Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon

SYLLABUS

for

Master of Science (M. Sc.)

Microbiology

Choice Based Credit System
(Outcome Based Curriculum)

For

Affiliated Colleges of
Kavayitri Bahinabai Chaudhari North Maharashtra University
Jalgaon 425 001 (MS)

2021 - 2022

Program at a Glance

Name of the program (Degree)	**:**	*M. Sc.*
Subject	**:**	*Microbiology*
Faculty	**:**	*Science and Technology*
Duration of the Program	**:**	*Two years (four semesters)*
Medium of Instruction and Examination	**:**	*English*
Credits of the program	**:**	*Total 88 credits (64 core credits including 4 credits of project/dissertation, skill enhancement- 08, subject elective credits 08 and audit 08 credits*
Examination Pattern	**:**	*The 60 : 40 (60 marks University assessment (exam) and 40 marks continuous internal college assessment (exam)*
Evaluation mode	**:**	*CGPA*
Passing standards	**:**	*The 40% in each exam separately (separate head of passing)*
Result	**:**	*As per the University's rules of CGPA system*

Prologue

The requirement for trained and skilled human resource is the need of time in the higher education and industry to match with rapid pace of technology development. Students need to acquire thorough knowledge of theoretical concepts and hands-on laboratory methods in the subject. Thus, it is imperative to revise and update the curriculum to accommodate the fundamental aspects as well as advanced developments in various disciplines of Microbiology and to complement the needs of its applied sectors. The program is designed to provide skilled manpower in this subject, facilitate to improve linkages with industries, and intended to offer practical skills needed to pursue the jobs in a chosen profession. Beside this, the students will be enlightened with knowledge in the newer areas of Bioinformatics, Bioinstrumentations, Biomolecules, Genetics, Immunology, etc.. Students are taught how to plan experiments, perform them carefully, analyse the data accurately, and present the results both, qualitatively and quantitatively through their dissertations or the project work. The students are encouraged to deliver seminars on the

topics of research to develop presentation skills and enable to build confidence which will lead them to read about different themes and enhances their assimilation abilities. A project component in the final semester will enable students to select a research problem, plan to execute experiments related to it, collect data and analyse it, and present the results in the form of an oral presentation as well as a thesis. This not only equips the student for a career in research as well as industry, but also fosters self- confidence and self-reliance in the student as he/she learns to work and think independently. At the end of the programme the student will be well-versed in this subject as well as be familiar with the most recent advances in the field of Life Sciences and will have gained hands-on experience in this subject of study. The student will be able to take up a suitable position in academia or industry and will be equipped to pursue a career in research or be an entrepreneur, if so desired.

Process of Curriculum Design

The Choice-Based Credit System (CBCS) provides a framework within which there is flexibility in the design of courses and their content, simultaneously also providing the student a choice of the courses he/she wishes to study. The courses are assigned credits based on teaching hours, which in turn is linked to course content and structure. When revising the syllabi for the courses, the courses to be implemented as well as the content of each course was extensively discussed and debated on, over meetings between the faculty members and the students. Several alumni contributed to useful inputs. Furthermore, the opinions of prospective employers of the corporate sector were also sought and obtained. The opinions of experts were taken into consideration as well. The syllabi presented here are the culmination of the combined efforts of the faculty members, feedback obtained from students, alumni, external experts and members of industry.

The student will acquire knowledge about Microbiology such as Genetic Engineering, plant-microbes interaction, and Microbial Diversity, Molecular Biology, Pharmaceutical Microbiology, Fermentation Technology Applied and Environmental Microbiology , Industrial Microbiology Immunology, Agricultural and Food Microbiology. The student can design and execute experiments related to Basic Microbiology, Molecular Biology, Recombinant DNA Technology, and Microbial Genetics and can execute a short

research project incorporating techniques of Basic and Applied Microbiology under supervision.

Program Objectives for M.Sc. Program:

1. *To impart the profound theoretical and practical knowledge of the specific science discipline along with the fundamental core concepts*
2. *To train the students to employ modern techniques, tools, methodologies, equipment, hardware/software etc. to perform objective oriented scientific and planned experiments.*
3. *To groom the students for all-round development and mold them in a trained workforce to provide teaching-learning, research, business, professional supports in the various science disciplines.*
4. *To make the student to develop the ability to think analytically, independently and draw logical conclusions to solve real-life problems.*
5. *To utilize the skills and knowledge gained through the subject to deal with real life situations and problems related to society, environment, research and development etc.*

Structure of M.Sc. program in Microbiology

M.Sc. Microbiology program is of two years duration and is conducted into four semesters. Since inception, the program was mostly student centric. Now in lieu of accreditation standards of NAAC, the university adopted outcome-based education approach. The various courses of the program are designed to include classroom teaching, laboratory work, project, seminars, assignments, etc. Three categories of courses are being offered in this program: (A) Prerequisites and Core courses (12 theory and 8 practical's of 4 credit each as mandatory courses), (B) Skill Based/ Subject Elective courses (04 courses of 4 credits each) and (C) Audit courses (4 Courses of 2 credits each). The core courses of 4 credits include theory as well as practical. The core courses embody a research-based course that leads to a project dissertation. The student is required to accumulate 22 credits each semester, a total of 88 credits, to fulfil the requirements for a M.Sc. degree. Forty percent of the total marks for each course will be awarded

through internal assessment. Final examinations for four credit courses will be of three hours duration while examinations for each laboratory- based courses will be held over two days of three hours (incubation based practicals) each or one day of 5-6 hours each. However, there could be certain changes in the number of classes of theory and practicals, ways of teaching either through online or offline mode and even the examination pattern owing to the prevailing situation like pandemic and as per the need by following the rules and regulations.

Duration

The duration of M.Sc. degree program shall consist of two academic years divided in to four semesters. Each Semester consist of 90 working days. Each theory and practical course should be completed in about 50 lectures.

Medium of instruction

The medium of instruction and examination for each course shall be English.

Credit to contact hour

One credit is equivalent to 15 periods of 60 minutes each for theory course lecture. While credit weightage for self-learning based on e-content shall be 50% or less than that for lectures.

Attendance

The student enrolled for this M.Sc. course must have 75% attendance in each course in order to appear for term end examinations, otherwise the candidate may not be allowed to appear for term end examination as per ordinance.

Examination

Each theory and practical course will be of 100 marks comprising of 40 marks internal (20 marks of 2 internal examinations) and 60 marks external examination. Separate head of passing in Internal and External examination is mandatory. In case of failure in internal examination of particular course, student will have to appear for the same in next semester as per the schedule of the examination. In case a student fails in particular course in a semester and the same course(s) are revised/removed from curriculum in due course, the student will have to appear as per new curriculum and or pattern in subsequent semester at his own responsibility observing the course equivalence..

Term end examination (60 marks) will be of three hours duration for each theory course. There shall be 5 questions each carrying equal marks (12 marks each).

Internal examination (40 marks each semester)

Internal assessment of the student by respective teacher will be comprehensive and continuous, based on written test. The written test shall comprise of both objective and subjective type questions. Two internal tests (20 marks each) will be conducted during semester as a part of continuous assessment.

Practical Examination

Practical examination shall be conducted at the end of the semester. Practical examination will be of minimum 6 hours duration and shall be conducted as per schedule (10 am to 5 pm on schedule date or can be scheduled 10 am - 1pm / 2 – 5 pm for 2 consecutive days) in case of practicals where incubation condition, allied aspects are essential. There shall be 5 marks for laboratory record book and well written certified journal, 10 marks for viva-voce and minimum three experiments (major and minor). Certified journal is compulsory to appear for practical examination. There shall be one expert and two examiners (external and internal) per batch for the practical examination.

Summary of Distribution of Credits under CBCS Scheme

for M.Sc. at Affiliated Colleges [w.e.f. 2021-22]

Sr. No	***Type of course***	***Sem I***	***Sem II***	***Sem III***	***Sem IV***
01	*Core*	***16***	***16***	***16***	***12***
02	*Skill based*	***04***	***04***	***-***	***-***
03	*Elective*	***-***	***-***	***04***	***04***
04	*Project*	***-***	***-***	***-***	***04***
05	*Audit*	***02***	***02***	***02***	***02***
06	*Total Credits*	***22***	***22***	***22***	***22***

Subject Type	***Core***	***Skill based***	***Elective***	***Project***	***Audit***	***Total***
Credits	***60***	***08***	***08***	***04***	***08***	***88***

Total Credits = 88

Affiliated Colleges of

Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon

Choice Based Credit System (Outcome Based Curriculum) with effect from 2021 -2022

Course credit scheme

Semester	(A) Core Courses			(B) Skill Based / Elective Course			(C) Audit Course			Total Credits (A+B+C)
	No. of Courses	Credits	Total Credits	No. of Courses	Credits	Total Credits	No. of Courses	Credits (Pract.)	Total Credits	
I	4	8 + 8	**1**	1	4 + 0	4	1	2	2	**2**
I	4	12 + 4	**1**	1	0 + 4	4	1	2	2	**2**
I	4	8 + 8	**1**	1	4 + 0	4	1	2	2	**2**
I	3	8 + 4	**1**	2	8 + 0	8	1	2	2	**2**
Total	**6**			**1**			**8**			**8**

(T, Theory; P, Practical)

Structure of Curriculum

		First				Second				Total Credit Value
		Semester I		Semester II		Semester III		Semester IV		
		Credit	Course	Credit	Course	Credit	Course	Credit	Course	
	Prerequisite and									
(A)	Theory	4	2	4	3	4	2	4	2	36
	Practical	4	2	4	1	4	2	4	1	24
(B)	**Skill Based / Subject Elective Courses**									
1	Theory /Practical	4	1	4	1	4	1	8	2	20
(C)	**Audit Course (No weightage in CGPA calculations)**									
1	Practicing	2	1							2
2	Personality & and Cultural Development			2	1					2
3	Technology Related + Value					2	1			
4	Professional and Social + Value							2	1	2
	Total Credit Value	14	6	14	6	14	6	14	6	88

List of Audit Courses (Select any ONE course of Choice from Semester II)			
Semester I (Compulsory)		**Semester II** (Choose One)	
		Personality and Cultural Development	
Course Code	**Course Title**	**Course Code**	**Course Title**
AC-101	Practicing Cleanliness	AC-201A	Soft Skills
		AC-201B	Sport Activities
		AC-201C	Yoga
		AC-201D	Music

Semester-wise Course Structure of M.Sc. Microbiology

Semester I

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MB-101	Core	Microbial Taxonomy and Diversity	4	--	4	40	--	60	--	4
MB-102	Core	Microbial Physiology and Biochemistry	4	--	4	40	--	60	--	4
MB-103	Core	Methods in Microbiology	--	4+4	8	--	40	--	60	4
MB-104	Core	Methods in Microbial Chemistry	--	4+4	8	--	40	--	60	4
MB-105	Skill Based	Bioinstrumentation	4	--	4	40	--	60	--	4
AC-101	Audit Course	Practicing Cleanliness		2	2	--	100	--	--	2
Total Credit for Semester I: 22 (T = Theory: 8; P = Practical:8; Skill Based:4; Audit Course:2)										

Semester II

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MB-201	Core	Molecular Biology and Bioinformatics	4	--	4	40	--	60	--	4
MB-202	Core	Microbial Enzymology	4	--	4	40	--	60	--	4
MB-203	Core	Immunology	4	--	4	40	--	60	--	4
MB-204	Core	Methods in Molecular Biology and Immunology	--	4+4	8	--	40	--	60	4
MB-205	Skill Based	Methods in Enzymology	--	4+4	8	--	40	--	60	4
AC-201 A/B/C/D	Audit Course	Choose one out of Four (AC-201A/ AC-201B/AC-201C/AC-201D) from Personality and Cultural Development	--	2	2	--	100	--	--	2
Total Credit for Semester II: 22 (T = Theory: 12; P = Practical:4; Skill Based:4; Audit course:2)										

Program Outcomes (PO) for M.Sc. Program:

Upon successful completion of the M.Sc. program, student will be able to:

PO No.	PO	Cognitive level
PO1	Understand the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.	**2**
PO2	Administer the skills in handling scientific instruments, planning and performing in laboratory experiments	**3**
PO3	Analyse the given scientific experimental data critically and systematically and the ability to draw the objective conclusions.	**4**
PO4	Develop various skills such as communication, managerial, leadership, entrepreneurship, teamwork, social, research etc., which will help in expressing ideas and views clearly and effectively	**3**
PO5	Model and formulate the real problems and find solution based-on knowledge acquired	**6**
PO6	To evaluate how developments in any science subject helps in the development of other science subjects and vice-versa and how interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments.	**5**

Program Specific Objectives for M.Sc. Microbiology program:

After completion, the students are expected to understand the;

- Basic concepts, principles and methods of Microbial Diversity, microbial Systematics and Bioinstruments used in isolation and identification of microbes and structural determination of biomolecules.
- Basic and applied aspects of Genetic makeup of bacteria, algae, fungi and viruses.
- Causes, mechanisms and consequences of defect in gene/genome of microorganisms.
- Basic concepts of microbial enzymes, enzyme kinetics, regulation of enzyme activity, industrial applications of enzymes.
- Biotechnological significance of enzymes of extremophiles in agriculture, environment, medicine and industry.
- Concepts and significance of enzymes in non-aqueous environment.

Program Specific Outcomes (PSOs) for M.Sc. Microbiology program:

Students who graduate with a Master of Science in Microbiology will:

PSO No.	PSO	Cognitive level
PSO1	Demonstrate an understanding of structure and metabolism of macromolecules, understand the regulation of metabolic pathways and understand the role of microbes in industry, health and environment.	**2**
PSO2	Gain proficiency in laboratory techniques in both microbiology and molecular biology and be able to apply the scientific methods to the processes of experimentation and hypothesis testing.	**3**
PSO3	Acquire significant knowledge on various aspects related to microbiology including biochemical techniques, immunology, physiology, agriculture, environment, pharmaceutical, molecular biology, applied recombinant DNA technology and technical skills related to microbial metabolites.	**4**
PSO4	Learn to work as a team as well as independently to retrieve information, carry out Research investigations and result interpretations.	**6**
PSO5	Develop the ability to understand and practice the ethics surrounding scientific research.	**5**
PSO6	Realize the impact of science in society and plan to pursue research.	**5**

Distribution of Course papers for M. Sc. Part I Microbiology

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part I Microbiology					
Semester I : Theory Courses					
MB-101	Microbial Taxonomy and Diversity	Core course	04	100	03
MB-102	Microbial Physiology and Biochemistry	Core course	04	100	03
MB-105	Bioinstrumentation	Skill based	04	100	03
Semester I : Practical Courses					
MB-103	Methods in Microbiology	Core course	**04+04**	**100**	**06**
MB-104	Methods in Microbial Chemistry	Core course	**04+04**	**100**	**06**
AC-101	Practicing Cleanliness	Audit Course	**02**	**100**	
Semester II : Theory Courses					
MB-201	Molecular Biology and Bioinformatics	Core course	**04**	**100**	**03**
MB-202	Microbial Enzymology	Core course	**04**	**100**	**03**
MB-203	Immunology	Core course	**04**	**100**	**03**
Semester II : Practical Courses					
MB-204	Methods in Molecular Biology and Immunology	Core course	**04+04**	**100**	**06**
MB-205	Methods in Enzymology	Skill based	**04+04**	**100**	**06**
AC-201A/B/C/D	Choose one out of Four (AC-201A/ AC-201B/ AC-201C/ AC-201D) from Personality and Cultural Development (Audit Course)	Audit Course	**02**	**100**	

M.Sc. Part I Semester I Microbiology: Core Courses

	MB - 101: Microbial Taxonomy and Diversity	
	Course Objectives: 1. To understand the ubiquitous nature of microbes to build basic concept 2. To give basic knowledge on extremophiles 3. To provide knowledge on characteristics of various microbes	
Unit 1	**Microbial Taxonomy** • **Concept:** Taxonomic ranks, Domain and species • **Introduction to Bergey's manual of Systematic bacteriology, 9th edition** • **Current techniques used for identification:** DNA fingerprinting electrophoresis, Ribotyping, DNA Fingerprinting using Pulsed Field Gel Electrophoresis (PFGE), Randomly amplified polymorphic DNA (RAPD), Fatty acid analysis, Use of NA probes • **Metagenomics concept, culturable and non-**culturable microbial diversity	**08 L**
Unit 2	**Extremophilic bacteria and Archea** • **Biotopes, Biochemistry and Physiology of adaptation to extreme environment and cultivation strategies of:** Thermophile, Psychrophile, Barophile, Halophile, Acidophile, Alkaliphile, Methanogens • **Applications of extremophiles**	**14 L**
Unit 3	**Algae** • **Characteristics:** Algae (Colonial Algae, Filamentous Algae, Siphonous Algae, Parenchymatous and Pseudo parenchymatous algae), • **Cytomorphology and Ultrastructure:** algal cell (Mucilage and Sheaths, Frustule, Cell Wall, Flagella and Associated Structures, Plastids, algal movement) • **Nutrition:** Physical and chemical requirements, Types based on nutrition • **Reproduction**: Vegetative, Asexual Reproduction, Binary Fission or Cellular Bisection, Zoospore, Aplanospore, Autospore. Fragmentation, Resting Stages, Sexual Reproduction. • **Significance of algae**: Biogeochemical role, Food, Extracts (Agar, Alginate, Carrageenan), Animal Feed, Fertilizers, Cosmetics, Therapeutic Supplements, Algal pigments, Microalgae as biofertilizer, Lichens • **Algal farming for biodiesel** • **BGA:** General features, cultivation and significance • **Prochloronus and cyanelles**	**8L**
Unit 4	**Fungi** • **Characteristics:** Fungi (Yeast, moulds and dimorphic fungi) and their Classification • **Cyto-morphology and Ultrastructure:** Fungal hyphae, thallus • **Nutrition:** Physical and chemical requirements, Types based on nutrition • **Reproduction**: sexual, asexual, fungal spores and parasexual • **Endophytic fungi**: Characteristics, cultivation and significance • **Ecological significance and applications of Fungi:** Biogeochemical role of fungi, Mycoses, Mycotoxins, Biocontrol, Mycorrhiza and Insect symbionts	**10 L**
Unit 5	**Virus** • **Virus structure:** Virus proteins, Capsids, Virion membranes, Ultrastructure of HIV, plant virus (TMV) and bacterial virus (T4 virus) • **Classification of viruses** • **Methods used in virology:** Cultivation of viruses, Isolation of viruses,	**10 L**

	Centrifugation, Structural investigations of cells and virions, Electrophoretic techniques, Detection of viruses and virus components, Infectivity assays. • **Detection and enumeration of viruses** • **Viruses in cancer:** oncogenic viruses, sources and mechanism of oncogenesis, Epstein-Barr virus-linked cancers, Kaposi's sarcoma, Cell lines derived from virus-associated cancers, Prevention of virus-induced cancers, Diagnosis and treatment • **Emerging viruses:** Viruses in new host species and in new areas, recently discovered viruses, Re-emerging viruses, Virus surveillance • **Prions:** nature of prions, Prion transmission, Transmissible spongiform encephalopathy	

Suggested readings:

1. Carter, John B and Saunders, Venetia A. (2007) **Virology:** Principles and applications, John Wiley and Sons Ltd., London
2. Wagner, E. K. and Hewlett, M. J (2004) Basic Virology, 2nd Edn., Blackwell Publications, Oxford,
3. Conrat, H.F. Kimball, P.C. and Levy, J. A (1994) Virology, 3rd Edn., Prentice Hall, Eaglewood Cliff, New Jersey, USA
4. Hull, R. (2002) Matthew's Plant Virology, 4th Edn., Academic Press, London
5. Dimmock, N. J. Easton, A. J. and Leppard, K. N. (2001) Introduction to Modern Virology, 5th Edn., Blackwell Science, London
6. Laura Barsanti, and Paolo Gualtieri (2006) Algae: Anatomy, Biochemistry and Biotechnology, Taylor & Francis Group, UK
7. Becker, E. W. (1994) Microalgae- Biotechnology and Microbiology, Cambridge University Press, UK. Burnett, J. H.
8. Kevin Kavanagh (2005) Fungi: Biology and Applications, John Wiley & Sons Ltd., West Sussex,
9. Jim Deacon (2006) Fungal Biology, 4th Ed. Blackwell Publishing Ltd., West Sussex
10. Alexopoulous, C. J. and Mims, C. W. (1979) Introduction to Mycology, Wiley Eastern Ltd., Delhi
11. Griffin, D. H. (1994) Fungal Physiology, Wiley-Liss, New York
12. Kathy Talaro and Barry Chess (2012) Foundations in Microbiology, 8th Edn., The McGraw-Hill Companies, Inc., New Delhi
13. Tortora, Funke and Case (2010) Microbiology, 10th Edn., Brenjamin Cummings Inc., California
14. Moselio Schaechter (2009) Desk encyclopaedia of Microbiology, 2nd Edn., Elsevier
15. Prescott, Harley and Klein's (2002) Microbiology, 5th Edn. The McGraw-Hill Companies, Inc.,
16. Ulhas Patil, JS Kulkarni, AB Chaudhari and SB Chincholkar (2017) Foundations in Microbiology, 9th Edn., Nirali Prakashan, Pune
17. Fred A. Rainey and Aharon Oren (2006) Extremophiles, Methods in Microbiology, Volume 35, Elsevier and Academic Press, London
18. Martin Dworkin (Editor) (2006) The Prokaryotes: A Handbook on the Biology of Bacteria, Volume 2, Ecophysiology and Biochemistry, Springer-Verlag, New York
19. Michael T. Madigan, John M. Martinko, Paul V. Dunlap, David P. Clark, (2009) Brock Biology of Microorganism, Benjamin Cummings, California, USA.
20. Bergey's Manual of Systematic Bacteriology (2001) Editor-in-chief: Garrity, George M. Boone, David R.; Castenholz, Richard W. (Eds.), (4 Volumes) Springer/ Williams and Wilkins, USA
21. Kushner, D.J. eds. (1978) Microbial life in extreme environments. Academic Press, London.
22. Horikoshi, K., Grant, W.D. eds. (1998) Extremophiles, Microbial Life in Extreme Environments. Wiley-Liss Publishers, New York.
23. Willey, J., Sherwood, L., Woolverton, C.J. and Prescott, L.M. (2017) Prescott's Microbiology, 10th edn., NY: McGraw-Hill Education, New York

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO	CO	Cognitive

No.		level
C101.1	Differentiate various groups of microbes and microbial taxonomy	**2**
C101.2	Acquire knowledge on adaptability of extremophiles and microbial diversity	**3**
C101.3	Acquaint with the scope of microbiology in different diversified areas.	**4**

	MB-102: Microbial Physiology and Biochemistry	
	Course Objectives: 1. To know the structural organization, characteristics and metabolism of biomolecules 2. To learn microbial metabolic pathways and its enzymatic regulation 3. To acquire knowledge on transport of solute and energy metabolism	
Unit 1	**Structure and properties of Biomolecules** • **Classification, Structure and function of:** carbohydrates, lipids, proteins, nucleic acids and vitamins. • **Conformation of proteins:** Primary, secondary, tertiary and quaternary structure; Ramachandran plot, domains; motif and folds • **Structural stability:** protein and nucleic acid	**10 L**
Unit 2	**Transport and Energy metabolism** • Cell membrane and its ultrastructure • **Types of cellular transport**: passive, facilitated, active, translocation, liposomes for transduction, Na/K+ ATPase, ABC transporter • Response to stress. • **Energy metabolism:** Free energy, Bacterial and Mitochondrial ETC, ATP Synthase complex, inhibitors of ETC and energetics of ETC	**10 L**
Unit 3	**Metabolism of carbohydrates** • **Metabolic pathway, bioenergetics and regulation of:** EMP, HMP, TCA, Glyoxylate pathway, C3 and C4 pathway • **Alternative glycolytic pathways**	**12 L**
Unit 4	**Metabolism of Lipids** • **Metabolic pathway, Bioenergetics and regulation of:** Fatty acid synthesis, Catabolism of lipids • FAS Complex	**06 L**
Unit 5	**Amino acid and Nucleotide metabolism** • **Metabolic pathway, Bioenergetics and regulation of:** amino acid degradation • **Metabolic fates of amino groups** • **Metabolic pathway, Bioenergetics and regulation:** Purines and Pyrimidine biosynthesis: De novo pathway and Salvage pathway, ribonucleotide reductase	**12 L**

Suggested readings:

1. White, D. (2000) The Physiology and Biochemistry of Prokaryotes, Oxford University Press, New York, USA
2. White, D., Drummond, J. and Fuqua, C. (2011) The Physiology and Biochemistry of Prokaryotes, 4th edn., Oxford University Press, New York
3. Cohen, G.N. (2014) Microbial Biochemistry, 2nd edn., Springer
4. Gottschalke, G (2004) Bacterial Metabolism, Springer, Weinheim
5. Moat, A. G., Foster, J. and Spector, M.P. (2002) Microbial Physiology, 4th edn., Wiley Interscience Publ., New York
6. Nelson, D.L. and Cox, M.M. (2000) Lehninger's Principles of Biochemistry, CBS Publications, New Delhi
7. Stryer, L. (2002) Biochemistry, 5th Edn., W.H. Freeman and Co., New York, USA

8. Price, N.C. and Stevens, L. (2000) Fundamentals of Enzymology, 3rd edn., Oxford University Press, NY, USA.
9. Voet, D., Voet, J.G. and Pratt C.W. (1999) Fundamentals of Biochemistry. John Wiley and Sons, Inc., Chicheter, UK
10. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2003) Harper's Biochemistry. Appleton and Lange, Stamford, Connecticut.
11. Jain, J.L., Jain, S. and Jain, N. (2009) Fundamentals of Biochemistry, S Chand, New Delhi
12. Doelle, H.W. (1975) Microbial Metabolism, 2nd Edn, Academic Press, London

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C102.1	Acquire knowledge on metabolism of biomolecules	**3**
C102.2	Familiarise with amino acids, proteins, lipids, nucleic acids and enzymes	**4**
C102.3	Understand biochemical reactions in microbial cells and metabolic pathway diversity	**2**

MB-103: Methods in Microbiology

Course Objectives:
1. To familiarize in General Microbiology techniques
2. To learn the basic microbial techniques used for characterization of microbial system
3. To know about effect of environmental condition on microbes

1	Biosafety: Safe Laboratory techniques, Equipment related hazards, Biosafety cabinets, Transport of infectious material/cultures, Waste disposals, Fire and electricity hazards, Immunisation to staff.
2	Growth Curve of yeast by Turbidity (Spectrophotometer/ Nephelometer) and Dry mass (Centrifugation) measurement
3	Isolation and cultivation of cyanobacteria/ Algae
4	Study on fungal hyphal growth and study on isolation, morphology of Actinomycetes
5	Isolation of Bacteriophage by plaque assay and enumeration
6	Isolation and partial characterisation of Acidophile/ Alkalophiles/ Halophile/ Thermophile/ Psychrophile bacteria from acidic/alkaline/high salt/high/low temperature environments
7	Cultivation of cancer cell lines (HeLa/ CHO/---)
8	SDS PAGE of protein
9	Agarose gel electrophoresis of DNA
10	Gel Permeation Chromatography/Affinity chromatography
11	16S rRNA gene sequence analysis using BLAST and preparation of phylogenetic tree
12	Demonstration of HPLC/ GC/AAS

Suggested readings:

1. Norris, J. R. Ribbons D. W. (Ed) (1969) Methods in Microbiology, Volume 1, Academic Press Inc. Ltd., London
2. Harley, J. P., Lansing, M. Prescott, H. (2002) 5th Edn., Laboratory Exercises in Microbiology, The McGraw−Hill Companies, New York
3. Benson, H.J. (2001) Microbiological Applications Lab Manual, 8th Edn. The McGraw−Hill Companies, New York
4. Aneja, K.R. (1996) Experiments in Microbiology, 3rd edn., Wishwa Prakashan, New Delhi.
5. Parija, S.C. (2005) Text Book of Practical Microbiology, Ahuja Publishing House, New Delhi.

6. Dubey, R.C. and Maheshwari, D.K. (2004) Practical Microbiology, S. Chand and Co. New Delhi.
7. Cappuccino, J.G. and Sherman, N. (2014) Microbiology: A Laboratory Manual. 10th Edition, Pearson Education Inc., San Francisco.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C103.1	Develop expertise in basic analytical techniques of microbiology.	**3**
C103.2	Get knowledge in the analysis of biomolecules	**3**
C103.3	Carry out microbial techniques related to isolation, identification of algae, fungi, archea	**4**

MB - 104: Methods in Microbial Chemistry

	Course Objectives: 1. To familiarize the student in biochemical techniques and learn basic microbial biochemistry 3. To utilize bioinformatics software tool to understand the biomolecule
1	Basic biochemical techniques: Use of hand glove, Use of pipette aid, Preparation of standard solutions and buffers, Dilution approaches.
2	Determination of pKa value of amino acid
3	Quantitative analysis reducing sugar by DNSA method
4	Quantitative analysis of total carbohydrate by Phenol sulphuric acid method
5	Quantitative analysis of protein by Folin-Ciocalteu / Biuret method and UV absorption method
6	Quantitative analysis of amino acids by ninhydrin method
7	Quantitative estimation of fatty acids by titration method
8	Determination of Iodine number and acid number of lipid sample
9	Detection of changes in the conformation of bovine serum albumin by viscosity measurement
10	Identification of the C-terminal amino acid of Protein
11	Quantitate estimation of DNA by Diphenyl Amine method
12	Quantitate estimation of RNA by Orcinol method
13	Study of biomolecules using RasMol/ SPDBV software
14	Demonstration of TLC for detection of biomolecules: Sugars and amino acids

Suggested readings:

1. Thomas, G.M. and Shalkhammer, (2004) Analytical Biotechnology, Springer, New Delhi
2. Thimmaiah, S.R. (2006) Standard Methods of Biochemical Analysis, Kalyani Publishers, New Delhi.
3. Plummer, D.T. (2001) An Introduction to Practical Biochemistry, 3rd edn., McGraw Hill Ltd. New Delhi
4. Sawhey, S.K. and Singh, R. (2002) Introductory Practical Biochemistry, Narosa Publication House, New Delhi.
5. Jayaraman, J. (2008) Laboratory Manual in Biochemistry, New Age International, New Delhi.
6. Schmauder, H.P, Schweizer, M. and Schewizer, L.M. (2003) Methods in Biotechnology, Taylor and Francis Ltd., London

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C104.1	Acquire expertise in basic biochemical techniques	**3**
C104.2	Get knowledge in the analysis and estimation of biomolecules	**4**
C104.3	Carry out biochemical analysis	**5**

M.Sc. Part I Semester I Microbiology: Skill Based Course

	MB - 105: Bioinstrumentation	
	Course Objectives: 1. To introduce the student to the variety of biophysical and biochemical techniques 2. To make them familiar with various approaches of analytical techniques	
Unit 1	**Principles of biophysical chemistry** • pH, pOH, pKa, Isoelectric pH, Henderson-Hasselbalch equation, buffer, colligative properties.	**05 L**
Unit 2	**Separation techniques** • **Chromatography:** Principle, design and applications of TLC, HPTLC, GC, HPLC, Gel filtration, • **Electrophoresis and electrofocusing:** Principle, design and applications of Agarose gel and capillary electrophoresis, PAGE, Iso-electric focusing. • Centrifugation and Ultracentrifugation	**16 L**
Unit 3	**Biophysical methods** • **Analysis of biomolecules**: UV/visible spectrophotometer, fluorescence, circular dichroism, IR, NMR and ESR spectroscopy, • **Structure determination**: X-ray diffraction and NMR; analysis using light scattering, different types of mass spectrometry.	**16 L**
Unit 4	**Radiolabeling techniques** • Properties of different types of radioisotopes used in biology, • Detection and measurement of radioactivity • Incorporation of radioisotopes in biological tissues and cells, • Safety guidelines for Radiolabeling techniques	**08 L**
Unit 5	**Microscopic techniques** • Scanning and transmission microscopes, different fixation and staining techniques for Electron microscope, freeze-etch and freeze-fracture methods for Electron microscope, • Image processing methods in microscopy.	**05 L**

Suggested readings:

1. Cantor, C.R. and Schimmel, P.R. (2008)
2. Upadhyay, A., Upadhyay, K. and Nath, N. (2000) **Biophysical Chemistry,** Himalaya Publisher, Nagpur.
3. Friefelder A, D. (1993) **Physical Biochemistry,** 2nd Edn. W. H. Freeman & Co., USA.
4. Van Holde, K. E. (1985) **Physical Biochemistry**, 2nd Edn., Prentice Hall Inc. New Jersey.
5. Skoog, D.A., Hollier, F.J. and Nieman, I.A. (1998) **Principles of Instrumental Analysis,** Harcourt Brace College Publishers, Orlando
6. Wilson, K. and Walker, J. (2000) **Practical Biochemistry: Principles and techniques,** 5th Edn., Cambridge University Press, Cambridge,
7. Willard, H.H. and Merrit, Jr. L.L. (1986) **Instrumental Methods of Chemical Analysis,** CBS Publishers, New Delhi

8. Wilson, K. and Goulding, K.H. **Biologists Guide to Principle and Techniques of Practical Biochemistry,** ELBS Publications, London
9. Mikkelsen, S.R. and Corton, E. (2004) **Bioanalytical Chemistry**, Wiley Interscience, New York
10. Sivasankar, B. (2005) **Bioseparations Principles and Techniques**, Prentice Hall of India Pvt. Ltd., New Delhi
11. Bengt Nölting (2009) **Methods in Modern Biophysics**, 3rd Edn., Springer, Berlin

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C105.1	Acquire knowledge on basic biophysical and biochemical aspects	**3**
C105.2	Learn purification of molecules, analytical tools, electrophoretic separation	**4**
C105.3	Learn how to interpret protein mobility on page under native and SDS	**3**

M.Sc. Part I Semester I Audit Course(s)

AC-101: Practicing Cleanliness
(Compulsory; Campus-level Audit Course; Practical; 2 Credits)

Course Objectives (CObs):

- To make students aware of Clean India Mission, inculcate cleanliness practices and community health awareness.

- Awareness program on
  - Swachh Bharat Abhiyan (Clean India Mission)
  - Clean Campus Mission
  - Role of youth in Clean India Mission
  - Community health awareness
- Cleaning activities inside and surroundings of Department buildings.
- Tree plantation and further care of planted trees
- Waste (Liquid/Solid/e-waste) Management, Japanese 5-S practices
- Planning and execution of collection of Garbage from different sections of University campus
- Role of youth in power saving, pollution control, control of global warming, preservation of ground water and many more issues of national importance.
- Cleanest Department and Cleanest Hostel contests
- Painting and Essay writing competitions
- Community health awareness to keep communicable diseases away

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC101.1	Identify need at of cleanliness at home/office and other public places.	**2**
AC101.2	Plan and observe cleanliness programs at home and other places.	**4**
AC101.3	Practice Japanese 5-S practices in regular life.	**3**

M.Sc. Part I Semester II (Microbiology): Core Courses

MB – 201: Molecular Biology and Bioinformatics		
	Course Objectives: 1. To extend the knowledge on structure and functions of genetic material 2. To introduce genome organization, transcription and translation process in Prokaryotes and study various tools to understand molecular mechanisms. 3. To introduce the basic principles of bioinformatics	
Unit 1	**Basics molecular biology**	**10 L**
	• DNA: topological properties (linking, writhing, twisting number), Structure of super helix, Base flipping, Palindrome, Inverted repeats and stem and loop. • Overview of DNA replication • RNA: Structure, types and functions • Denaturation and renaturation kinetics of nucleic acids • Proteins: Domain and motifs Histone proteins, • DNA-Protein interactions: helix-loop-helix, helix-turn-helix, leucine zipper, Zinc finger motifs,	
Unit 2	**Transcription**	**10 L**
	• Types of RNA polymerase (prokaryotic & eukaryotic), Process of transcription • mRNA processing, editing: capping, adenylation, splicing, RNA transport • Transcriptional regulation: transcriptional bursting/pulsing, specificity factors, enhancers, repressors, activators and general transcription factors • Post-transcriptional modifications, RNA degradation, nuclear transport, mRNA localization, anti-sigma factors, RNAi (siRNA, miRNA and CRISPR mechanism)	
Unit 3	**Translation**	**10 L**
	• Ribosome (structure and composition), Activation of tRNA, tRNA synthetase • Genetic code and its properties • Steps: Initiation: factors and their regulation, Elongation, Termination • Inhibitors • Post translational modification of proteins and protein degradation • Translational regulation: Cytoplasmic polyadenylation, UTR sequence elements, RNA binding proteins, ribosomal regulation, non-sense mediated RNA decay, 5` decapping	
Unit 4	**Protein targeting and degradation**	**10 L**
	• Signal hypothesis • Signal sequences in bacteria • Membrane and Lysosomal protein targeting • HSP and Chaperons • Protein degradation	
Unit 5	**Basic Bioinformatics**	**10 L**
	• Biological databases: Nucleic acid databases (GenBank, EMBL, DDBJ) • Protein sequence data base (UniProt, PDB) • Scoring matrices, local. global and multiple sequence alignment • Database search for homologous sequences, BLAST • Phylogenetic analysis: Overview and tree construction methods	
Suggested Readings: • Lewin B. (2013) Gene XI, Pearson Prentice Hall, Pearson Education, Inc., NT, USA (ISBN: 0-13-123826-4)		

- Malacinski GM (2003) Essentials of Molecular Biology, 4th edn., Jones and Batiett, London. (ISBN: 0-7637-2133-6)
- Watson JD, Baker JA, Bell SP, Gann A, Lewin M, Losick R (2007) Molecular Biology of the Gene, 6th edn., Benjamin Cummings- CSHL Press, USA
- Stryer, Lubert (2002) Biochemistry 5th edn. W. H. Freeman and Co. New York
- Wink M. (2006) An Introduction to Molecular Biotechnology, Wiley-VCH Verlag Gmbh and Co., Weinheim, Germany (ISBN: 978-3-527-31412-6/3-527-31412-1)
- Weaver, RF (1999) Molecular Biology, WCB McGraw-Hill Co. Inc., NY (ISBN: 0-697-14750-9)
- Brown, TA (1995) Essential Molecular Biology, Vol. I, A Practical Approach, IRL Press, Oxford, UK
- Nelson DL & Cox MM (2005) Lehninger's Principles of Biochemistry, 4th edn., McMillan Worth Publ. Inc. NY
- Russell, PJ (1998) Genetics, 5th edn, Benjamin-Cummings Publ. Co. Inc., NY (ISBN: 0-321-0038-2)
- Oliver, RP and Schweizer, M. (1999) Molecular Fungal Biology, Cambridge University Press, Cambridge, UK (ISBN: 0-521-56784-X)
- Klug, WS and Cummings, MR (2003) Concepts of Genetics, 7th edn., Pearson Education Inc., (ISBN: 81-7808-884-3)
- Bates, AD and Maxwell, A (2006) DNA Topology, Indian Edn., Oxford University Press, New Delhi (ISBN: 0-19-56831-X)
- Turner, PC, McLennan, AG, Bates AD and White, MRH (2002) Instant Notes: Molecular Biology, 2nd edn., Viva Books Pvt. Ltd., New Delhi (ISBN: 81-7649-215-9)
- Lesk, AM (2002) Introduction to Bioinformatics, Oxford University Press, UK (ISBN:0-19-925196-7)
- Korf, I, Yandell, M and Bedell, J (2003) An Essential Guide to the Basic Local Alignment Search Tool-BLAST, O'Reilly Network Publishers, Tokyo (ISBN:)
- Baxevanis, A. D. and Ouellette, B. F. F. (2001) Bioinformatics: A practical guide to the analysis of genes and proteins. Second Edition. John Wiley & Sons, New York.
- Mount, D. W. (2001) Bioinformatics: sequence and genome analysis. Cold Spring Harbor Laboratory Press, New York.
- Zoe L. and Terence C. (2004) Bioinformatics: Managing Scientific Data, Morgan Kaufmann Publishers, New Delhi.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C201.1	Receive elaborate knowledge on nucleic acids and molecular mechanisms in bacteria	**3**
C201.2	Understand gene expressions and signal sequences in bacteria	**2**
C201.3	Get thorough knowledge about fundamental aspects on bioinformatics	**5**

	MB - 202: Microbial Enzymology	
	Course Objectives: 1. To understand basic aspects of microbial enzyme 2. To learn the kinetics of enzyme catalysed reactions and applications of enzymes 3. To introduce what kind of catalytic mechanism is adopted in enzyme	
Unit 1	**Basic Enzymology**	**10 L**

	• General Characteristics of enzyme, Ribozyme, Abzyme and Coenzymes • Enzyme Nomenclature, classes of enzymes, enzyme activity, Specific activity, katal, Substrate specificity, Active site • Effects of pH, temperature, substrate concentration, activator on enzyme activity • Enyme turnover: Concept and significance. • Isoenzyme: concept and properties, ex. LDH • Multienzyme complexes: pyruvate dehydrogenase and fatty acid synthetase, advantages of multienzyme complex	
Unit 2	**Enzyme Kinetics** • Elementary reactions, Reversible reactions, Rates of reactions, Transition state, • Equilibrium and steady state theory • The Michaelis–Menten Equation, Concept of Km and Vmax, Double reciprocal plot, Analysis of Kinetic Data. • Enzyme Inhibition: Competitive Inhibition, Non-competitive, Uncompetitive Inhibition and Mixed Inhibition, • Bi-substrate, and Multi substrate reactions	**10 L**
Unit 3	**Catalytic Mechanisms and regulation** • Acid–Base Catalysis, Covalent Catalysis, Metal Ion Catalysis, Electrostatic Catalysis, Catalysis through Proximity and Orientation Effects, Catalysis by Preferential Transition State Binding • Serine Proteases: Kinetics and Catalytic Groups, X-Ray Structures, Catalytic Mechanism, Testing the Catalytic Mechanism, Zymogens • Enzyme regulation: feedback inhibition, feed forward stimulation, enzyme reparation, induction and degradation, enzyme regulation by cAMP, covalent modification, allosteric regulation of enzymes w.r.t. ATCase	**10 L**
Unit 4	**Industrial applications of Enzymes** • Perspective of use of enzyme in industry • Source, Significance and biotechnological applications of Cellulases, Proteases in dough/Flour and protein hydrolysate, Amylases in starch industry, Lipases in oil industry, Pectinases in fruit industry, Laccases	**10 L**
Unit 5	**Extremozymes** • Microbial source, characteristics and biotechnological significance of extremozymes of thermophiles, psychrophiles, acidophiles, alkalophiles, halophiles • Non-aqueous enzymology	**10 L**

Suggested readings

1. Stryer, L. (2004) **Biochemistry**, 5th Edn., W. H. Freeman & Co., New York
2. Palmer, T. (2004) **Enzymes: Biochemistry, Biotechnology and Clinical Chemistry,** Affiliated East-West Press Pvt. Ltd., New Delhi
3. Price, N. C. and Stevens, L. (2000) **Fundamentals of Enzymology**, Oxford University Press, New York.
4. Dixon, M. Webb, E. C., Throne, C.J.R. and Tipton, K. F., **Enzymes**, Academic Press, NY.
5. Cook, Paul, F. and Cleland, W.W. (2007) **Enzyme Kinetics and Mechanism**. Garland Science, New York.
6. Nooralabettu, K. P. (2011) **Enzyme Technology Pacemakar of Biotechnology,** PHI Learning Pvt. Ltd., New Dehli
7. Shanmugam, S. and Sathishkumar, T. (2009) **Enzyme Technology,** I K International, Delhi
8. Satyanaryana, T. (1999) **Biochemistry**, Books and Allied Pvt. Ltd., Calcutta
9. Nelson, D.L. and Cox, M.M. (2000) **Lehninger's Principles of Biochemistry**, CBS Publications, New Delhi.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C202.1	Understand fundamental as well as kinetics of enzyme catalysed reactions	**2**
C202.2	Apply the knowledge to explore applications of various enzymes	**3**
C202.3	Identify how extremophiles act as a source of extremozyme.	**5**

	MB - 203: Immunology	
	Course Objectives: 1. To understand various components of host immune system, its structure and function 2. To acquaint with operational mechanisms of the host defence system, allergy, GVR	
Unit 1	**Overview of the Immune System** • Cells and organs of the immune system • Cytokines and Interleukins • Characteristics and Types: Antigen, Immunogen, Allergen. • Antibody: Types, structure, Antibody diversity (Somatic gene recombination, Genesis of light and heavy chain) • Major Histocompatibility Complex: properties of MHC genes, structure, properties and cellular distribution of MHC molecules, binding of peptides to MHC	**10 L**
Unit 2	**Immune Response** • Cell mediated Immune response: T cell, Types of T cells, T cell activation • Humoral Immune response: B cell, Plasma cell, B cell activation (T dependent and T-independent pathway), regulation of humoral immune responses by Fc receptors • Complement system and Opsonisation • Inflammatory response • Immunologic tolerance: General features of immunologic tolerance, T and B lymphocyte tolerance, tolerance induced by foreign protein antigens	**12 L**
Unit 3	**Hyper immune response** • Graft rejection: Immunological basis, First set and second set of reaction, Significance of HLA and MHC, Immunological Tolerance • Hypersensitivity: types and mechanism with example	**08 L**
Unit 4	**Immune response to infections and diseases** • Immunity against viral and protozoal infections • Cancer immunology: Types of tumours, oncogenesis and tumour antigens (TATAs, TSTA) • Autoimmune diseases: Mechanisms for induction of autoimmunity, Organ-specific and systemic, Treatment of autoimmune diseases • Immunodeficiency diseases (e.g. SCID, CVI, AIDS)	**10 L**
Unit 5	**Histochemical and immunotechniques** • Production of monoclonal and polyclonal antibodies, detection of molecules using ELISA, RIA, western blot, immunoprecipitation and immuno-fluorescence microscopy, • *in situ* localization by FISH and GISH	**10 L**

Suggested readings:

1. Goldsby, R.A., Kindt, T.J. and Osborne, B. and Kuby, A. (2003) **Immunology**, 5th edn., W. H. Freeman and Company, New York.
2. Roitt, I. (2000) **Essentials of Immunology**, 5th edn., Blackwell ELBS Science Publication, Oxford.

3. Paul, W. E (2013) **Fundamental Immunology**, 7th edn., Lippincott Williams and Wilkins Publishers, USA
4. Tizard, I. R. (1995) **Immunology: An Introduction**, Saunders College Publishing, Philadelphia
5. Banerjee, A. K. and Banerjee, N. (2006) **Fundamentals of Microbiology and Immunology**, New Central Book Agency (Pvt.) Ltd., Kolkata
6. Coleman, R.M., Lombard, M.F. and Sicard, R.E. (2000) **Fundamental Immunology**, 4th edn., WmC Publications, London
7. Barrett, James T. (1998) **Microbiology and Immunology Concepts**, Lippincott Williams & Wilkins, Philadelphia, PA
8. Janeway, Charles, Travers, Paul, Walport, Mark and Shlomchik, Mark (2004) **Immunobiology,** Garland Science,
9. Owen, J.A., Punt, J. and Stranford, S.A. (2013) Kuby Immunology, 7th edn, WH Freeman, USA

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C203.1	Understand fundamental basis of immune system and immune response	**2**
C203.2	Apply host defence, allergy, organ transplant and immunological diseases	**3**
C203.3	Use various immunochemical techniques for diagnosis of diseases.	**5**

MB - 204: Methods in Molecular Biology and Immunology

Course Objectives:
1. To impart hands on training in molecular biology and immunochemical techniques
2. To familiarize the student with bacterial gene transfer and immunodiagnostic tools

1	To study bacterial transformation
2	To study bacterial conjugation
3	Isolation and detection of bacterial/ Fungal DNA
4	Plasmid isolation and curing
5	Restriction digestion by endonucleases
6	PCR amplification of DNA
7	To study the spontaneous mutation by Fluctuation test
8	Immuno-diffusion by Ouchterlony double diffusion
9	Immuno-electrophoresis
10	Bacterial gene expression using IPTG inducible promoter
11	ELISA
12	Western/Southern/Northern blot

Suggested readings:

1. Schmauder, H. P., Schweizer, M. and Schweizer, L. M. (2003) **Methods in Biotechnology**, Taylor and Francis, London
2. Joe Sambrook (2001) **Molecular Cloning: A Laboratory Manual**, 3rd Edn., (3 volume set) Cold Spring Harbor Laboratory Press,
3. Sawhey, S.K. and Singh, R. (2002) **Introductory Practical Biochemistry,** Narosa Publication House, New Delhi.
4. Thimmaiah, S.R. (2006) **Standard Methods of Biochemical Analysis**, Kalyani Publishers, Delhi.
5. Davis, L.G., Dibner, M.D. and Battey, J.F. (1986) **Basic Methods in Molecular Biology**, Appleton and Lange, Norwalk.

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C204.1	Undertake gene transfer in different bacteria and make use of PCR amplification of DNA.	**5**
C204.2	Apply molecular diagnostic and immunodiagnostic techniques.	**3**

M.Sc. Part I Semester II (Microbiology): Skill Based Course

MB - 205: Methods in Enzymology

Course Objectives:
1. To introduce qualitative and quantitative tools to search for enzyme from microbes
2. To learn enzyme characteristics and identify use of enzyme

Important note: Use any ONE suitable enzyme from microbial source: Amylase/ Protease/ Phytase/ Laccase/ Lipase/ β-Galactosidase/ Xylanase/ Cellulase for the following experiments

1	Qualitative assay of enzyme detection in microbial source
2	Quantitative assay of enzyme (activity and specific activity)
3	Effect of pH and temperature on enzyme activity
4	Effect of activator and inhibitor on enzyme activity
5	Partial Purification of enzyme by ammonium sulphate precipitation and dialysis or solvent Purification fold and purified enzyme yield calculations of enzyme purification procedures
6	Enzyme Purification by Ultrafiltration/
7	Determination of K_m and V_{max} of enzyme
8	Kinetic study of Inhibitors on K_m and V_{max}
9	Native PAGE
10	Enzyme stabilization by immobilization technique: gel entrapment/ crosslinking
11	Production of maltodextrin using amylase or blood stain removal / gelatinolysis of X-ray film by protease
12	Structural prediction using ExPaSy server
13	Determination of enzyme activity in organic solvent media

Suggested readings:

1. Thimmaiah, S.R. (2006) **Standard Methods of Biochemical Analysis**, Kalyani Publishers, Delhi.
2. Bisswanger, Hans (2011) **Practical Enzymology**, Wiley-VCH, Germany
3. Robert Eisenthal and Michael Danson (2002) **Enzyme Assays: A Practical Approach,** 2nd Edn. Oxford University Press, USA
4. Plummer, D.T. (2001) **In introduction to Practical Biochemistry**, 3rd edn., McGraw Hill Ltd. Delhi
5. Sawhey, S.K. and Singh, R. (2002) **Introductory Practical Biochemistry,** Narosa Publication House, New Delhi.
6. Jayaraman, J. (2008) **Laboratory Manual in Biochemistry**, New Age International, New Delhi

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C205.1	Isolate, purify enzyme of interest from microbial system, characterize the	**5**

	enzyme and trace out application(s) of that enzyme	
C205.2	Use the technique of enzyme assay to determine its specific activity, pH and temperature optima, Km, Vmax, Kcat of enzyme and activation energy using Arrhenius plot.	**4**
C205.3	Immobilize enzyme for particular application and familiarize with algorithm for protein	**5**

M.Sc. Part I Semester II : Audit Courses

	AC-201(A): Soft Skills **(Personality and Cultural Development Related Audit course; Practical; 2 Credits)** **(Optional: Campus-level)**	
	Course Objectives (CObs): • To inculcate different soft skills among students.	
Unit 1	**Introduction to soft skills** Formal definition, Elements of soft skills, Soft vs. Hard skills, Emotional quotient, Goal setting, life skills, Need for soft skills, Communication skills, Etiquettes& Mannerism.	**2 hrs.**
Unit 2	**Self-Assessment** Goal setting, SWOT analysis, attitude, moral values, self-confidence, etiquettes, non-verbal skills, achievements, positive attitude, positive thinking and self-esteem. Activity: The teacher should prepare a questionnaire which evaluate students in all the above areas and make them aware about these aspects.	**4 hrs.**
Unit 3	**Communication Skills** Types of communication: Verbal, Non-verbal, body language, gestures, postures, gait, dressing sense, facial expressions, peculiarity of speaker (habits). Rhetoric speech: Prepared speech (topics are given in advance, students get 10 minutes to prepare the speech and 5 minutes to deliver, Extempore speech (students deliver speeches spontaneously for 5 minutes each on a given topic), Storytelling (Each student narrates a fictional or real-life story for 5 minutes each), Oral review (Each student orally presents a review on a story or a book read by them) Drafting skills: Letter, Report & Resume writing, business letters, reading & listening skills Activity: The teacher should teach the students how to write the letter, report and build resume. The teacher should give proper format and layouts. Each student will write one formal letter, one report and a resume.	**8 hrs.**
Unit 4	**Formal Group Discussion, Personal Interview & Presentation skills** Topic comprehension, Content organization, Group speaking etiquettes, driving the discussion & skills. Preparation for personal interview: dress code, greeting the panel, crisp self-introduction, neatness, etiquettes, language tone, handling embarrassing & tricky questions, graceful closing. Activity: Each batch is divided into two groups of 12 to 14 students each. Two rounds of a GD for each group should be conducted and teacher should give them feedback. Mock interview are to be conducted.	**4 hrs.**
Unit 5	**Aptitude and analytical skills** Quantitative aptitude, Numerical reasoning, verbal reasoning, diagrammatic test, situational tests, logical thinking. Analytical skills: Definition, Types, problem solving	**8 hrs.**

Unit 6	**Life skills** Time management, critical thinking, sound and practical decision making by dealing with conflicts, stress management, leadership qualities Activity: The teacher can conduct a case study activity to train students for decision making skills. The teacher should conduct a session on stress management and guide students on how to manage stress. The teacher may conduct a stress relieving activity in the class. He/she may counsel students individually to know their problems and guide them on dealing with them effectively.	**4 hrs.**

Suggested readings:

1. Basics of Communication In English: Francis Sounderaj, MacMillan India Ltd.
2. English for Business Communication: Simon Sweeney, Cambridge University Press
3. An Introduction to Professional English and Soft Skills: Das, Cambridge University Press
4. Quantitative Aptitude: R.S. Agrawal

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201A.1	Identify their lacunas about some soft skills and try to overcome the same.	**2**
AC201A.2	Practice learned soft skills in real life and do their jobs more effectively.	**3**

AC-201(B): Practicing Sports Activities

(Personality and Cultural Development Related Audit course; Practical; 2 Credits)
(Optional: Campus-level)

Course Objectives (CObs):

- To motivate students towards sports and provide them required training.

SR NO.	NAME OF THE SPORT/GAME (Select ONE of the Following)	SYLLABUS OF THE COURSE	TIMING (02 Hours in a Week)	SEMESTER
1	Volleyball	• General Fitness • Basic Fitness • Specific Fitness • History of the Game • Basic Skill of the Game • Major Skill of the Game • Technique & Tactics of the Game • Game Practice	Morning : 07 to 09 AM OR Evening : 05 to 07 PM	Total 30 Hours in Each Semester
2	Athletics			
3	Badminton			
4	Cricket			
5	Basketball			
6	Handball			
7	Kabaddi			
8	Kho-Kho			
9	Table-Tennis			
10	Swimming			

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201B.1	Identify one or more sports of their choice and develop more interest to participate at University/National level sport events.	**2**
AC201B.2	Practice the learned sports activities regularly in real life.	**3**

AC-201(C): Practicing Yoga

(Personality and Cultural Development Related Audit course; Practical; 2 Credits)
(Optional: Campus-level)

Course Objectives:

- To motivate students towards yoga and provide them required training.

- Yog: Meaning, Definition & Introduction, Objectives
- Primary Introduction of Ashtanga Yoga
- Preparation of Yogabhyas
- Omkar Sadhana, Prayer, Guru Vandana
- Sukshma Vyayamas
- Suryanamaskar (12 Postures)
- Asanas :
  - Sitting (Baithaksthiti) - Vajrasana, Padmasan, Vakrasan, Ardha-Pashchimotanasanan
  - Supine (Shayansthiti) - Uttan Padaasan(Ekpad/Dwipad), Pavanmuktasana, Viparitakarani Aasan, Khandarasan, Shavasana
  - Prone (Viparitshayansthiti) - Vakrahasta, Bhujangasana, Saralhasta Bhujangasana, Shalabhasana(Ekpad/Dwipad), Makarasana
  - Standing (Dhandsthiti) - Tadasana , TiryakTadasana, Virasana, Ardh Chakrasana
- Primary Study of Swasana: Dirghaswasana, Santhaswasana, JaladSwasana - 6 Types
- Pranayama : Anuloma-viloma, Bhramari

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201C.1	Identify and practice some Yoga asanas regularly in their life to remain healthy.	**2**
AC201C.2	Provide guidance and practice about Yoga to their friends, parents and relatives.	**3**

AC-201(D): Introduction to Indian Music

(Personality and Cultural Development Related Audit course; Practical; 2 Credits)
(Optional: Campus-level)

Course Objectives:

- To motivate students towards Indian music and provide them minimum required training.
- Definition and brief about generation of Swar, Saptak, Thaat, Raag, Aavartan, Meend, Khatka, Murkee, Taal, Aalaap etc.
- Taal and its uses - Treetaal, Daadraa, Zaptaal, Kervaa.
- Information of Badaakhyaal, Chhotaakhyaal (one), Sargam, Lakshangeet (information)
- Detailed information of Tambora
- Detailed information of Harmonium and Tablaa.
- Five filmy songs based on Indian Classical Music (Theory and Presentation)
- Sound Management - Basic information of Sound Recording (including Practicals)
- Composition of Music as per the Story
- Preparing news write-ups of the Seminars, Library Musical Programmes held at the nearest Akashwani, by personal visits.

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201D.1	Identify different types of Indian music.	**3**
AC201D.2	Develop more interest to learn and practice Indian music.	**4**

Epilogue

Skills imparted:
This is the first-year syllabus of the two-year post-graduate course in Microbiology. Overall, the curriculum is designed in such way that the student will get basic and applied knowledge of the subject. One of the major objectives considered during designing is to create human resource which is technically sound with knowledge having practical utility. The included basic subjects in theory and practical would be helpful to find out unseen facts in various problems in day to day life. The subjects like genetic engineering, and bioinstrumentation are designed in such a way that students will get theoretical and practical knowledge of modern scientific advances in the field. To make skillful human resource with precision, the important allied courses are also included. This course after completion of 2 years would give not only the practical knowledge of industry and industrial processes but also make aware the students with the global environmental problems like pollutions, contamination, infections and food quality.

Practical courses are based on theory courses and are designed to improve research-oriented skills of students.

Job opportunity: The designed curriculum offers job opportunities in various sectors like,

- Pharmaceutical industry: Clinical, medicine, vaccine, QC division
- Biotech industry: Recombinant product, QC, QA
- Agrochemical & pesticide industry
- Chemical industry: synthesis, testing
- Environmental protection industry & Agencies
- Research leading up to Ph. D. degree
- Marketing of biological & pharmaceutical products
- Food and nutraceutical industry, Govt. agencies

Entrepreneurship: This is another avenue available for the candidates making them sound in technical knowledge of Microbiology upon completion of this two year post graduate course that could be useful in Entrepreneurship in Microbiology.

Equivalence

M.Sc. Microbiology (Affiliated Colleges)

Old Syllabus (AY 2018-2019)	New Syllabus (CBCS pattern AY 2021-22)
SEM-I	
MB-101: Microbial Taxonomy and Diversity (T)	**MB-101**: Microbial Taxonomy and Diversity (T)
MB 102: Microbial Biochemistry (T)	**MB 102** - Microbial Physiology and Biochemistry (T)
MB-103: Bioanalytical Techniques (T)	**MB-105**: Bioinstrumentation (T)
MB 104: Methods in Microbiology (P)	**MB 103**: Methods in Microbiology (P)
MB 105: Methods in Biochemistry (P)	**MB 104**: Methods in Microbial Chemistry (P)
SEM-II	
MB-201: Microbial Genetics (T)	**MB 201**: Molecular Biology and Bioinformatics (T)
MB-202: Microbial Enzymology (T)	**MB 202**: Microbial Enzymology (T)
MB-203: Immunology (T)	**MB 203**: Immunology (T)
MB-204: Methods in Enzymology (P)	**MB 205**: Methods in Enzymology (P)
MB-205: Methods in Molecular Biology & Immunology (P)	**MB 204**: Methods in Molecular Biology & Immunology (P)

AY: Academic Year, (T) : Theory, (P): Practical

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