganisms, Pearson Ed. Ltd.
3. Pelczar, M.J., Chan, E.C.S, Kreig, N.R. Microbiology: Concepts and Application, Tata Mc. Hill.
4. Stainier R.Y., Ingraham, J.L., Wheelis, M.L., Painter, P.R., General Microbiology, MacMillan.
5. Vandenmark, P.V, Batzing, B.L., The Microbes - An Introduction to their nature and Importance, Benjamin Cummings.
6. Whitman, W.B., Goodfellow, M., Kämpfer, P., Busse, H.J., Trujillo, M.E., Ludwig, W., Suzuki, K., Bergey's Manual of Systematic Bacteriology, Springer-Verlag.
7. Salle, A.J., Fundamental Principles of Bacteriology, McGraw-Hill Book Company.

M.Sc. Microbiology
Semester II

19MB 202
Molecular Immunology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: The objective of this course is to provide the information regarding cells, molecules and processes associated with the immune system and their role in health & diseases. In addition, an exposure to the recent developments in immunology will also be the integral part of the subject.
Outcome: The subject will emphasize to develop students' understanding to molecular, cellular and clinical perspectives in the area of immunology.

Unit I

Introduction to immunity: Preface of immunology, innate and acquired immunity, cardinal features of immune system, cells and effector molecules of the immune system, hematopoiesis and its regulation, organization and structure of primary and secondary lymphoid organs.

Antigens antibodies and complement system: Concept of antigen, super antigen, immunogen, epitopes and hapten carrier system; chemical and molecular nature of antigen and factors affecting immunogenicity; structure and classes of antibodies; complement system and its evasion by microbes.

Unit II

Immune receptors and their diversity: Structure and functions of Toll receptor, TCR, BCR, MHC; antigen processing and presentation; self MHC restriction; somatic recombination and generation of antibody diversity. Immune cell maturation and trafficking: Immunological tolerance and lymphocyte trafficking.

Unit III

Activation of immune cells, T cell activation, mechanism of T cell and NK cell mediated target cell lysis, antibody dependent cell mediated cytotoxicity, macrophage mediated cytotoxicity, immunity to infectious agents (intracellular parasites, helminthes, viruses) and tumors. Regulation of immune system, Negative regulators of T cell activation, cytokines and their role in immune regulation.

Unit IV

Transplantation and disorders of immune response, rejection, autoimmunity, hypersensitivity, immunodeficiencies. Immunotechnology: Antigen-antibody interactions, agglutination, immuno-electrophoresis, immunoblotting, ELISA, ELISPOT, epitope mapping, abzymes and antibody engineering.

Books Recommended:

1. Kuby, J.W.H, Immunology. Freeman & Co.
2. Abul, K. A., Lichtman, A.H., Pillai, S., Cellular and Molecular Immunology. Elsevier.
3. Cioco, R., Sunshine, G., Immunology: A Short. Willey-Blackwell Press.
4. Roitt, I.M., Essential Immunology. Oxford Black Well Science, London.
5. Khanna, R., Immunology. Oxford Press.
6. Chakravarty, A.K., Immunology and Immunotechnology. Oxford press.
7. Fahim, H. K., The elements of Immunology. Pearson Education

M.Sc. Microbiology
Semester II

20MB 203
Molecular Biology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: To make students understand the complex molecular mechanisms of the cell and the applications of molecular technologies.

Outcome: The study of molecular biology provides the necessary information about the chemistry of life to allow the students to understand the basics and the functional unit of life.

Unit-I

DNA Replication: Mechanism of DNA replication in Prokaryotic and Eukaryotic cells. Enzymes and accessory proteins involved in DNA replication and DNA repair. Transcription: Prokaryotic & Eukaryotic transcription, RNA polymerase, General and specific transcription factors & their regulation, Transcriptional and post-transcriptional gene silencing, Modifications in RNA: 5'- Cap formation, Transcription termination, 3'-end processing and Polyadenylation, Splicing, Editing, Nuclear export of mRNA & its stability.

Unit -II

Antisense and Ribozyme Technology: Molecular mechanism of antisense molecules, inhibition of splicing, polyadenylation and translation, disruption of RNA structure and capping Translation: Prokaryotic and Eukaryotic translation, Regulation of translation, genetic code, co- and post translational modifications of proteins.

Unit -III

Biochemistry of ribozyme: hammer head & their desigining strategies, hairpin and other ribozymes, Homologous Recombination: Holliday junction, excision repair, RecA and other recombinases and DNA repair mechanisms. Molecular gene targeting, gene disruption, FLP/FRT and Cre/Lox recombination,

Unit -IV

Genome Sequencing: Genome sizes, organelle genomes, Genomic libraries, YAC, BAC libraries, Packaging, transfection and recovery of clones, Application of Sequencing: sequence information for identification of defective genes.

Books Recommended:

1. J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M. Weiner. Molecular Biology of the Gene. The Benjamin/Cummings Pub. Co.
2. J. Darnell, H. Lodish and D. Baltimore Molecular Cell Biology, Scientific American Books, Inc., USA.
3. B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson Molecular Biology of the Cell, Garland Publishing Inc., New York.
4. R.A. Meyers, Molecular Biology and Biotechnology. A comprehensive desk reference, VCH Publishers, Inc., New York.
5. J. Sambrook, E.F. Fritsch and T. Maniatis. Molecular Cloning: a Laboratory Manual, Cold Spring Harbor Laboratory Press, New York.
6. P.D. Dabre, Introduction to Practical Molecular Biology, John Wiley & Sons Ltd., New York.

M.Sc. Microbiology
Semester II

19MB 204
Biotechniques

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: The course also commonly known as recombinant DNA technology is the set of molecular tools and techniques that are used for the manipulation of genes.
Outcome: This course will train the students for the use of molecular tools such as enzymes, various cloning vectors, and library preparation. This course will open new vistas for getting jobs.

Unit I
Scope in genetic engineering techniques, Basic cloning method: Cloning vectors, steps involved in gene cloning, Different enzymes and their Applications: DNA and RNA polymerase, reverse transcriptase, alkaline phosphatase, kinase, ligase, RNase, DNase, topoisomerase, Restriction endonucleases: R-M system, nomenclature of RE, Types and recognition, cleavage sites and application of endonucleases.

Unit II
Nucleic Acid Purification, cDNA Synthesis, Yield Analysis, agarose gel electrophoresis, PCR (DNA Amplification, primer designing and its Applications), Gene Cloning Vectors: Plasmids, lambda bacteriophage, yeast cloning vector, Artificial chromosome (YAC, BAC), Shuttle vector, expression vector. Cloning and expression of DNA in Plant, yeast, insect cells, mammalian cells.

Unit -III
Nucleic Acid Sequencing (Chain termination, chemical degradation, automated, pyrosequencing), Nucleic acid blotting and hybridization (Southern, Northern and dot blot hybridizations), Introduction to Microarray, molecular markers: RFLP, RAPD, AFLP, SNP

Unit -IV
Recombinant proteins: Purification of proteins and folding, characterization and stabilization. Protein analysis: SDS Page and Western blotting, T-DNA and Transposon Tagging, Zinc finger nucleases (ZFN), Transcription activator-like effector nucleases (TALEN) and clustered regularly interspaced short palindromic repeats (CRISPR), Gene therapy, Gene knockout and gene silencing.

Books Recommended:

1. Principles of gene manipulation and genomics by Primose SB and Twyman RM, Blackwell publishing.
2. Gene cloning and DNA analysis–An introduction by Brown TA, Blackwell publisher
3. Biotechnology: expanding horizons by BD Singh, Kalyani Publishers
4. Molecular cloning: A laboratory manual by J Sambrook and Michael R Green.
5. Essential genes by Benzamin Lewin, Pearson education international.

M.Sc. Microbiology
Semester II

19LS201
Biostatistics

Maximum Marks: 50
Theory Examination: 40
Internal Assessment: 10
Time: 3 hrs.

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective and scope of the course:
The course is designed to train students in basic statistical applications in biology.

Unit I
Preliminary concepts: Variables and constants; random samples; discrete and continuous variables; variables in biology; accuracy and precision.
Presentation of data: Types of graphs; modes of graphical representation of data; line graph; bar diagram; pie, circle and sector chart; histogram; frequency polygon; frequency curve; frequency distribution; relative and cumulative frequency distribution.

Unit II
Measures of central tendency: Mean; median; mode; empirical relationship between mean**,** median and mode; quartile and percentile.
Measures of dispersion: Variability; range; mean deviation; coefficient of mean deviation; standard deviation; merits, demerits and uses of standard deviation; calculation of standard deviation.

Unit III
Regression analysis: Regression coefficients; properties of regression coefficients; student's t-test; chi-square test; f-test; one- and two-way ANOVA.

Unit IV
Correlation analysis: Correlation; co-variance; calculation of co-variance; correlation analysis; correlation coefficient calculated from ungrouped data; Spearson's rank correlation coefficient; estimation of correlation coefficient using scattered diagrams.

Books Recommended:
1. Zar, J.H., Biostatistical Analysis, Pearson Education.
2. Bhise, S.B., Textbook of computer applications and biostatistics, Trinity Publishing house.
3. Gupta, S.P., Statistical Methods, S. Chand & Sons, New Delhi.
4. Arora, P.N., and Malhan, P.K., Biostatistics, Himalayan publishing house.
5. Grant, G.R., Ewens, W.J., Statistical methods in bioinformatics: An introduction. Springer Verlag.
6. Jagota, A., Data analysis and classification for bioinformatics. Bioinformatics by the bay.

M.Sc. Microbiology
Semester II

Lab course I
19MB 205 **Total Marks: 50**
Time: 4 hours

Evaluation scheme in examination:

Practical Performance & Evaluation	**Viva-voce Practical**	**Record/File**
35	**10**	**05**

Course contents:

1. Methods of isolation, purification and maintenance of microorganisms from different environments (air, water, soil, milk and food)
2. Staining of bacteria and actinomycetes
3. Use of selective media
4. Enrichment culture technique – isolation of asymbiotic nitrogen fixing bacteria
5. Isolation of asymbiotic nitrogen fixing bacteria
6. Isolation of symbiotic nitrogen fixing bacteria from nodules
7. Isolation of antibiotic producing microorganisms
8. Morphological, physiological and biochemical characterization of isolated bacterial cultures.
9. Blood film preparation and identification of cells
10. To identify blood group antigens
11. Lymphoid organs and their microscopic organization
12. Immunization, Collection of Serum
13. Transfection of Hela Cells
14. Radial Immuno diffusion
15. Purification of IgG from serum
16. Separation of mononuclear cells by Ficol1-Hypaque method
17. Enzyme Linked Immuno Sorbent Assay
18. Hapten Conjugation and quantitation
19. Immunodiagnostics (demonstration using commercial kits)
20. Field Visit/Project report/presentation by the students.

M.Sc. Microbiology
Semester II

Lab course II
19MB 206 **Total Marks: 50**
Time: 4 hours

Evaluation scheme in examination:

Practical Performance & Evaluation	**Viva-voce Practical**	**Record/File**
35	**10**	**05**

Course contents:

1. Isolation of Genomic DNA.
2. Isolation of RNA.
3. Quantitative analysis of DNA.
4. Restriction digestion of DNA.
5. Ligation of DNA fragments.
6. Molecular weight analysis using agarose gel electrophoresis.
7. Isolation of plasmid DNA.
8. Preparation of competent cell
9. Blotting techniques.
10. Identification of parasites through PCR
11. DNA isolation from soil sample and study microbial diversity using 16s rDNA universal primers
12. Demonstration of PAGE and SDS-PAGE.
13. To study principle and working of spectrophotometer.
14. Demonstration of thin layer chromatography.
15. Demonstration of paper chromatography.
16. Isolation of industrially important microorganism from different sources using specific substrates; Design and Preparation of Media for Bioprocesses.
17. Growth curve studies of bacteria/Yeasts in batch culture and calculation of maximum specific growth rate.
18. To study the various methods of biomass measurement; Production of ethanol from sucrose by yeast.
19. Determination of yield coefficient and Monod's constant and metabolic quotient of E.coli culture on glucose.
20. To study the design of fermenter and its working.
21. Production of citric acid using sucrose and molasses.
22. Production of extracellular enzymes.
23. Ethanol production using immobilized yeast culture.

M.Sc. Microbiology
Semester III

19MB 301
Virology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: The syllabus is designed to do a comparative study of viruses from general characteristics to diagnosis and application of the field in current science.
Outcome: It will open new vistas to work in an atmosphere of group leading, interdisciplinary work and to face challenges in the very competitive world in the subject.

Unit I
Historical account and development of virology, general characteristics, morphological variations, envelope, capsid, nucleic acid, Discovery of the viruses as disease causing pathogens, development of methods of virus isolation & characterization. General description of viral vaccine available against human and animal viruses. Deadly viruses and their outbreak.

Unit II
Classification of plant, animal & human viruses. ssDNA viruses, dsDNA viruses, ssRNA viruses, dsRNA viruses, reverse transcribing viruses, satellite virus, viroid & prions. Assay of plant viruses, biophysical properties of viruses, thermal in-activation end point, dilution end point, longevity in-vitro and virus culture.

Unit III
Natural & mechanical transmission of viruses, isolation & purification of viruses, criteria of purity of viruses, serological & molecular based detection of viruses, Chloroplast agglutination, hem agglutination, use of electron microscopy in virology. General properties of bacteriophage, type of phages, one-step growth, Life cycle of M13 phage.

Unit IV
Viral diseases of plants: papaya, banana, potato, symptoms, infections & control. Transmission of viruses by vectors & other means. Viral diseases of animals' human, Ranikhet disease of poultry farm, bird flu, SARS & Covid-19 diseases and their control. Viruses in genetic engineering.

Books Recommended:
1. Cann, Alan.J. Principles of Molecular Virology, Elsevier Science Publishing Company Inc.
2. Comparative Plant Virology. Roger Hull. Elsevier Sc Publishing Co Inc
3. Viruses & Mycoplame diseases in India, Raychandri, S.P. & Nariani, T.R. Malhotra Publishing House, New Delhi.
4. N. Dimmock, A. Earton and K. Leppard: Introduction to Modern Virology, Blackwell Publishing.
5. E.K. Wagner and M.J. Hewlett. Basic virology Blackwell publishing.
6. Fields Virology. Bernard N Field by Lippincott Williams & Wilkins.
7. Virology by S.Rajan & V Kumaresan , Saras Publication

M.Sc. Microbiology
Semester III

19MB 302
Soil and Agricultural Microbiology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: Objective of this course is to teach students regarding microbiology of soil, biogeochemical cycles, plant growth promoting rhizobacteria and microbial interactions in soil.
Outcome: The students will be taught the role of various bio-geochemical cycles in the environment. Biochemistry involved in the process of nitrogen fixation and role of biofertilizers will be studied.

Unit-1
Soil microorganisms: major groups, effect on soil health, soil enzymes activities and importance, Root exudates and rhizosphere effects. Nitrogen cycle: ammonification, nitrification, mineralization, immobilization and denitrification. Biological nitrogen fixation–symbiotic and asymbiotic, biochemistry and genetics of nitrogen fixation.

Unit-II
Microbiology of rhizosphere, phyllosphere, plant growth promoting rhizobacteria and their mode of action. Biofertilizers; preparation and role of bio-fertilizers in agriculture. Formation and composition of soil organic matter, fulvic acid and humic acid and Factors affecting the degradation of organic matter.

Unit-III
Microorganisms involved in phosphorus solubilisation, potassium solubilisation and sulfur solubilisation. Microbial biomass, Carbon cycle, C: N ratio. Mycorrhiza and its role in plant growth promotion. Compost; types and methods, biogas plant and method for preparation of biogas. Bioremediation of contaminated soil.

Unit-IV
Biocontrol, concept, types, mode of action & applications of biopesticides and bioherbicides. Major biopesticides based on bacteria, viruses & fungi (*Bacillus thuringiensis* (Bt) toxin, Boverin, DeVine, Collego). Microbial degradation of polymers: lignin, cellulose, hemicelluloses and biodegradation of pesticides.

Books Recommended:

1. Martin Alexander. Soil Microbiology. John Wiley.
2. Paul EA. Soil Microbiology, Ecology and Biochemistry. Academic Press.
3. Sylvia et al. Principles and Applications of Soil Microbiology. Pearson Edu.
4. Van Elsas JD, Trevors JT & Wellington EMH. Modern Soil Microbiology. Marcel Dekker.
5. N S Subha Rao, Soil Microbiology, 4th edition. Enfield, Science Publishers.

M.Sc. Microbiology
Semester III

19MB 303
Industrial Microbiology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: The main objective of the course is to create general understanding regarding about industries, different industrial processes and reactors used in commercial areas of microbiology.
Outcome: The students will become familiar and have knowledge about process and different reactors used in industries.

Unit-I
Introduction to industrial microbiology: sources of industrially important microorganisms, Isolation and selection of industrially important microorganisms, metabolic pathways and control mechanisms of industrially important microorganisms. Genetic improvement of microorganisms, preservation and maintenance of microbial cultures, lyophillization and crystallization.

Unit-II
Microbial strains, substrates, formulation and optimization of media. Kinetics of cell growth and substrate utilization. Biomass production and product formation in batch, fed batch and continuous cultivation. Application, advantages and disadvantage of type of reactors. Production of metabolites of non-microbial origin *e.g*. Insulin, Interleukin, Cytokines using rDNA technology.

Unit-III
Types of fermentation and fermenters: Static and submerged fermentations, Recent developments in fermentation technology. Types and design of bioreactor: Stirred tank reactor, bubble column reactor, airlift reactor, Packed bed reactor, fluidized bed reactor. Bioprocess control and fermentation economics. Downstream processing; Enzyme, immobilized enzymes and bio surfactants.

Unit-IV
Types of microbial products: Production of Biomass, Baker's yeast, Mushroom, Single cell proteins, biopesticides and biofertilizers. Production of primary metabolites: Ethanol, organic acids (lactic acid, acetic acid, citric acid), Amino acids (glutamic acid, alanine, valine), Vitamins (vitB, vitC, vitA), Industrial enzymes (protease, amylase, glucose isomerase). Production of secondary metabolites: Antibiotics (cephalosporins, tetracyclines, polyenes), pigments (zeaxanthin, β-carotene, prodigiosin).

Books Recommended:
1. Casida LE. Industrial Microbiology, New Age Publishers, New Delhi.
2. Crueger W, Crueger A. Biotechnology. A Textbook of Industrial Microbiology, Sinauer Associates, USA.
3. Shuler ML, F Kargi. Bioprocess Engineering Basic Concepts, Prentice Hall, New Jersey, USA.
4. Stanbury P. F., A. Whitaker, S.J. Hall. Principles of Fermentation Technology, Butterworth-Heinemann, UK.
5. Vogel H.C., C.L. Todaro, C.C. Todaro: Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by Publisher: Noyes Data Corporation/ Noyes Publications.
6. Prescott and Dunn's Industrial Microbiology .Publisher: Gerald Reed: Books.

M.Sc. Microbiology
Semester III

19MB 304
Bioinformatics

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: It applies information technology and computer science into the area of biology for the purpose of studying, analyzing, and processing the information related to genomic as well as other biological processes.
Outcome: Students will learn the integration of computers, software tools, and databases in an effort to address biological problems.

Unit I
Introduction to bioinformatics: Branches, scope and research areas of bioinformatics; introduction to various sequence file formats; introduction to PERL: scalar variables, strings and numbers, arrays, hashes, operators, loops, regular expression; applications of PERL in bioinformatics**.** Introduction to databases: Classification scheme and features of biological databases; overview of various primary and secondary databases dealing with protein and nucleic acid sequences.

Unit II
Major biological databases: Primary databases of nucleic acid and protein: NCBI-Gen bank, EMBL, DDBJ; Swiss Prot, PIR. Other databases: Secondary protein database Prosite and PRINTS; secondary genomic database OMIM and OMIA, literature database Pub Med, metabolic database KEGG, *Plasmodium* database Plasmo DB, specialized databases including MIPS, TIGR, TAIR.

Unit III
Sequence comparison methods: Methods for the comparison of two sequences viz., dot matrix plots, Needleman Wusch & Smith Waterman algorithms; analysis of computational complexities and the relative merits and demerits of each method; theory of scoring matrices and their use for sequence comparison; difference between PAM and BLOSUM; sequence similarity tools: CLUSTAL X/W; molecular phylogeny.

Unit IV
Database search algorithms: Methods for searching sequence databases like FASTA and BLAST algorithms; BLAST and its types; PSI-BLAST and RPS-BLAST; concept of position specific weight matrices and their use in sequence analysis; theory of profiles and their use with special reference to PSI BLAST; Markov chains and models; concept of HMMS, Viterbi algorithm; forward algorithm and Baum welch algorithm.

Books Recommended:
1. Essential Bioinformatics by Jin Xiong, Cambridge publisher, ISBN: 9780511806087
2. Bionformatics: Principles and Applications) by Zhumur Ghosh and Bibekanand Mallick, Oxford University Press publisher.
3. Bioinformatics by Orpita Bosu and Simminder Kaur Thukral, Oxford University Press publisher
4. Introduction to Bioinformatics by M Lesk, Oxford University Press publisher.
5. Fundamental Concepts of Bioinformatics by Dan E Krane, Michael L Raymer, Michaeel L Raymer, Elaine Nicpon Marieb, Benjamin/Cummings.
6. Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery by P Rastogi and N Mendiritta, Prentice-Hall of India Pvt. Ltd.

M.Sc. Microbiology
Semester III

19MB 305
Intellectual property rights (IPR) and Biosafety

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: The main objective of this course is to familiarize the students with the issues of intellectual property rights and disputes arising due to biotechnological patents. The course also emphasizes on biosafety of GMOs and other ethical issues.
Outcome: Students will become aware of biosafety, bioethics and IPR. They are supposed to follow the regulatory framework in their future venture to ensure product safety and benefit the society.

Unit I
Introduction to intellectual property: Types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge and geographical indications. Establishment and functions of GATT, WTO and WIPO; main features of TRIPS agreement; WIPO treaties and PCT.

Unit II
Concept of 'prior art': Invention in context of "prior art"; patent databases; basics of patents: types of patents, Indian Patent Act 1970 and recent amendments; types of patent applications: PCT and convention patent applications; patent application forms and guidelines, fee structure, time frames; international patenting-requirements, procedures and costs; patent infringement- meaning, scope, litigation, case studies and examples.

Unit III
Introduction to bioethics: Bioethical issues related to genetically-modified organisms and gene therapy/gene editing; international bioethics advisory committees and their tasks (IBC, IBA, IBS etc.); ethical issues in human cloning; ethics for using animals in research; social and ethical implications of biological weapons.

Unit IV
Introduction to biosafety: biological safety cabinets; primary containment for biohazards; biosafety levels for microorganisms, infectious agents and infected animals; biosafety guidelines of Government of India and WHO; GMOs & LMOs; International regulations of GMOs: Cartagena protocol, OECD consensus documents and codex alimentarius; Indian regulations of GMOs: Environmental protection (EP) act and rules, guidelines; regulatory framework RCGM, GEAC, IBSC etc.

Books Recommended:
1. Laws relating to Intellectual Property Rights by VK Ahuja, Lexis Nexis Publishers.
2. IPR, Biosafey and Bioethics by Deepa Goel and Somini Prashar, Pearson.
3. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology by Padma Nabisan, Elsevier Publishing.
4. Biotechnology and Intellectual Property Rights by Kshitij Kumar Singh, Springer.
5. A Guide to Biotechnology Law and Business by Robert A. Bohrer,Carolina Academic Press.

M.Sc. Microbiology
Semester III

Lab course I **Total Marks: 50**
19MB306 **Time: 4 hours**

Evaluation scheme in examination:

Practical Performance & Evaluation	Viva-voce Practical	Record/File
35	**10**	**05**

Course contents:

1. To study symptoms of virus infected plants.
2. To study biophysical properties of a plant virus.
3. Demonstration of virus isolation procedure in the laboratory.
4. To study phage isolation from sewerage water
5. To study indication of plant virus infection.
6. UV spectroscopy of the purified/semi purified samples of plant virus preparations.
7. To study Agarose Gel electrophoresis of given samples of DNA
8. To study SDS- PAGE electrophoresis of given samples of proteins
9. To Estimate protein in virus infected & normal plants by Lowry's method.
10. To demonstrate the liberation of ammonia from nitrogenous organic compound (ammonification).
11. To demonstrate the reduction of nitrates to nitrogen gas (denitrification).
12. Isolation of rhizospheric and nonrhizospheric microflora.
13. Isolation of cellulose degrading microorganisms from soil.
14. Isolation of *Rhizobium* from root nodules.
15. Isolation of phosphate solubilizing bacteria from soil.
16. Isolation of *Azotobacter* bacteria from soil.

M.Sc. Microbiology
Semester III

Lab course II **Total Marks: 50**
19MB307 **Time: 4 hours**

Evaluation scheme in examination:

Practical Performance & Evaluation	Viva-voce Practical	Record/File
35	**10**	**05**

Course contents:

1. Isolation of industrially important microorganism from different sources using specific substrates
2. Design and Preparation of Media for fermentation
3. To study growth curve studies of bacteria/Yeasts in batch culture and calculation of maximum specific growth rate
4. To study the various methods of biomass measurement
5. To study production of ethanol from sucrose by yeast
6. To study the design of fermenter and its working
7. Production of citric acid using sucrose and molasses
8. Basics of sequence analysis retrieving a sequence-nucleic acid/Protein
9. Local and global alignment-concepts, pair wise sequence alignment, multiple sequence alignment
10. Phylogenetic analysis HMM for sequence analysis, retrieving protein structure from PDB.
11. To predict homology of any protein sequence.
12. To Perform Homology Modelling using Swiss Modeller.
13. To study SNP databases
14. To prepare a list of important sources of firewood and timber in your locality.
15. To study the patent searching on national/international data basis.
16. Preparation of charts based on biosafety and bioethics.
17. Case study and plagiarism check.
18. To study the working of biosafety cabinets

Note: Discipline specific elective (DSE) practical's will be allotted for the students as per their option for discipline.

M.Sc. Microbiology
Semester IV

19MB 401
Environmental Microbiology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: The course aims to teach students the scientific principles of technologies to clean up contaminated environments and to generate valuable resources for the society.
Outcome: The students will become familiar with different types of biotechnological methods to improve the environment.

Unit-I

Concept, development and scope of the microbial community in biosphere, biofilm and its ecological implication. Microorganisms in terrestrial, aquatic and aerial environments. Soil microbiome and climate change. Global warming, effect of global warming and control of global warming. Dispersal of microorganisms, the role of physical, biological factors and various methods to study microorganisms in natural environments.

Unit-II

Microbial Degradation of Organic Pollutants: Degradation and microbial remediation of xenobiotics, pesticides, hydrocarbons and phytoremediation of pollutants. Understanding microbial diversity in the environment by culture-dependent approaches, limitations and by culture-independent molecular approaches involving DNA hydrogenity. Analysis of FAME profiles, G+C analysis, slot-blot hybridization of the community DNA and fluorescent in situ hybridization.

Unit-III

Microbiology in Wastewater 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 an up-flow anaerobic sludge blanket reactor. Microorganisms as bio-indicators.

Unit-IV

Solid Waste Treatment, management of solid wastes, sanitary landfills. Bioconversion of solid waste, utilization as fertilizer, composting and vermicomposting. Bio-fuels, Bio-mining, bioremediation strategies for soils and water polluted with heavy metals and organic pollutants. Treatment of industrial effluents from dairy, distillery, tannery, sugar, paper and pharmaceutical industries.

Books Recommended:

1. Microbial Ecology By Atlas R.M., Bartha R., Benjamin Cummings Publishing Co, Redwood City, CA.
2. Environmental Microbiology by A.H. Varnam & M.G. Evans, Manson Publishing Ltd.
3. Manual of Environmental Microbiology by Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, ASM Press.
4. Maier, R.M., Pepper, I.L. & Gerba, C.P. Environmental Microbiology. Academic Press.
5. Environmental Microbiology by R. Mitchel, Wiley-Blackwell.
6. Environmental Microbiology by Raina Maier, Ian Pepper, & Charles Gerba, Academic Press.
7. Environmental Microbiology: Principles and Applications by Patrick K. Jjemba, Science Publishing In.

M.Sc. Microbiology
Semester IV

19MB 402
Food and Dairy Microbiology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: To impart knowledge regarding the biochemical aspects of various nutrients and their interactions in foods during processing, storage and deterioration.
Outcome: To familiarize the students with food microbiology includes fermented food, dairy, food preservation, spoilage and detection of food borne diseases, their control measures.

Unit I
Food and Microorganisms, historical developments, microorganisms important in food-molds, Yeast and bacteria-general characteristics and importance. Intrinsic and extrinsic factors affecting microbial growth in foods: Intrinsic factors: Nutrient contents, pH, moisture content, water activity, antimicrobial barriers, antimicrobial substances. Extrinsic factors: relative humidity, temperature, gaseous atmosphere.

Unit-II
Food fermentation; Fermented dairy products (Yogurt and Cheese), vegetable products (Pickle and Sauerkraut), meat products (Fresh and ground meat, sausages); Preservatives and preservation methods; physical methods, biologically based preservation system, chemical preservatives, natural antimicrobial compounds and effect of food preservatives on health.

Unit-III
Contamination and spoilage of different foods; vegetables, fruits, milk, milk products, meat, meat products, poultry and fish, advanced techniques in detecting food borne pathogens and toxins, Hurdle technology and Hazard analysis. Critical control point systems in controlling microbiological hazards in foods. Bacteriocins and their applications; Prebiotic, synbiotics and probiotic bacteria.

Unit-IV
Food borne infections and intoxications; Bacterial and nonbacterial infection with examples of infective and toxic types, *Brucella, Bacillus, Clostridium, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio, Yersinia* , fungi, viruses, and emerging food-borne pathogens; Foodborne outbreaks, laboratory testing procedures and preventive measures, food sanitation in manufacture and retail trade.

Books recommended:

1. Bibek Ray. Fundamentals of Food Microbiology. CRC Press.
2. Frazier WC & Westhoff DC. Food Microbiology. Tata McGraw Hill.
3. George J Banwart. Basic Food Microbiology. AVI.
4. James M Jay. Modern Food Microbiology. CBS.
5. Peppler HJ & Perlman D. Microbial Technology. Academic Press.
6. https://www.fssai.gov.in/cms/food-safety-and-standards-regulations.php
7. https://www.fssai.gov.in/cms/act-2006.php

M.Sc. Microbiology
Semester IV

19MB 403
Medical Microbiology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: To provide the knowledge about microbial diseases, their causative agents, virulence and control measures.
Outcome: This course will impart knowledge about disease transmissions, pathogenesis and diagnostics of diseases.

Unit 1
History and scope of medical microbiology, microorganisms and diseases. Host microbial interactions governing the infection and establishment of disease. Definition; infection, invasion, pathogen, pathogenicity, virulence, carrier, types of carrier. Nosocomial infections, opportunistic infections, factors affecting virulence, portals of entry and portals of exit.

Unit II
Normal microbial residents of the human body, characteristics of normal flora, distribution and occurrence of normal flora. Normal flora of the skin, respiratory tract, gastrointestinal tract and genitourinary tract. Sources and transmission of infection, reservoirs of infection. Human sources, animal sources and inanimate sources of infection. Transplacental infection, respiratory tract infection, food and water-borne infections.

Unit III
Clinical features, laboratory diagnosis, treatment and prevention of Cholera, Diphtheria & DPT vaccination. Tuberculosis, DOT treatment, MDR tuberculosis, Pneumonia, Hepatitis: type of hepatitis, vaccine schedule of hepatitis. General studies on Plague, HIV/AIDS, Rickettsia, Yellow fever, Trypanosomiasis, Malaria and Syphilis.

Unit IV
Principles of diagnostic tests such as ELISA, Immunofluorescence, agglutination, PCR assay. Chemotherapeutic agents for antibacterial, antifungal and antiviral activity. Drug resistance, prophylactic measures, advances in pathogen detection, nanotechnology application in disease detection and control (HIV/COVID19).

Book Recommended:

1. Medical Microbiology by C.G.A. Thomas. Bailliere Tindall/ WB Saunders,London.
2. Medical Microbiology by Mims, Playfiar, Roitt, Wakelin and Williams, Mosby- year Book Europe Ltd., U.K.
3. Microbiology: Concepts and Applications by Pelczar, Chan and Krieg. McGraw Hill, Inc., U.S.A.
4. Microbiology: A Human Perspective by Nester, E.W. Roberts C.E., Anderson, seventh edition McGraw Hill Education, Europe.
5. Sherris Medical Microbiology. K.J Ryan, Mc Graw Hill, Europe.
6. Essentials of Medical Microbiology by Apurba Sankar Sastry & Sandhya Bhat K. Jaypee brothers medical publishers
7. Medical Microbiology (LANGE) Geo Brooks, Karen C. Carrol, Janet Butel and Stephen Morse, McGraw Hill Education, Europe.

M.Sc. Microbiology
Semester IV

19MB 404
Cell Biology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: This course is intended to provide the basic understanding of structures and purposes of basic components of cell membranes, different cell organelles, cellular communication, cell division and its regulation.
Outcome: After studying this paper students will be able to understand how cell ultrastructure is related to cell function and acquired knowledge will prepare the students to develop themselves.

Unit-I
Introduction to Cell biology: Ultrastructure of prokaryotic & eukaryotic cells, Structural organization & function of cell wall. Membrane structure and function: Molecular composition of the cell membrane, Structural models of membrane, lipid bilayer and membrane proteins, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.

Unit-II
Structural organization and function of intracellular organelles: Mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, Nucleus; structure and organization, nuclear pores, nucleolus. Cell shape and motility: cytoskeleton, organization and role of microtubule and microfilaments, Motor movements; implications in flagella and other movements.

Unit-III
Cellular communication: Regulation of homeostasis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Cell cycle: Mitosis and meiosis; various stages in cell cycle, regulation and control of cell cycle, cyclin dependent kinases.

Unit-IV
Protein Localization: Synthesis of secretory and membrane proteins, Protein sorting and targeting of proteins into nucleus, mitochondria, chloroplast, vacuoles and peroxisomes, Receptor mediated endocytosis. Apoptosis(programmed cell death); its Mechanism and inducing factors, apoptosis triggered by internal and external pathways.

Books Recommended:
1. Essential Cell Biology by Bruce Albert, Garland Science (2nd Ed).
2. Cell and Molecular Biology by Phillip Sheeler and Donald E. Bianchi, John Wiley and Sons (3rd Ed).
3. The World of Cell by W.M Becker, L.J. Kleinsmith and J. Hardin. Pearson Education (5th Ed).
4. Molecular Cell Biology by Harvey Lodish, W H Freeman & Co (8th Ed)
5. Cell Biology by P S VermaandV K Agarwal, S Chand Publishing (1st Ed)
6. Brown and Berke: Text Book of Cytology, Blackstains Sons & Co.
7. Lewin, B. Genes VII, Oxford University Press, USA.

M.Sc. Microbiology
Semester IV

19MB 405
Mycology and Phycology

Maximum Marks: 100
Theory Examination: 80
Internal Assessment: 20
Time: 3 hrs

Note: There shall be nine questions in all. Question no.1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Objective: To educate and train the students for professional and research career in the field of phycology, mycology and lichenology.
Outcome: By studying this course the students will learn about general account and economic importance of algae fungi and lichens with their impact on human life.

Unit: I
Phycology: Algae in diversified habitats (terrestrial, freshwater, marine), thallus organization, cell ultrastructure, reproduction (vegetative, asexual and sexual), Classification of algae, Algal Classes: Overview and characteristics of Protochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta. Criteria for classification (pigments, reserve food and flagella).

Unit: II
Algae as pollution indicators, eutrophication agent and role in bioremediation, global warming and environmental sustainability. Economic importance of algae: as food, feed, in medicine and industry, Algal blooms, algal biofertilizers, the importance of algae in production of algal pigments, biofuels, hydrogen production and important bioactive molecules.

Unit: III
Mycology: General characters, Organization of the thallus, nutrition and reproduction; General account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina. Heterokaryosis, Heterothallism, Parasexuality, and economic importance of fungi.

Unit IV
Lichens: ascolichens, basidiolichens, deuterolichens, Mycorrhiza: ectomycorrhiza, endomycorrhiza, ectendomycorrhiza, VAM, Fungi as insect symbionts, biocontrol agents, attack of fungi on other microorganisms, potential application in agriculture, environment, industry and food. Role of fungi in biodeterioration of wood, paper, textile. Mycotoxins and quorum sensing in fungi.

Books Recommended:

1. Alexopoulos, C.J. and C.W. Mims 1988. Introduction to Mycology (3rd Ed.) Wiley Eastern Ltd., New Delhi
2. Charlile M. & Watkinson S.C. The Fungi, Publisher: Academic Press.
3. E.Moore –Landeekeer: Fundamentals of the fungi, Publisher: Prentice Hall.
4. L. Barsanti, Paolo Gualtieri: Algae: anatomy, biochemistry, and biotechnology
5. Ayhan Demirbas, M. Fatih Demirbas: Algae Energy: Algae as a New Source of Biodiesel (2010)
6. Linda E. Graham, James Graham, James M. Graham: Algae (2009)
7. Burnett J.H., Publisher: Edward, Arnold Crane Russak: Fundamentals of Mycology.

M.Sc. Microbiology
Semester IV

Lab course I
19MB 406 **Total Marks: 50**
Time: 4 hours

Evaluation scheme in examination:

Practical Performance & Evaluation	Viva-voce Practical	Record/File
35	**10**	**05**

Course content:

1. Detection of coliforms in water by multiple tubes fermentation test (Presumptive, confirmed, completed test)
2. Enumeration of water microflora by standard plate count (SPC)
3. To determine the quality of water sample using membrane filter method
4. Isolation of thermophilic microbes from environmental samples
5. Screening of thermophilic microbes for hydrolytic enzymes
6. To study DNA isolation from environmental samples and study the microbial diversity
7. To study dye and industrial effluent treatment by the microbial cultures.
8. To study Litmus milk reactions.
9. Culturing and identification of yeast involved in production of bread and beer
10. To perform methylene blue reduction test of raw and pasteurized milk
11. Isolation of *Lactobacilli* and *Streptococci* from curd
12. Sauerkraut production in the laboratory
13. Statutory, recommended and supplementary tests for microbiological analysis of various foods:
    a) Canned foods
    b) Baby foods
    c) Milk and dairy products
    d) Eggs
    e) Meat
    f) Vegetables
    g) Fruits
14. To study the production of wine in the laboratory conditions
15. Identification of microorganisms from spoiled foods.
    a) Bread
    b) Fruits
    c) Meat
    d) Cake

M.Sc. Microbiology
Semester IV

Lab course II
19MB 407 **Total Marks: 50**
Time: 4 hours

Evaluation scheme in examination:

Practical Performance & Evaluation	Viva-voce Practical	Record/File
35	**10**	**05**

Course contents:

1. To study total lymphocytes count, TLC, DLC and ESR estimation
2. To study estimation of blood sugar and urea from given samples.
3. To study lipid profile from given samples.
4. To study estimation of Creatinine from given samples
5. How to do Urine culture for UTI infections
6. How to test Malaria, Hepatitis B in the laboratory
7. To do ELISA for detection of HBV through serum
8. Isolation and identification of fungi from different environmental samples
9. Study the nutritional requirement of fungi, Cultivation of fungi in submerged and solid state fermentation
10. Production of enzymes, organic acids and other metabolites by fungi,
11. Collection and study of basidiomycetous fungi
12. Study and culturing of yeasts, study yeast dimorphism
13. Isolation and identification of algae from different habitats, Culturing of algae under lab conditions
14. Algae as a source of SCP study and pollution control
15. Ultrastructure of the cell
16. Cell staining and visualization under microscope.
17. Mitotic division in root tip cells.
18. Preparation of chromosomes.
19. Effect of different factors on cell membrane permeability.
20. Effect of tonicity on animal and plant cells Production, isolation and characterization of mutants.

Note: Discipline specific elective (DSE) practical's will be allotted for the students as per their option for discipline.

Available Swayam Courses for the session 2020-21

The department of microbiology is offering following courses. The students can opt for maximum 8 credit courses instead of open elective / discipline specific courses.

1. Food microbiology and food safety
2. Research methodology
3. Forensic toxicology
4. Forensic biology and serology
5. Functional foods and nutraceuticals
6. Biomolecules: Structure function in health and disease
7. Experimental biotechnology
8. Dairy and food process and food technology
9. Food safety and biocontrol
10. Biomedical nanotechnology
11. Solid and hazardous waste management
12. Functional genomics
13. Introduction of Proteogenomics
14. Medical chemistry