K. C. E. Society's
Moolji Jaitha College
An 'Autonomous College' Affiliated to
K.B.C. North Maharashtra University, Jalgaon.
NAAC Reaccredited Grade - A (CGPA : 3.15 - 3rd Cycle)
UGC honoured "College of Excellence" (2014-2019)
DST(FIST) Assisted College

KNOWLEDGE IS POWER
ESTD. 1945

के. सी. ई. सोसायटीचे
मूळजी जेठा महाविद्यालय
क.ब.चौ. उत्तर महाराष्ट्र विद्यापीठ, जळगाव संलग्नित
'स्वायत्त महाविद्यालय'
नॅकद्वारा पुनर्मानांकित श्रेणी – 'ए' (सी.जी.पी.ए. : ३.१५ – तिसरी फेरी)
विद्यापीठ अनुदान आयोगाद्वारा घोषित 'कॉलेज ऑफ एक्सलन्स' (२०१४-२०१९)
डी.एस.टी. (फीस्ट) अंतर्गत अर्थसहाय्य प्राप्त

Date :- 25/04/2025

NOTIFICATION

Sub :- CBCS Syllabi of B. Sc. in Microbiology (Sem. V & VI)

Ref. :- Decision of the Academic Council at its meeting held on 22/04/2025.

The Syllabi of B. Sc. in Microbiology (Fifth and Sixth Semesters) as per **NATIONAL EDUCATION POLICY – 2020 (2023 Pattern)** and approved by the Academic Council as referred above are hereby notified for implementation with effect from the academic year 2025-26.

Copy of the Syllabi Shall be downloaded from the College Website (www.kcesmjcollege.in)

Sd/-
Chairman,
Board of Studies

To :

1) The Head of the Dept., M. J. College, Jalgaon.
2) The office of the COE, M. J. College, Jalgaon.
3) The office of the Registrar, M. J. College, Jalgaon.

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समर्थ कॉलनी जवळ, जळगांव – ४२५ ००२. (महाराष्ट्र, भारत) । दूरध्वनी क्र. : +९१ २५७–२२३७३६३, २२३४२८१ । ई–मेलः mjcollege@kces.in । वेबसाईटः mjcollege.kces.in

Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College"

Affiliated to

Kavayitri Bahinabai Chaudhari

North Maharashtra University, Jalgaon-425001

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STRUCTURE AND SYLLABUS

B.Sc. Honours/Honours with Research (T.Y. B.Sc. Microbiology)

Under Choice Based Credit System (CBCS)

and

as per NEP-2020 Guidelines

[w.e.f. Academic Year: 2025-26]

Preface

Skilled human resources is a prerequisite in higher education, and it is necessary to acquire a thorough knowledge of theoretical concepts and hands-on laboratory methods. The Moolji Jaitha College (Autonomous) has adopted a department-specific model in accordance with the guidelines of the UGC, NEP-2020, and the Government of Maharashtra. The Board of Studies in Microbiology and Biotechnology of the college has prepared the syllabus for the Third-year undergraduate of Microbiology. The syllabus develops theoretical and practical knowledge in various fields of microbiology. The syllabus contents have been prepared to encompass both the fundamental and applied aspects of various microbiology disciplines. Additionally, in the first year, students will be educated about the skills related to microbial isolation, identification, and testing, which will enhance their employability.

The overall curriculum, spanning three to four years, covers general microbiology, biomolecules and microbial metabolism, molecular biology and microbial genetics, medical microbiology and immunology, industrial and applied microbiology, and environmental microbiology, as well as various biotechniques. Furthermore, the syllabus is meticulously structured to cater to the present and future needs of the Industrial Sector, research field, Environmental Area, and entrepreneurship, ensuring that our graduates are well-prepared for real-world challenges. The curriculum strongly emphasises imparting hands-on skills, with more experiments that run hand-in-hand with theory. The detailed syllabus of each paper is appended with a list of suggested readings.

Hence, the Board of Studies in Microbiology and Biotechnology, in its meeting held on 22 March 2025, resolved to accept the revised syllabus for T.Y. B.Sc. (Microbiology) based on the Choice-Based Credit System (CBCS) of the UGC, NEP-2020, and the Government of Maharashtra guidelines.

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

Program outcomes associated with a B.Sc. degree are as follows:

No.	PO
1	Graduates should have a comprehensive knowledge and understanding of the fundamental principles, theories, and concepts in their chosen field of study.
2	Graduates should possess the necessary technical skills and competencies related to their discipline, including laboratory techniques and data analysis.
3	Graduates should be able to identify, analyze, and solve complex problems using logical and critical thinking skills. They should be able to apply scientific methods and principles to investigate and find solutions.
4	Graduates should be proficient in effectively communicating scientific information, both orally and in writing.
5	Graduates should possess a solid foundation in research methods and be able to design and conduct scientific investigations.
6	Graduates should be able to work effectively as part of a team, demonstrating the ability to collaborate with others, respect diverse perspectives, and contribute to group projects.
7	Graduates should recognize the importance of ongoing learning and professional development. They should be equipped with the skills and motivation to engage in continuous learning, adapt to new technologies and advancements in their field, and stay updated with current research.

Programme Specific Outcome (PSO) for B.Sc. Microbiology Honours/Honours with Research:

After completion of this program, students are expected to learn/understand the:

PSO No.	PSO
1	Isolation, identification and characterization of various microbes from diverse habitats.
2	Impact of various groups of microbes on atmosphere, plant, human and animal health.
3	Principle and applications of various bio-analytical tools and techniques
4	Structure, properties, pathways and applications of biomolecules in various fields
5	Biochemical mechanisms, regulation and application of enzymes in various sectors
6	Applications of microbes in various fields such as agriculture, industry, medicine, etc.

Multiple Entry and Multiple Exit options:

The multiple entry and exit options with the award of UG certificate/ UG diploma/ or three-year degree depending upon the number of credits secured;

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
4.5	UG Certificate	40	44	2	1
5.0	UG Diploma	80	88	4	2
5.5	Three-Year Bachelor's Degree	120	132	6	3
6.0	Bachelor's Degree- Honours **Or** Bachelor's Degree- Honours with Research	160	176	8	4

Credit distribution structure for Three/Four-year Honors/ Honors with Research Degree Programme with Multiple Entry and Exit

F.Y. B.Sc.

Year (Level)	Sem	Subject-I (M-1)	Subject-II (M-2)	Subject-III (M-3)	Open Elective (OE)	VSC, SEC (VSEC)	AEC, VEC, IKS	CC, FP, CEP, OJT, RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
I (4.5)	I	DSC-1(2T) DSC-2(2P)	DSC-1(2T) DSC-2(2P)	DSC-1(2T) DSC-2(2P)	OE-1(2T)	---	AEC-1(2T) (Eng) VEC-1(2T) (ES) IKS(2T)	CC-1(2T)	22	**UG Certificate**
	II	DSC-3(2T) DSC-4(2P)	DSC-3(2T) DSC-4(2P)	DSC-3(2T) DSC-4(2P)	OE-2(2T) OE-3(2P)	---	AEC-2(2T) (Eng) VEC-2(2T) (CI)	CC-2(2T)	22	
	Cum. Cr.	**8**	**8**	**8**	**6**	**---**	**10**	**4**	**44**	
Exit option: Award of UG Certificate with 44 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major and Minor.										

S.Y. B.Sc.

Year (Level)	Sem	Subject-I (M-1) Major*		Subject-II (M-2) Minor #	Subject-III (M-3)	Open Elective (OE)	VSC, SEC (VSEC)	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
		Mandatory (DSC)	Elective (DSE)	(MIN)							
2 (5.0)	III	DSC-5(2T) DSC-6(2T) DSC-7(2P)	---	MIN-1(2T) MIN-2(2T) MIN-3(2P)	---	OE-4(2T)	SEC-1(2T)	AEC-3(2T) (MIL)	CC-3(2T) CEP(2)	22	**UG Diploma**
	IV	DSC-8(2T) DSC-9(2T) DSC-10(2P)	---	MIN-4(2T) MIN-5(2P)	---	OE-5(2T)	SEC-2(2T) SEC-3(2P)	AEC-4(2T) (MIL)	CC-4(2T) ۞FP(2)	22	
	Cum. Cr.	**12**	**---**	**10**	**---**	**4**	**6**	**4**	**8**	**44**	
	Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major & Minor.										

***** Student must choose one subject as a Major subject out of M-1, M-2 and M-3 that he/she has chosen at First year

Student must choose one subject as a Minor subject out of M-1, M-2 and M-3 that he/she has chosen at First year (Minor must be other than Major)

۞ OJT/Internship/CEP should be completed in the summer vacation after 4th semester

T.Y. B.Sc.

Year (Level)	Sem	Subject-I (M-1) Major		Subject-II (M-2) Minor	Subject-III (M-3)	Open Elective (OE)	VSC, SEC (VSEC)	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
		Mandatory (DSC)	Elective (DSE)	(MIN)							
3 (5.5)	V	DSC-11(2T) DSC-12(2T) DSC-13(2T) DSC-14(2P) DSC-15(2P)	DSE-1A/B (2T) DSE-2A/B (2P)	---	---	---	VSC-1(2T) VSC-2(2P)	---	OJT/Int (4)	22	UG Degree
	VI	DSC-16(2T) DSC-17(2T) DSC-18(2T) DSC-19(2T) DSC-20(2T) IKS DSC-21(2P) DSC-22(2P)	DSE-3A/B (2T) DSE-4A/B (2P)	---	---	---	VSC-3(2T) VSC-4(2P)	---	---	22	
	Cum. Cr.	**24**	**8**	**---**	**---**	**---**	**8**	**---**	**4**	**44**	
	Exit option: Award of UG Degree in Major with 132 credits OR Continue with Major and Minor										

Fourth Year B.Sc. (Honours)

Year (Level)	Sem	Major Core Subjects		Research Methodology (RM)	VSC, SEC (VSEC)	OE	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
IV (6.0)	VII	DSC-23(4T) DSC-24(4T) DSC-25(4T) DSC-26(2P)	DSE-5A/B (2T) DSE-6A/B (2P)	RM(4T)	---	---	---	---	22	UG Honours Degree
	VIII	DSC-27(4T) DSC-28(4T) DSC-29(4T) DSC-30(2P)	DSE-7A/B (2T) DSE-8A/B (2P)	---	---	---	---	OJT/Int (4)	22	
	Cum. Cr.	**28**	**8**	**4**	**---**	**---**	**---**	**4**	**44**	
Four Year UG Honors Degree in Major and Minor with 176 credits										

Fourth Year B.Sc. (Honours with Research)

Year (Level)	Sem	Major Core Subjects		Research Methodology (RM)	VSC, SEC (VSEC)	OE	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
IV (6.0)	VII	DSC-23(4T) DSC-24(4T) DSC-26(2P)	DSE-5A/B (2T) DSE-6A/B (2P)	RM(4T)	---	---	---	RP(4)	22	UG Honours with Research Degree
	VIII	DSC-27(4T) DSC-28(4T) DSC-30(2P)	DSE-7A/B (2T) DSE-8A/B (2P)	---	---	---	---	RP(8)	22	
	Cum. Cr.	**20**	**8**	**4**	**---**	**---**	**---**	**12**	**44**	
Four Year UG Honours with Research Degree in Major and Minor with 176 credits										

Sem- Semester, **DSC**- Department Specific Course, **DSE**- Department Specific Elective, **OE/GE**- Open/Generic elective, **VSC**- Vocational Skill Course, **SEC**- Skill Enhancement Course, **VSEC**- Vocation and Skill Enhancement Course, **AEC**- Ability Enhancement Course, **IKS**- Indian Knowledge System, **VEC**- Value Education Course, **T**- Theory, **P**- Practical, **CC**-Co-curricular **RM**- Research Methodology, **OJT**- On Job Training, **FP**- Field Project, **Int**- Internship, **RP**- Research Project, **CEP**- Community Extension Programme, **ENG**- English, **CI**- Constitution of India, **MIL**- Modern Indian Language

- Number in bracket indicates credit
- The courses which do not have practical 'P' will be treated as theory 'T'
- If the student selects a subject other than faculty in the subjects M-1, M-2 and M-3, then that subject will be treated as a Minor subject and cannot be selected as a Major in the second year.

Details of T.Y. B.Sc. (Microbiology)

Course	Course Type	Course Code	Course Title	Credits	Teaching Hours/ Week			Marks			
					T	P	Total	Internal		External	
								T	P	T	P
Semester V, Level – 5.5											
DSC-11	DSC	MIB-DSC-351	Disease and Clinical Microbiology	2	2	---	2	20	---	30	---
DSC-12	DSC	MIB-DSC-352	Microbial Metabolism	2	2	---	2	20	---	30	---
DSC-13	DSC	MIB-DSC-353	Microbial Genetics	2	2	---	2	20	---	30	---
DSC-14	DSC	MIB-DSC-354	Practical on Diagnostic Microbiology	2	---	4	4	---	20	---	30
DSC-15	DSC	MIB-DSC-355	Practical on Biomolecules	2	---	4	4	---	20	---	30
DSE-1A	DSE	MIB-DSE-351A	Applied Microbiology	2	2	---	2	20	---	30	---
DSE-1B	DSE	MIB-DSE-351B	Biological process design for wastewater treatment	2	2	---	2	20	---	30	---
DSE-2A	DSE	MIB-DSE-352A	Practical on Applied Microbiology	2	---	4	4	---	20	---	30
DSE-2B	DSE	MIB-DSE-352B	Practical on waste management	2	---	4	4	---	20	---	30
VSC-1	VSC	MIB-VSC-351	Fermentation Technology	2	2	---	2	20	---	30	---
VSC-2	VSC	MIB-VSC-352	Practical on fermentation technology	2	---	4	4	---	20	---	30
OJT/Int	OJT	MIB-OJT-351	On Job Trainning/Internship	4	---	8	8	---	40	---	60
Semester VI, Level – 5.5											
DSC-16	DSC	MIB-DSC-361	Immunology	2	2	---	2	20	---	30	---
DSC-17	DSC	MIB-DSC-362	Microbial Enzymology	2	2	---	2	20	---	30	---
DSC-18	DSC	MIB-DSC-363	Concepts in Molecular Biology	2	2	---	2	20	---	30	---
DSC-19	DSC	MIB-DSC-364	Environmental Microbiology	2	2	---	2	20	---	30	---
DSC-20	DSC/IKS	MIB-DSC-365	Indian Knowledge System in Microbiology	2	2	---	2	20	---	30	---
DSC-21	DSC	MIB-DSC-366	Practical on Immunology and Enzymology	2	---	4	4	---	20	---	30
DSC-22	DSC	MIB-DSC-367	Practical on Molecular and Environmental Biology	2	---	4	4	---	20	---	30
DSE-3A	DSE	MIB-DSE-361A	Agricultural Microbiology	2	2	---	2	20	---	30	---
DSE-3B	DSE	MIB-DSE-361B	Microbiology for Sustainable Food Systems	2	2	---	2	20	---	30	---
DSE-4A	DSE	MIB-DSE-362A	Practical on Agricultural Microbiology	2	---	4	4	---	20	---	30
DSE-4B	DSE	MIB-DSE-362B	Practical on Food Microbiology	2	---	4	4	---	20	---	30
VSC-3	VSC	MIB-VSC-361	Pharmaceutical Microbiology	2	2	---	2	20	---	30	---
VSC-4	VSC	MIB-VSC-362	Practical on Pharmaceutical Microbiology	2	---	4	4	---	20	---	30

Examination Pattern

Theory Question Paper Pattern:

- 30 (External) +20 (Internal) for 2 credits
    - External examination will be of 1½ hours duration
    - There shall be 3 questions: Q1 carrying 6 marks and Q2, Q3 carrying 12 marks each. The tentative pattern of question papers shall be as follows;
    - Q1 Attempt any 2 out of 3 sub-questions; each 3 marks
    - Q 2 and Q3 Attempt any 3 out of 4 sub-question; each 4 marks.

Rules of Continuous Internal Evaluation:

The Continuous Internal Evaluation for theory papers shall consist of two methods:

1. Continuous & Comprehensive Evaluation (CCE): CCE will carry a maximum of 30% weightage (30/15 marks) of the total marks for a course. Before the start of the academic session in each semester, the subject teacher should choose any three assessment methods from the following list, with each method carrying 10/5 marks:

i. Individual Assignments
ii. Seminars/Classroom Presentations/Quizzes
iii. Group Discussions/Class Discussion/Group Assignments
iv. Case studies/Case lets
v. Participatory & Industry-Integrated Learning/Field visits
vi. Practical activities/Problem Solving Exercises
vii. Participation in Seminars/Academic Events/Symposia, etc.
viii. Mini Projects/Capstone Projects
ix. Book review/Article review/Article preparation
x. Any other academic activity
xi. Each chosen CCE method shall be based on a particular unit of the syllabus, ensuring that three units of the syllabus are mapped to the CCEs.

2. Internal Assessment Tests (IAT): IAT will carry a maximum of 10% weightage (10/5 marks) of the total marks for a course. The IAT will be conducted at the end of the semester and will assess the remaining units of the syllabus that were not covered by the CCEs. The subject teacher is at liberty to decide which units are to be assessed using CCEs and which unit is to be assessed on the basis of IAT.The overall weightage of Continuous Internal Evaluation (CCE + IAT) shall be 40% of the total marks for the course. The remaining 60% of the marks shall be allocated to the semester-end examinations.The subject teachers are required to communicate the chosen CCE methods and the corresponding syllabus units to the students at the beginning of the semester to ensure clarity and proper preparation.

Practical Examination Credit 2: Pattern (30+20)

External Practical Examination (30 marks):

- Practical examination shall be conducted by the respective department at the end of the semester.
- Practical examination will be of 3 hours duration and shall be conducted as per schedule.
- Practical examination shall be conducted for 2 consecutive days for 2 hr/ day where incubation conditions required.
- There shall be 05 marks for journal and viva voce. A certified journal is compulsory to appear for practical examination.

Internal Practical Examination (20 marks):

- The department will conduct the internal practical examination of 10 marks as per the schedule given.
- For internal practical examination, students must produce the laboratory journal of completed practicals, along with the completion certificate signed by the concerned teacher and the Head of the department.
- There shall be continuous assessment of 30 marks based on student performance throughout the semester. This assessment may include quizzes, group discussions, presentations, and other activities assigned by the faculty during regular practical sessions. For details, refer to internal theory examination guidelines.
- Finally 40 (10+30) marks performance of student will be converted into 20 marks.

SEMESTER-V

T.Y. B.Sc. Microbiology (Major)
Semester-V
MIB-DSC-351: Disease and Clinical Microbiology

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To understand the human anatomy with functions and microbial Infections. ▪ To introduce the concepts of pathological sampling and routine diagnosis. ▪ To gain knowledge about biochemical and microbial tests ▪ To update the students about infectious diseases.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Get a clear vision of various aspects of human systems and infectious diseases. ▪ Understand the methods of sampling, haematology, and serology. ▪ To implement the tests biochemical and microbial tests for diseases. ▪ Aware about various types of diseases and their mechanism of infection.	
Unit	**Contents**	**Hours**
Unit I	**Human system: Anatomy and microbial infections** Anatomical changes and pathophysiology evidence during microbial infection ▪ Respiratory System ▪ Gastrointestinal System ▪ Central Nervous System - CNS and PNS ▪ Excretion system – Urinary tract ▪ Special Senses – Eye, Ear, Skin ▪ Reproductive system	**7**
Unit II	**Diagnosis of infection I** ▪ Preliminary diagnosis based on signs and symptoms ▪ Collection of pathological sample o Blood, urine, sputum, stool, throat swab, CSF ▪ Routine diagnostic tests o Hematology**:** Hemoglobin, hematocrit, enumeration of blood cells o Urine analysis ▪ Serological tests (Principle, method and interpretation) o Widal, VDRL, Malaria, HIV DOT ELISA	**7**
Unit III	**Diagnosis of infection II** ▪ Biochemical tests (Principle, method and interpretation) o albumin, urea, uric acid and bilirubin, SGOT, SGPT ▪ Microbiological tests o Microscopy, isolation, antibiotic sensitivity and M.D.R., M.I.C. ▪ Advanced diagnostics: PCR/RT-PCR, DNA probe, Biolog and VITEK system.	**8**
Unit IV	**Unit IV: Microbial infections and diseases** Study of diseases concerning causative agent, infectious dose, the portal of entry, pathogenicity, epidemiology, laboratory diagnosis, prophylaxis, treatment, prevention and control of the following: ▪ Bacterial diseases –Tuberculosis, Typhoid, Tetanus ▪ Viral diseases – Rabies, Hepatitis ▪ Protozoal diseases – Malaria, Amoebic dysentery ▪ Fungal disease – Candidiasis ▪ Antibacterial agents: modes of action with an example	**8**

Study Resources

- Ananthanarayan R, Paniker Jayaram, SaxenaSonal (2024) Ananthanarayan and Paniker's Textbook of Microbiology, Orient Longman, Madras.
- Atlas, R. M. (1995), Microorganisms in our world, Mosby Yearbook Inc

- Chakraborty P (2013), A textbook of Microbiology, New Central Book Agency, Delhi
- Davis, B. D., Dulbecco, R., Eisen, H. N., Ginsberg, R. S., (1990), Microbiology, 4th Ed., Harper and Row Publishers, Singapore
- Dey, N. C. and Dey, T. K., (1999) Medical Bacteriology and Microbiology, 16th Edn, Allied Agency, Calcutta
- Prescott, L. M., Hartley, J. P. and Klein, D. A., (1993), Microbiology, 2nd Ed., W. M. C. Brown Publ, England
- Tortora, G. J., Funke, B. R. and Case, C. L., (2004), Microbiology, 8th Edn., Person Education (Low Price edition), Delhi.
- Nagoba, B. S. and Pichare, Asha (2012), Medical Microbiology: Prep Manual for Under Graduates, Elsevier.
- Mukherjee, K. L. (1993) Medical laboratory technology, Vol I to III, McGraw-Hill Publ. New Delhi
- Web sites
    - http://www.who.ch.- World Health Organization
    - http://www.ncbi.nlm.nih.gov/PubMed- PubMed -Medline on the Web.
    - http://www.cdc.gov- US Centers for Disease Control (Atlanta)
    - http://www.who.int/emc/-WHO Communicable Disease Surveillance and Response

T.Y. B.Sc. Microbiology (Major)
Semester-V
MIB-DSC-352: Microbial Metabolism

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To understand the concept of thermodynamics and bioenergetics. ▪ To acquaint with the process of biological oxidation. ▪ To study the types of catabolic pathways. ▪ To learn the types of anabolic pathways.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Understand the concept principles of thermodynamics. ▪ To gain knowledge of ETC and oxidative phosphorylation. ▪ Get well-versed with catabolic pathways ▪ Correlate various anabolic pathways.	
Unit	**Contents**	**Hours**
Unit I	**Bioenergetics** ▪ Concepts of open and closed systems, equilibrium ▪ Laws of thermodynamics: Zeroth, First, Second, Third ▪ Concepts of Gibbes free energy, entropy and enthalpy ▪ High-energy compounds with examples ▪ ATP-ADP Cycle ▪ Redox potential	**7**
Unit II	**Biological oxidation** ▪ Electron transport chain (ETC) o Components, ATP synthase complex o Inhibitors o Reverse electron transport chain (RETC) in the aerobic bacterium ▪ Oxidative Phosphorylation o Concept and Mechanism o Inhibitors and Uncouplers ▪ Shuttle pathways (Malate aspartate and Glycerol phosphate shuttles)	**7**
Unit III	**Anabolic pathways** ▪ Gluconeogenesis and its regulation ▪ Cori cycle ▪ Polysaccharides: Glycogen and Peptidoglycan biosynthesis ▪ Fatty acid biosynthesis o FAS Complex: Structure and Significance ▪ Ketone bodies: Concept and ketogenesis ▪ Purine and Pyrimidine nucleotide biosynthesis (de Novo and Salvage pathway)	**8**
Unit IV	**Catabolic Pathways** ▪ HMP Shunt ▪ Concept of anaplerosis ▪ PDH Complex: Reactions and Regulation ▪ Uronic acid Pathway ▪ Catabolism of Polysaccharides: Starch and glycogen ▪ Fatty acid oxidation o Beta oxidation (odd, even, saturated and unsaturated regulation) ▪ Overview of catabolism of proteins o Transamination o Deamination (Oxidative and Non-oxidative) ▪ Urea cycle	**8**

Study Resources

- Satyanarayana U., and Chakrapani U., (2006), Biochemistry, Books and Allied (P) Ltd. Kolkata.
- Nelson, D. L., and Cox, M. M. (2009), Lehninger's Principles of Biochemistry. New York: WH Freeman.
- Moat, A., and Foster, J., (1988), Microbial Physiology. Wiley Interscience Publications, New York.
- Stamen R. Y., Ingraham, J. L., Wheelis, M. L., and Painter, P. R., (1990), General Microbiology, MacMillan Edu. Ltd., London.
- Berg, J. M., Tymoczko, J. L., and Stryer, L. (2008), Biochemistry (Loose-Leaf). Macmillan.
- Zubay, G. L., Parson, W. W., and Vance, D. E. (1995), Principles of Biochemistry. W.C.B. Publishers, Oxford, England.

T.Y. B.Sc. Microbiology (Major)
Semester-V
MIB-DSC-353: Microbial Genetics

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To provide an introduction to the concept of the central dogmaof molecular biology. ▪ To acquaint with the gene transfer techniques for bacteria. ▪ To learn the gene repair mechanism of the microbial genome. ▪ To update knowledge in the field ofviral genetics.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ acquainted with the concepts of Central Dogma. ▪ apply knowledge of the gene transfer mechanism. ▪ gain the basic knowledge of DNA repair mechanisms. ▪ Understand concepts in viral genetics.	
Unit	**Contents**	**Hours**
Unit I	**Central Dogma** ▪ Concept of Central Dogma ▪ Replication of DNA o Modes of Replication: Conservative, Semiconservative, Dispersive o Meselson and Stahl Experiment ▪ Mechanism of Bacterial DNA Replication ▪ Models of Replication (Eukaryotic): Theta, Rolling Circle, Linear ▪ Fidelity of DNA Replication ▪ Transcription in prokaryotes o Components of Transcription: Template, Transcription Unit, Bacterial RNA polymerase o Steps: Initiation, Elongation, Termination (Rho-dependent and independent) ▪ Translation in prokaryotes: Activation of Amino acid and Charging of t-RNA, Initiation, Elongation,Termination	**7**
Unit II	**Gene Transfer** ▪ Gene Transfer by Transformation o Development of competence o Mechanism in Gram Positive and Gram Negative bacteria ▪ Gene Transfer by Conjugation o F plasmid, F^+, Hfr and F' strains o Conjugation in F^+ and Hfr cells ▪ Gene Transfer by Transduction o Generalized, Specializedand Abortive Transduction ▪ Transposition o Transposable elements that move via DNA intermediates: IS, Composite o Mechanism of DNA-mediated transposition o Transposable elements that move via RNA intermediates: Retrotransposons	**8**
Unit III	**Repair Mechanisms** o DNA damage o Direct Reversal of DNA damage o Base Excision Repair by base flipping o Nucleotide Excision Repair o Recombination repair o Translesion DNA synthesis o SOS Repair	**7**

Unit IV	**Viral Genetics** ▪ Classification of viruses based onthe genome (Baltimore) ▪ Salient features of the viral genome ▪ Structure of Double-Stranded DNA phages: T4 and Lambda ▪ Lytic and Lysogenic Cycle ▪ Bacteriophage mutants o Plaque morphology o Conditional lethal (Ts and Am) mutants o Deletion Mutants	**8**

Study Resources

- Gunther, S. Stent, (1978), Molecular Genetics: An Introductory Narrative, 2nd Edn. W.H. Freeman & Co.
- Hayes, W. (1964), The Genetics of Bacteria and their Viruses, C.B.S. Pub. New Delhi.
- Gardner, Simmons, Snustad. (2006), Principles of Genetics, 8th Ed. John Wiley & Sons. Inc. New York.
- Primrose, S. B. (2002), Principles of Gene Manipulation 6th Edition, Oxford: Blackwell Scientific Publications
- Strickberger, M.W. (2015), Genetics, 3rd Edition Macmillan Pub. Co. NY.
- Uldis N. Streips, Ronald E. Yashbin (2002), Modern Microbial Genetics, 2nd Edition, Wiley-Liss, Inc.
- Watson et al., (2004), Molecular Biology of Genes, International Edition, Benjamin Cummings Publishers
- Dale,Jeremy W. and Park,Simon F. (2004), Molecular Genetics of Bacteria, 4th Edition, John Wiley and Sons, Ltd.
- David Freidfelder, (2004).Molecular Biology, 2nd Edition. Jones & Bartlett Pub
- Websites
  - http://biology.kenyon.edu/courses/biol114/Chap03/mobile_genes.html
  - https://www.biointeractive.org/classroom-resources/central-dogma-and-genetic-medicine
  - https://courses.lumenlearning.com/microbiology/chapter/the-viral-life-cycle/

T.Y. B.Sc. Microbiology (Major)
Semester-V
MIB-DSC-354: Practical on Diagnostic Microbiology

Total Hours: 60 **Credits: 2**

Course Objectives	▪ To learn the microbial isolation and identification techniques from various clinical samples. ▪ To acquaintthe knowledge about the diagnostic tests for diseases. ▪ To train the learners to determine the potency of antibiotics using various standard methods.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Achieve skill in pure culture techniques. ▪ Learn principles underlying diagnostic tests and handle kits for diagnosis of disease ▪ Know various stages involved in malarial and diarrheal infections.	
Sr. No.	**Contents**	**Hours**
1	Isolation and identification of *Proteus* sp. from a urine sample	**4**
2	Isolation and identification of *E. coli* from a stool sample	**4**
3	Isolation and identification of *Salmonella* from a blood sample	**4**
4	Isolation and identification of *Staphylococcus* from pus sample	**4**
5	Isolation and identification of *Pseudomonas* from pus sample	**4**
6	Isolation and identification of *Candida* from skin/mouth	**4**
7	Antimicrobial Sensitivity Test: Kirby-Bauer method	**4**
8	Determination of Minimum Inhibitory Concentration (MIC) of an antibiotic	**4**
9	Study of ear microflora using swab technique	**4**
10	Effect of different hand sanitizer on skin microflora	**4**
11	Study of mouth microflora using swab technique	**4**
12	Cultivation of Anaerobic bacteria by a suitable method	**4**
13	Presumptive diagnosis of fungal infectionusing Potassium hydroxide wet mounting	**4**
14	Demonstration of medical waste disposal methods	**4**
15	Visit to medical college/ Pathological lab/Hospital/interaction with medicinal practitioner	**4**

Study Resources

- Harley, J.P. and Prescott, L. M (1996), Laboratory Exercises in Microbiology, 3rd Ed, W.C.B. / McGraw Hill Inc.
- Jayaraman, I. (2011) Laboratory Manual in Biochemistry, Wiley Eastern Ltd., New Delhi.
- Mackie TJ and McCartney JE (1989), Practical Medical Microbiology, 13th Collee, J. E., Duguid, J. P., Fraser, A. G, Marmion, B. P., Churchill Livingstone International Student Ed
- Parija, Subhash Chandra (2008), Textbook of Microbiology, Ahuja Publishing House, New Delhi, ISBN: 81 89443-06-2
- Willey, J. M, Sherwood, L. M., and Woolverton, C. J. (2013), Prescott, Harley and Klein'sMicrobiology. 9th Edition. McGraw Hill Higher Education
- Deshmukh. A.M. (1997), 1stEd., Handbook of Media, Stains and Reagents in Microbiology Pama Publications.
- Reddy, M. G., Reddy, M. N., Saigopal, D. V. R. and Mallaiah, K. V. (2008), Laboratory experiments in Microbiology, Himalaya Publishing House, Mumbai

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Microbiology (Major)
Semester-V
MIB-DSC-355: Practical on Biomolecules

Total Hours: 60 **Credits: 2**

Course Objectives	▪ To learn preparative steps in the experimentation ▪ To understand the techniques related to carbohydrate and nucleic acid ▪ To acquaint the isolation and detection of protein and lipids
Course Outcomes	After successful completion of this course, students are expected to: ▪ Prepare solutions with appropriate calculations ▪ Isolate and detect sugars and nucleic acid from a natural source ▪ Extract and detect the biomolecules lipid and protein

Sr. No.	Contents	Hours
1	Preparation and calculation of solution for molecular biology: Normal, Molar, percentage	4
2	Preparation of stock solutions: 1 N HCl, 1 N NaOH and subsequent dilutions	4
3	Determine the pKa value of amino acid	4
4	Preparation of standard buffer solution, e.g. phosphate/citrate/ acetate etc	4
5	Precipitation of protein using a suitable solvent	4
6	Qualitative detection of DNA and RNA by suitable method	4
7	Detection of reducing sugar with a suitable method (Benedict's test)	4
8	Detection of non-reducing sugar with a suitable method (Barfoed's test)	4
9	Isolation and estimation of starch content in potato (iodine test)	4
10	Determination of lipid using estimation of iodine number	4
11	Determination of rancidity of lipid by acid number	4
12	Extraction of proteins from soaked sprouted legumes by salting out method	4
13	Qualitative detection of protein using suitable method	4
14	Detection of protein using UV-Vis spectrophotometer	4
15	Detection of amino acid/sugar using paper/ TLC technique	4

Study Resources

- Jayaraman, J (2011), Laboratory Manual in Biochemistry, Wiley Eastern Ltd., New Delhi.
- Aneja, K. R. (2022), Experiments in Microbiology, Plant Pathology, Tissue culture and Mushroom cultivation, 2nd Ed., Wishwa Prakashan, New Delhi (New Age International, Pvt. Ltd.)
- Plummer, D. T. (1992), An Introduction to Practical Biochemistry, Tata McGraw Hill Publisher, New Delhi.
- Sharma Kanika, Manual of Microbiology Tools and Techniques, 2nd Ed. (2007), Ane's Book India, New Delhi

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Microbiology (Elective)
Semester-V
MIB-DSE-351A: Applied Microbiology

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To learn air and water Microbiology ▪ To study Dairy Microbiology ▪ To acquire knowledge of Food Preservation Techniques ▪ To know concepts in interdisciplinary microbiology	
Course Outcomes	After successful completion of this course, students are expected to: ▪ aware ofassessment of Microbes in air and water ▪ gain knowledge about microbial quality and safety of milk ▪ apply Food Preservation Techniques ▪ learn the fundamentals in Geo-microbiology and nano-biotechnology	
Unit	**Contents**	**Hours**
Unit I	**Air and water microbiology** **Air microbiology** • Terminologies: Bio-aerosols, droplet nuclei, air-borne microbes, allergens • Significance in human health, environmental, food and pharmaceutical industries, and surgical operations. • Microbial sampling of air: aerosol sampling, fate of aerosols, inactivation by UV light and HEPA filter • Assessment of air quality by solid-liquid impingement • Airborne transmission of microbes and preventive control measures **Water microbiology** • Water ecosystem: Freshwater, Marine water, Microflora of water • Bacterial assessment of water and potability of water: TVC, MPN • Indicator bacteria: *E. coli, Streptococcus fecalis* and *Staphylococcus aureus* • Physiochemical characteristics of water with permissible limits: TSS, TDS, DO, BOD, COD	**8**

Unit II	**Dairy Microbiology**
	• Sources of microbial contamination in milk
	• Factors affecting microbial growth in milk
	• Causes of milk spoilage (psychrotrophic, coliforms, proteolytic & lipolytic bacteria)
	• Common defects in milk and milk products
	• Microbial Quality and Safety of Milk
	  • Standard Plate Count (SPC) and Coliform count
	  • Pathogenic bacteria in milk
	  • Pasteurization and its role in microbial control
	• Starter Cultures in Dairy Industry
	  • Types of starter cultures (single-strain, multi-strain, mixed cultures)
	  • Role of lactic acid bacteria (LAB) in dairy fermentation
	  • Probiotic microorganisms and their health benefits
	• Dairy products: Yoghurt, Cheese, kefir
		8

Unit III	**Food Preservation Techniques**
	▪ Factors influencing food preservation.
	▪ Temperature-dependent control:
	  o Low temperature: Chilling and freezing
	  o High temperature
	▪ Chemical preservatives with examples
		7

	▪ Antibiotics as preservative (Natamycin) ▪ Canning: Concept and Method ▪ Control of Water activity: Dehydration ▪ Use of radiations: Microwave, UV and Ionizing	
Unit IV	**Geo-microbiology and nano-biotechnology** • Importance and scope of geomicrobiology • Microbial leaching o Laboratory methods o In-situ and ex-situ methods o Examples: copper and manganese leaching • Nanobiotechnology o Fundamental concepts o Tools and techniques o Applications: Nanomaterials, Nanoelectronics, Health and Environmental o Microbial synthesis of nanoparticle o Microbial analysis of the toxicity of nanoparticle	**7**

Study Resources

- Clesceri L S., Greenberg, A. E, and Eaton A. D. (1998) Standard Methods for Examination of Water and Wastewater, 18th Edition, American Public Health Association, Washington.
- Maier R.M., pepper, I.L. and Gerba, C.P. (2009) Environmental Microbiology, 2nd ed., Academic Press, NY.
- Salle, S.J. (1974) Fundamental Principals of Bacteriology, 2nd edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- Bums, R.G. and Slater, J.H. (1982) Experimental Microbial Ecology, Blackwell Scientific Publ., Oxford.
- Atlas, R.M. and Bartha, R. (2000) Microbial Ecology, 4th ed., Benjamin/Cumming Science Publ., USA.
- Benson, H. (2001) Microbiological Applications Lab Manual, 8th edition, The McGraw-Hill Companies, New York.
- Dubey, R.C. and Maheshwari, D.K (2010) Practical Microbiology, S. Chand and Co. New Delhi.
- Harley, J.P. and Prescott, L.M (1996) Laboratory Exercise in Microbiology, 3rd edition, WCB/McGraw Hill, London.

T.Y. B.Sc. Microbiology (Elective)
Semester-V
MIB-DSE-351B: Biological process design for wastewater treatment
(NPTEL course: noc25-ch08)

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To learn Biological treatment fundamentals ▪ To study Aerobic and anaerobic treatment ▪ To acquire knowledge of Advanced Biological Wastewater Treatment ▪ To learn concepts in Sludge Management and Sustainability	
Course Outcomes	After successful completion of this course, students are expected to: ▪ aware ofbiological treatment processes ▪ gain knowledge of various aerobic and anaerobic biological treatment processes ▪ know various biological wastewater treatment reactors ▪ be acquainted with the fundamentalsof Sludge characteristics and its Management	
Unit	**Contents**	**Hours**
Unit I	**Biological treatment fundamentals** ▪ Microbial ecology, Fundamentals of Biochemical Operations ▪ Conversion processes of organic and inorganic matter. ▪ Wastewater characterization ▪ Modeling of biological treatment processes o Stoichiometry, reaction and bacterial growth kinetics o Reactor hydraulics. Mass and heat balance	**7**
Unit II	**Aerobic and anaerobic treatment** ▪ Aerobic Biological Treatment Processes o Aerated lagoon, activated sludge systems, trickling filter o Rotating disc reactors and sequential batch reactors. ▪ Anaerobic Biological Treatment Processes o UASB, and hybrid UASB reactors, biotowers. o Aeration and sedimentation o Classification of biological treatment Processes.	**8**
Unit III	**Advanced Biological Wastewater Treatment** o Fluidized bed bioreactors o Membrane bioreactors (MBRs) o Moving bed biofilm reactor (MBBR), o Biological nitrogen removal o Biological nitrification, denitrification, and phosphorus removal	**7**
Unit IV	**Sludge Management and Sustainability** **Sludge Management** o Sludge characteristics, production, stabilization o Thickening and dewatering o Pathogen removal o Sludge transformation and disposal methods ▪ Sustainability in wastewater treatment plant designing o Greater water availability; lower energy and chemical consumption o Resource recovery o Case studies on biological wastewater treatment	**8**

Study Resources

- Henze M., van-Loosdrecht M.C.M., Ekama G.A. and Brdjanovic D., (2008) "Biological Wastewater Treatment: Principles, Modelling and Design", IWA publishing, .
- Márcia Dezotti, Geraldo Lippel, João Paulo Bassin, (2018) Advanced Biological Processes for Wastewater Treatment: Emerging, Consolidated Technologies and Introduction to Molecular

Techniques, Springer Nature, .
- Davide Dionisi. (2017) Biological wastewater treatment processes: mass and heat balances. CRC Press, .
- Marcos von Sperling, (2007) Basic Principles of Wastewater Treatment. IWA Publishing,
- C. P. Leslie Grady, Glen T. Daigger, Nancy G. Love, Carlos D. M. Filipe. (2011) Biological Wastewater Treatment. Co-published by IWA Publishing & CRC Press, .
- Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes. (2007) Sludge Treatment and Disposal. IWA Publishing,
- Tchobanoglous G., Burton F.L., Stensel H.D., "Metcalf and Eddy Inc.(2017) Waste Water Engineering Treatment and Reuse", Tata McGraw-Hill,
- Arceivala S.J. and Asolekar S.R., (2007) "Wastewater Treatment for Pollution Control and Reuse", 3rd Ed., Tata McGraw Hill,
- Sincero A.P. and Sincero G.A., (1996) "Environmental Engineering – A Design Approach", Prentice-Hall,

T.Y. B.Sc. Microbiology (Elective)
Semester-V
MIB-DSE-352A: Practical on Applied Microbiology

Total Hours: 60 **Credits: 2**

Course Objectives	▪ To learn the food fermenting /spoilage-causing microbes. ▪ To understand the principles and methods of microbiological examination of milk and sewage. ▪ To acquaint the students with the concept of nanobiotechnology and environmental cross-cutting issues.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Detect food poisoning-causing microbes ▪ Determine quality control of the dairy products (milk). ▪ Synthesize and characterize nanoparticles by biological methods	
Sr. No.	**Contents**	**Hours**
1	Isolation of wood-decaying microbes and detection of cellulose/lignin degradation (Congo red method/ O phenyl phenol method/ lignin agar/ tannic acid agar)	**4**
2	Isolation of bacteriophage from sewage (Plaque assay).	**4**
3	Isolation and identification of food poisoning causing *S. aureus/ Bacillus cereus/ Clostridium botulinum* from a spoiled food sample.	**4**
4	Isolation and Characterization of Food Fermenting Microorganisms from Idli Batter/Curd.	**4**
5	Isolation and characterization of probiotics/ lactic acid bacteria	**4**
6	Isolation and screening of xanthan gum-producing microbes from natural habitat.	**4**
7	Microbial analysis of milk by MBRT / Resazurin test	**4**
8	Analysis of milk adulterations (urea, starch, salt, oil, etc.) and	**4**
9	Demonstration/ Preparation of fermented product,e.g. curd / fermented food	**4**
10	Study of stormy fermentation.	**4**
11	Demonstration of mushroom cultivation.	**4**
12	Synthesis of silver nanoparticles by using Fungi / BGA / Bacteria and determination of λmax.	**4**
13	Assignment on Environmental Awareness/Group Discussion on Cross-Cutting Issues, viz. Environmental hazards/sustainability/ethics, biodiversity, waste management, bioenergy, environmental issues and rural development	**4**
14	Determination of Dissolved Oxygen and Biological Oxygen Demand (BOD) of sewage water effluent	**4**
15	Demonstration of copper detection using AAS	**4**

Study Resources

- Harley, J.P. and Prescott, L. M (1996), Laboratory Exercises in Microbiology, 3rd Ed, W.C.B. / McGraw Hill Inc.
- Mackie TJ and McCartney JE (1989), Practical Medical Microbiology, 13th Collee, J. E., Duguid, J. P., Fraser, A. G, Marmion, B. P., Churchill Livingstone International Student Ed
- Parija, Subhash Chandra (2008), Textbook of Microbiology, Ahuja Publishing House, New Delhi, ISBN: 81 89443-06-2
- Dubey, R.C. and Maheshwari, D.K. (2011), Practical Microbiology, S. Chand and Co. Delhi.
- Sharma Kanika, Manual of Microbiology Tools and Techniques, 2nd Ed. (2007), Ane's Book India, New Delhi
- Mudili Jayababu (2007) Introductory Practical microbiology, Narosa Publishing House, New Delhi

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Microbiology (Elective)
Semester-V
MIB-DSE-352B: Practical on waste management

Total Hours: 60 **Credits: 2**

Course Objectives	▪ To learn different waste management aspects ▪ To know various analytical techniques for wastewater ▪ To understand sustainable utilization approach for waste
Course Outcomes	After successful completion of this course, students are expected to: ▪ Collect and analyze the wastewater from the industry ▪ Perform the wastewatertreatment process ▪ To utilize the waste sustainably

Sr. No.	Contents	Hours
1	To learn the sample collection techniques for wastewater	4
2	To determine the TVC of the wastewater	4
3	Study of microbial communities under a microscope to understand microbial diversity in wastewater	4
4	Determination of the BOD of wastewater samples to assess the organic matter content.	4
5	Determination of pH and turbidity of wastewater	4
6	Determination of Total Suspended Solid (TSS) of wastewater	4
7	Isolation of microorganisms from sewage using various selective media	4
8	Setting up a small-scale continuous flow reactor to study biological treatment performance	4
9	Designing ofworking/ static model of any wastewater treatment process	4
10	Analysis of sludge samples for parameters like solid and moisture content	4
11	Laboratory experimental setup for the production of biogas from waste	4
12	Demonstration ofpreparation of compost from waste	4
13	Analysis of final compost for C and N	4
14	Visitto the effluent treatment plant (ETP)	4
15	Reviewing and analyzing real-world case studies of sustainable biological wastewater treatment practices	4

Study Resources

- Parija, Subhash Chandra (2008), Textbook of Microbiology, Ahuja Publishing House, New Delhi, ISBN: 81 89443-06-2
- Harley, J.P. and Prescott, L. M (1996), Laboratory Exercises in Microbiology, 3rd Ed, W.C.B. / McGraw Hill Inc.
- Dubey, R.C. and Maheshwari, D.K. (2004), Practical Microbiology, S. Chand and Co. Delhi.
- Sharma Kanika, Manual of Microbiology Tools and Techniques, 2nd Ed. (2007), Ane's Book India, New Delhi
- Mudili Jayababu (2007) Introductory Practical microbiology, Narosa Publishing House, New Delhi
- Thimmaiah S. R. (2006) Standard methods of biochemical analysis, Kalyani Publication, New Delhi

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Microbiology (Vocational)
Semester-V
MIB-VSC-351: Fermentation technology

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To introduce the architecture of various bioreactors and their applications. ▪ To acquaint with industrial processes of strain improvement, scale-up, scale-down, and start-up. ▪ To understand the upstream processes involved in fermentation.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Know a bioreactor, its parts, types working and applications. ▪ Imbibed the knowledge about the crucial processes in a bioreactor like strain improvement, inoculum development, sterilization and scale-up, and scale-down. ▪ Understand and be familiar with industrial upstream processes, fermentation economics, and the genesis of start-ups in India.	
Unit	**Contents**	**Hours**
Unit I	**Bioreactors** Types of bioreactorsconcerning construction, working and applications o Air-lift fermenter, o Deep jet fermenter o Cylindro-conical bioreactor o Packed Bed Bioreactors o Fluidized Bed Bioreactors o Photo-Bioreactors	**7**
Unit II	**Downstream processing I** • Recovery of fermentation products o Criteria for choice of recovery process o Cell removal for recovery of product: o Precipitation o Filtration: Theory of filtration, Filter aid, Batch Filter (e.g. Plate & Frame filter), Continuous Filter (e.g. Rotary vacuum filter) o Centrifugation: Theory, Basket, Tubular bowl, Multi-chamber o Cell aggregation and flocculation	**8**
Unit III	**Downstream processing II** • Cell disruption: Mechanical, Physical and Chemical methods • Liquid-Liquid extraction: Co-current and Counter current extraction, • Distillation: Batch and Continuous • Purification of fermentation products using Chromatography: o Ion exchange, Adsorption, Affinity chromatography • Membrane process: Ultrafiltration, Reverse Osmosis,	**7**
Unit IV	**Scale-up, Scale-down and Fermentation Economics** • Scale-up and scale down o Major factors involved in scale-up, Scale-up window, Scale Down: Concept and Methods • Fermentation economics o Basic objectives of development of economically viable successful process o Parameters under the economics of Fermentation: Isolation of industrially potential microbes, Stain improvement, Market potential, Plant and equipment, Media, air sterilization, heating cooling, aeration and agitation, Recovery Costs, Water usage, Effluent treatment, • Startups and related policies in India.	**8**

Study Resources

- Okafor N, Okeke B.C., (2021), Modern Industrial Microbiology and Biotechnology, 2nd Edition, CRC Press, Taylor and Francis Group, US.
- Stanbury, P.F., Whitaker, A. and Hall S.J.(2017), Principles of Fermentation Technology, 3rd Edition, , Butterworth-Heinemann.
- Casida, L.E (2019) Industrial Microbiology, 2nd Edition, New Age International Pvt Ltd Publishers, New Delhi
- Crueger, W., Crueger, A., Aneja K.R.(2017), Crueger's Biotechnology: A Textbook of Industrial Microbiology, 3rd Edition, Medtech Publishers, New Delhi.
- Patel A. H. (2012); Industrial Microbiology, 2nd Edition, ISBN: 9350590085, Macmillan India Ltd.
- Tortora, G.J., Funke, B.R. and Case, C.L. (2010) Microbiology: An Introduction. 10th Edition, Pearson Benjamin Cummings, San Francisco.
- Stainer, R.Y., Ingraham, J.L., Wheelis M.L., Painter R.K. (1999) General Microbiology, 5th Edition, MacMillan Press Ltd., London.
- Singh B. D. (2023) Biotechnology: Exploring Horizons, 5th Edition, Medtech Science Press, New Delhi
- Modi H.A., (2011), Fermentation Technology, Pointer Publications, India
- Prescott S.C and Dunn C.G. (1983) Industrial Microbiology, McGraw Hill Book Co. Inc., New York.
- Vahoniya, Dilip & Halpati, Jerul & Baruri, Sukanya & Garval, Anil. (2022). Start-up India: Eligibility, benefits and current scenario. The Pharma Innovation Journal; SP-11(6): 2630-2636.
- Web link: https://www.startupindia.gov.in/

T.Y. B.Sc. Microbiology (Vocational)
Semester-V
MIB-VSC-352: Practical on fermentation technology

Total Hours: 60 **Credits: 2**

Course Objectives	▪ To develop practical skills in microbial fermentation techniques ▪ To understand and apply microbiological methods for microbial growth assessment. To analyze and evaluate industrial microbiological processes	
Course Outcomes	After successful completion of this course, students are expected to: ▪ apply fermentation and microbial techniques for the production and estimation ▪ demonstrate proficiency in microbial isolation, identification, and growth analysis through various techniques. ▪ critically evaluate industrial microbiology applications, including sterilization validation	
Sr. No.	**Contents**	**Hours**
1	Production and estimation of alcoholic beverages from fruit juice	**4**
2	Isolation of a resistant mutant using the replica plate technique.	**4**
3	Isolation ofa resistant mutant using the gradient plate technique.	**4**
4	Determination of sugar/salt tolerance of yeast/bacteria	**4**
5	Sterilization of liquid/air by membrane filtration	**4**
6	Measurement of fungal growth by biomass (mycelia dry weight) method	**4**
7	Total fungal spore count using Neubauer's chamber	**4**
8	Development of inoculum and production of Citric acid/ acetic acid	**4**
9	Recovery and estimation of Citric acid/ acetic acid	**4**
10	Determination of concentration of substrates/ carbon source before and after fermentation.	**4**
11	Study of economics for enzyme production using agro waste.	**4**
12	Validation of sterilization vessel using a suitable indicator.	**4**
13	Study of the growth of microorganisms in batch cultures, measuring parameters like cell density, pH, and dissolved oxygen.	**4**
14	Study of the effect of fumigation on environmental microorganisms.	**4**
15	Study of the startup ecosystem in India: A case study.	**4**

Study Resources

- Aneja, K.R (2022) Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology, 3rd edition, Wishwa Prakashan, New Delhi.
- Dubey, R.C. and Maheshwari D. K (2023) Practical Microbiology, S. Chand and Co., New Delhi.
- Harley, J.P. and Prescott, L. M (1996), Laboratory Exercises in Microbiology, 3rd Ed, W.C.B. / McGraw Hill Inc.
- Jayaraman, I. (2011) Laboratory Manual in Biochemistry, Wiley Eastern Ltd., New Delhi.
- Mackie, T. J. and McCartney, J. E. (1989), Practical Medical Microbiology, 13th Edn Collee, J. E., Duguid, J. P., Fraser, A. G, Marmion, B. P., Churchy Livingstone International Student Ed.
- Parija, S. C., (2007), Textbook of Practical Microbiology, Ahuja Publishing House New Delhi.
- Plummer, D.T. (2017) An Introduction to Practical Biochemistry, Tata McGraw Hill Publisher, New Delhi.
- Sharma Kanika, Manual of Microbiology Tools and Techniques, 2nd Ed. (2007), Ane's Book India, New Delhi

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Microbiology (On Job Training)
Semester-V
MIB-OJT-351: On Job Training/Internship

Total Hours: 120 **Credits:4**

Course Objectives	▪ To provide the students with actual work experience ▪ To make aware of prescribed standards and guidelines at work ▪ To develop the employability of participating student ▪ To avail of opportunities to acquire job experience eventually
Course Outcomes	After successful completion of this course, students are expected to: ▪ Get actual work experience with office and virtual exposure to various management styles, technical, industrial, and proceduralsystems ▪ Acquaint the knowledge related to working hours, work protocols and guidelines ▪ Understand the roles and responsibilities of employees as well as teamwork ▪ Justify job experiences that match their potential, skills, and competencies
	Internship An internship is a professional learning experience that offers meaningful, practical work related to a student's field of study or career interest. An internship provides students with the opportunity for career exploration and development, as well as the chance to acquire new skills. **On-the-job training** On-the-job training is a form of training provided at the workplace. During the training, employees are familiarized with the working environment they will become part of. Employees also gain hands-on experience using machinery, equipment, tools, and materials.
	Contents

Internship / OJT Mechanism:

1. **Pre-Approval**: Students should obtain approval from the college before commencing the Internship/OJT. This ensures that the Internship / OJT aligns with the curriculum and meets the necessary criteria.
2. **Mentor and Supervisor**: Each student should have an assigned mentor within the organization or industry where they are interning. Additionally, an Internship / OJT supervisor from the college will be appointed to guide and monitor the progress.
3. **Regular Reporting:** Students should maintain regular communication with their supervisor and mentor, providing progress reports and seeking feedback.
4. **Professional Conduct**: Students must adhere to professional conduct throughout the Internship/OJT, including punctuality, respect for colleagues, and compliance with the organization's and industry's policies and guidelines.
5. **Student Diary**: Students should maintain a diary to document their experiences, challenges faced, and lessons learned during the internship or on-the-job training (OJT).
6. **Final Report**: At the conclusion of the internship or OJT, students are required to submit a comprehensive final report that summarizes their accomplishments, contributions, and key takeaways.
7. **Evaluation**: The Internship / OJT is worth 4 credits (equivalent to 100 marks), and the evaluation will be divided into two categories: one by the mentor and the other by the Internship / OJT supervisor. The mentor's evaluation (internal examination) will carry 40 marks and be based on the student's performance during the Internship/OJT. An external examination will be conducted by the mentor and supervisor, based on the student's diary, the final report prepared by the student, and their performance in the final viva voce, and will carry 60 marks. The total marks obtained by

students in both evaluations will be combined for the final evaluation. The assessment of the students will be conducted by the mentor using the evaluation sheet provided by the college.

Internal Evaluation Criteria for Students by the Mentor:

1. **Quality of Work** (10 marks): How well did the student perform their assigned tasks during the Internship / OJT? Evaluate the accuracy, thoroughness, and attention to detail in their work.
2. **Initiative and Proactiveness** (10 marks): Did the student show initiative in taking on additional responsibilities or tasks beyond their assigned role? Did they demonstrate a proactive attitude towards problem-solving?
3. **Communication Skills** (10 marks): Assess the student's ability to communicate effectively with colleagues, superiors, and clients (if applicable). Consider both written and verbal communication.
4. **Problem-Solving SkillsandTime Management** (10 marks): Evaluate the student's ability to analyze problems, propose solutions, and implement effective strategies to overcome challenges. How effectively did the student manage their time during the Internship/OJT? Were they able to meet project deadlines and handle multiple tasks efficiently?

External Evaluation Criteria for Students by the Supervisor and Mentor:

1. **Student Diary** (15 marks): Review the student's diary to understand their reflections, insights gained, and self-assessment of their performance during the Internship / OJT.
2. **Final Report** (15 marks): Evaluate the quality and comprehensiveness of the student's final report, including the clarity of their achievements and contributions.
3. **Presentation of Student in Viva Voce** (30 marks): Evaluate the responses given by the student to the questions asked by the faculty in the Viva Voce.

Evaluation Criteria for Final Viva Voce:

1. Presentation Skills
2. Knowledge of the Internship / OJT Project
3. Practical Application and Work Experience
4. Problem-solving and Critical Thinking
5. Communication and Professionalism

SEMESTER-VI

T.Y. B.Sc. Microbiology (Major)
Semester-VI
MIB-DSC-361: Immunology

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To study the fundamentals of antigen and antibody. ▪ To get knowledge about MHC and Antigen Presentation. ▪ To study the various immune responses in the body. ▪ To be aware of the various immunological techniques	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Get acquainted with Antigenicity and Immunogenicity. ▪ Understand the structure and role of MHC and APC ▪ Know the role of immune cells, organs and the functional mechanisms of each. ▪ Be familiar with principles and methods of immunotechniques	
Unit	**Contents**	**Hours**
Unit I	**Concepts in immunology** ▪ Characteristics of antigen (Foreignness, Molecular size and Heterogeneity) ▪ Adjuvants and Carriers, T-dependent and T-independent antigens ▪ Antigenicity versus Immunogenicity ▪ Factors influencing Immunogenicity ▪ Genetic basis of antibody formation:VDJ rearrangements ▪ Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic) ▪ Theories of antibody formation	**8**
Unit II	**Major Histocompatibility Complex and antigen presentation** ▪ Definition of MHC ▪ Structure and Functions of MHC Class I & II molecules ▪ Organization of class I and class II MHC gene locus ▪ Antigen processing and presentation by MHC ▪ Antigen presentation pathways: Cytosolic and Endocytic pathways, Cross presentation	**7**
Unit III	**Protective Mechanisms** ▪ Nonspecific mediators of immune response: inflammation, fever, phagocytosis, NK cells, role of lymphokines ▪ Interferon: introduction, mechanism of action and significance ▪ Tumor Necrosis Factor (TNF) ▪ Specific mediators of immune response o B-cell activation, Proliferation, Differentiation o T cells: Effector T cell activation, Differentiation& Memory T cells o Killing Mechanisms by CTL o Interaction between immune cells ▪ Complement: Classical and Alternative cascade ▪ Immunological tolerance	**8**
Unit IV	**Immunological Techniques** ▪ Principles, methods and application of o Precipitation, Agglutination o Immunodiffusion, Immuno-electrophoresis o ELISA: Direct and Indirect& ELISPOT assay o Western blotting o Immunofluorescence o Flow cytometry	**7**

Study Resources

- Abbas, A. K, Lichtman, A. H, Pillai, S. (2007), Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
- Ananthanarayan R, Paniker Jayaram, Saxena Sonal (2024) Ananthanarayan and Paniker's

Textbook of Microbiology, Orient Longman, Madras.
- Banker, D (1980), Modem Practice in Immunization, 3rd Ed., Popular Prakashan Pvt. Ltd., Bombay
- Coleman, R. M, Lombard M F, Sicard, R. E., (1992), Fundamental Immunology,2nd Ed., W. C. Brown Publishers, U.S.A.
- Delves P, Martin S, Burton D, Roitt IM. (2006), Roitt's Essential Immunology, 11th ed. Wiley-Blackwell Scientific Publication, Oxford.
- Glazier, A. M., Nikaido, H., (1995), Microbial Biotechnology, W. H. Freeman and Co., New York.
- Goldsby, R. A., Kindt, T. J., Osborne, B. A. (2007), Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
- Murphy, K., Travers, P., Walport, M. (2008), Janeway's Immunobiology. 7th Ed., Garland Science Publishers, New York.
- Peakman, M., and Vergani, D. (2009), Basic and Clinical Immunology. 2nd Ed., Churchill Livingstone Publishers, Edinburgh.
- Richard, C. and Geiffrey, S., (2009), Immunology. 6th Edition. Wiley Blackwell Publication

T.Y. B.Sc. Microbiology (Major)
Semester-VI
MIB-DSC-362: Microbial Enzymology

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To develop a comprehensive understanding of vitamins and coenzymes. ▪ To explore enzyme regulation mechanisms. ▪ To introduce various enzyme purification techniques. ▪ To familiarize students with enzyme immobilization and engineering techniques.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ explain the role of vitamins and coenzymes in enzymatic reactions. ▪ demonstrate an understanding of enzyme regulation. ▪ acquire practical skills in enzyme purification, characterization, and assay techniques ▪ apply enzyme immobilization and engineering principles for industrial and biotechnological applications.	
Unit	**Contents**	**Hours**
Unit I	**Vitamins and CoEnzymes** ▪ Concepts of Coenzymes, cofactor and its type ▪ Occurrence, Structure and Biochemical functions of the following: o Nicotinic acid: NAD and NADP o Riboflavin: FMN and FAD o Thiamine: TPP o Pantothenic acid: Coenzyme A o Biotin: Biocytin o Folic acid: THF o Pyridoxine: Pyridoxal Phosphate	**7**
Unit II	**Enzyme Regulation** • Modifiers: Definition, type and its role in enzyme activity • Allosteric enzyme: Concept, Properties, Positive and Negative Cooperativity, Example-ATCase • Isoenzyme: Concept and example -LDH • Enzyme Inhibition: o Reversible Inhibition: Competitive. Uncompetitive, Noncompetitive with examples o Irreversible Inhibition • Covalent modification: Glycogen Phosphorylase • Proteolytic modification of Zymogens	**8**
Unit III	**Enzyme Technology** Methods of Enzyme Purification based on various properties: • Molecular size: Molecular Exclusion Chromatography, membrane filteration • Solubility: Isoelectric Precipitation& Salt precipitation • Electric Charge: SDS-PAGE electrophoresis • Adsorption: Affinity chromatography • Enzyme assay: Spectrophotometric Assay	**8**
Unit IV	**Immobilization and Enzyme Engineering** • Immobilization of Enzyme o Concept	**7**

	○ Methods: adsorption, entrapment, covalent binding, and cross-linking. ○ Applications • Enzyme Engineering ○ Objectives and Principle ○ Methods: rDNA technology, mutagenesis, directed evolution, rational design. ○ Applications	

Study Resources

- Nelson, D L and Cox, M. M. (2013) Lehninger Principles of Biochemistry, 6th edn., Nelson, D L and Cox, M. M. (eds.) WH Freeman and Co., New York.
- Moat, A., Foster, J., (2009), Microbial Physiology, 2nd Ed., Wiley Interscience Publications, New York.
- Palmer T., (1995). Understanding Enzymes. 2nd Ed., Ellis Horwood Ltd., Chichester.
- Price, N. C, Stevens, L, (2009), Fundamentals of Enzymology, 2nd Ed., Oxford Sci. Publ., Oxford.
- Rose, A. E.L., (1983), Chemical Microbiology, 3rd Ed., Butterworth Publishers
- Satyanarayana U., (2013), Biochemistry, Books and Allied (P) Ltd. Calcutta
- Stryer, L., (1988), Biochemistry, W H Freeman and Co., New York.
- Zubay, G. L (1998), Biochemistry, 4th Edition, Wm. C. Brown publishers.

T.Y. B.Sc. Microbiology (Major)
Semester-VI
MIB-DSC-363: Concepts in Molecular Biology

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To provide a comprehensive understanding of gene regulation mechanisms. ▪ To introduce key molecular biology techniques such as blotting, PCR, DNA sequencing etc ▪ To explore the principles and applications of recombinant DNA technology. ▪ To examine the practical applications of genetic engineering.	
Course Outcomes	After successful completion of this course, students are expected to: ▪ explain the mechanisms of gene regulation, including operon systems, induction, repression, and attenuation. ▪ demonstrate proficiency in molecular biology techniques such as PCR, blotting methods, gene sequencing, and DNA fingerprinting for genetic analysis. ▪ acquire practical knowledge of recombinant DNA technology. ▪ analyze and apply genetic engineering techniques in various sectors.	
Unit	**Contents**	**Hours**
Unit I	**Gene Regulation** • Definition and mode of regulation • Mechanism of Regulation: Induction and Repression • Concept of Operon • Lac Operon o Structural organization o Positive and Negative Regulation o Lac Mutants • Tryptophan Operon: Repressible System and Attenuation	**7**
Unit II	**Techniques in Molecular Biology** ▪ Principles and Applications of: o Blotting techniques: Dot and Slot blotting, Southern, Northern & Western Blotting o Autoradiography o Gene Sequencing: Sanger's method, Maxam-Gilbert method, Ribotyping, Automated DNA. sequencing & Shotgun Sequencing o DNA Fingerprinting o Polymerase Chain Reaction (PCR) ▪ Construction of Genome Library&cDNA Library	**8**
Unit III	**Recombinant DNA Technology I** ▪ Restriction Enzymes: Type I, II, III ▪ Role of Enzymes in genetic engineering o DNA Polymerases, Terminal deoxynucleotidyl transferases, Kinases, Phosphatases &DNA Ligase ▪ Cloning Vectors: Definition and Properties o Plasmid Vectors: pBR322 and pUC o Lambda Vector o Cosmids, BACs and YACs ▪ Use of Linkers and Adaptors	**7**
Unit IV	**Recombinant DNA Technology II** ▪ Steps for the recombinant DNA molecule o Cutting and joining the DNA molecules o Methods to transfer recombinant DNA into host cells o Methods of screening the cells containing recombinant DNA	**8**

	○ Identification of clones using probes ▪ Applications of rDNA technology in ○ Health and Medicine: Production of insulin, interferon & Hepatitis vaccine ○ Agriculture: Herbicide-resistant crops &BT cotton ○ Environment: Bioremediation of pollutants ▪ CRISPR-Cas gene editing	

Study Resources

- Bruce Alberts , Rebecca Heald, et al.(2022), Molecular Biology of the Cell, 7th Edition. Publisher: Garland Science, New York.
- Watson,James D., Baker,Tania A., Bell,Stephen P., Gann,Alexander, Levine,Michael, Losick,Richard, (2013), Molecular Biology of the Gene, 7th Edn. Pearson Publishers.
- Krebs,Jocelyn E., Goldstein,Elliott S., Kilpatrick,Stephen T., (2012) Lewin's GENES XI, 11th Edition. Jones & Bartlett Learning.
- Gunther, S. Stent, (1978), Molecular Genetics: An Introductory Narrative, 2nd Edn. W.H. Freeman & Co.
- Jeremy Dale and Malcom von Schantz (2002) From Genes to Genomes, John Wiley and Sons Ltd.
- Lodish H. et al. (2012), Molecular Cell Biology, 7th Edn W. H. Freeman & Company. New York.
- Streips Uldis N.and Yashbin Ronald E. (2002), Modem Microbial Genetics, 2nd Edition, Wiley-Liss, Inc.
- Dale,Jeremy W. and Park,Simon F. (2004), Molecular Genetics of Bacteria, 4th Edition, John Wiley and Sons, Ltd.

Websites

- https://www2.le.ac.uk/proiects/vgec/highereducation/topics/recombinanttechniques
- https://www.mvbiosource.com/learn/recombinant-ICT-Technology/
- http://www2.csudh.edU/nsturm/CHEMXL153/RegulationofGeneExpression.htm
- http://www2,csudh.edu/nsturm/CHEMXL153/Regulati onofGeneExpression.htm

T.Y. B.Sc. Microbiology (Major)
Semester-VI
MIB-DSC-364: Environmental Microbiology

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To understand the Fundamental Concepts of Microbial Ecology ▪ To analyze Microbial Roles in Biogeochemical Cycles ▪ To explore Microbial Adaptations and Environmental Interactions ▪ To examine Microbial Applications in Bioremediation and Waste Management	
Course Outcomes	After successful completion of this course, students are expected to: ▪ explain the key principles of microbial ecosystems, biodiversity, population dynamics, and community interactions. ▪ analyze and describe microbial processes in nitrogen, carbon, sulfur, and phosphorus cycles ▪ assess microbial survival strategies in different natural environments ▪ demonstrate an understanding of microbial biodegradation, bioremediation techniques, and waste management practices	
Unit	**Contents**	**Hours**
Unit I	**Microbial Ecology** • Basic concept of Ecosystem and Biosphere • Microbial biodiversity – types, distribution, abundance, ecological niche • Concept of population growth and community dynamics in microbe • Basic of food chain-food web and energy flow • Development of microbial communities: r and k strategies • Molecular analysis of function and diversity of microbial community • Introduction to metagenomics and microbiomics • Micro organisms and their natural habitats: o Terrestrial (Soil), Aquatic (fresh water and marine), Atmosphere (Aeromicroflora), Animal (Microbiomics and ruminants), Extreme Habitats	**7**
Unit II	**Biogeochemical Cycles** • Nitrogen Cycle o Role of microorganisms in the nitrogen cycle o Nitrogen fixation, nitrification, denitrification, and ammonification o Symbiotic and non-symbiotic nitrogen fixation • Carbon Cycle o Microbial involvement in the carbon cycle o Decomposition of organic matter • Sulfur and Phosphorus Cycles o Microbial roles in sulfur oxidation, reduction, and sulfur cycle dynamics o Phosphorus cycle and microbial phosphate mineralization	**8**
Unit III	**Microbial Degradation of Pollutants** • Concept, types and principles of biodegradation • Biodegradation of pollutants/xenobiotic (e.g., hydrocarbons, pesticides, plastics) • Bioremediation techniques: in situ and ex situ methods • Bioremediation: importance, types, methods • Phytoremediation	**7**

Unit IV	**Pollution and Waste management** ▪ Sources of pollution: air, water, soil ▪ Effect of pollution on human health ▪ Waste: source, types and management ▪ Solid waste o Composting: necessity, microbiology, methods ▪ Industrial/agricultural by-product and waste o Potential and prospectus of waste from food, dairy, poultry and agrowaste ▪ Biogas: o Feedstock, process (hydrolysis, acidogenesis, acetogenesis and methanogenesis) o Factors affecting biogas production	**8**

Study Resources

- Poole, R. K. (2017). *Environmental Microbiology* (2nd ed.). Oxford University Press.
- Dubey R C and Maheshwari D. K. (2005) A textbook of Microbiology, S. Chand, New Delhi
- Oladele Ogunseitan (2004) Microbial Diversity: Form and Function in Prokaryotes, Wiley–Blackwell
- Bruce E. Rittmann, and Perry L. McCarty. (2001). Environmental Biotechnology: Principles and Applications. McGraw-Hill,
- Madigan, M., Bender K. S., Buckley D.H., Sattley W. M., and Stahl D.A.. (2017) Brock Biology of Microorganisms. 15th ed. New York: Pearson, .
- Sharma P. D. (2005) Environmental microbiology, Alpha Sciences international,
- Ian Papper and Charles Gerba (2014) Environmental microbiology, Elsevir Press.
- Patrick K. Jjemba (2004) Environmental microbiology: principles and applications, Science publisher, US

T.Y. B.Sc. Microbiology (Major with IKS)
Semester-VI
MIB-DSC-365: Indian Knowledge System in Microbiology

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To understand Vedic Perspectives on Microbiology ▪ To learn ancient Indian Insights into Microbial Diseases ▪ To know traditional Knowledge and Modern Microbiology ▪ To make aware contributions to Microbiology from Indian Scholars	
Course Outcomes	After successful completion of this course, students are expected to: ▪ interpret Vedic scientific terms and characteristics of microorganisms as described in ancient texts ▪ assess microbial diseases mentioned in Vedic literature and compare ancient preventive strategies with modern microbiological approaches ▪ integrate ancient bacteriological knowledge into contemporary microbiological studies and research. ▪ understand and appreciate the contributions of Indian-origin scientists in microbiology	
Unit	**Contents**	**Hours**
Unit I	**Microbiology in Vedas** • Vedic scientific terms for microorganisms • Major characteristics of microorganisms as per *Vedas* • Microbial diseases as per *Vedas* • Contribution to writings of *Sage* o Baadarayani on disease-curing herbs o Sage Chatana and control of microbes o Kannva and Agni Hotra o Agastya on toxicology and ecology o Maharsi Charaka on microbial classification o Maharshi Susruta on skin diseases and dental caries o Bhav Misra and ancient medicine o Surpala on plant pathology o Chyavana and health • Vedic mantras related to microbiology	**8**
Unit II	**Ancient Indian bacteriology** ▪ Knowledge of Medical Microbiology o *Krumi* in water, milk and food o *Krumi* on/in the body o Human health and pathogenic germs (*krumis*) ▪ Disease – defences by good health and Vedic concept ▪ Microbial transfer and *Madhav Nidan* ▪ Knowledge of communicable diseases ▪ Examples of disease in ancient Indian literature o *Piliya*(Jaundice), *Masurika* (smallpox), *Galaganda* (mumps), etc ▪ Prophylaxis stratagies in anicient literature o Viral disease, social distancing, change in eating and clothinghabits ▪ Eradication pathogen and ancient text o Elimination of pathogens by sun rays	**8**

	○ Herbal remedies for microbial infection ○ Agnihotra and microbial control	
Unit III	**Traditional Indian fermented food** ▪ Milk-based fermented foods ○ Dahi, paneer, Mishti doi, Lassi, Shrikhand ▪ Cereal and legume-based fermented foods ○ Idli, dosa, dhokla, kadhi, Punjabi wadi, bibde-papad, kurdai ▪ Milk and cereal/legume-based fermented foods ○ Rabadi, Kulcha, Naan ▪ Vegetable-based fermented foods ○ Pickle, kanji, solkadhi ▪ Prohibition of the use of contaminated food and milk	**7**
Unit IV	**Contributions of researchers of Indian origin** ▪ Ananda Mohan Chakraborty - multi-plasmid hydrocarbon-degrading Pseudomonas ▪ Subba Rao - rhizosphere ▪ Natteri Veeraraghavan - diseases like rabies, tuberculosis, and leprosy ▪ Khem Shahani - probiotics ▪ M.S. Swaminathan - vaccine against foot-and-mouth disease ▪ Yogesh S. Shouche - Microbiome ▪ Sabyasachi Tripathi – TB ▪ Vinay Kumar – immunology Indian institutes working in field of Microbiology – NCIM, MTCC, NIV, Agharkar Research institute, ICMR, etc	**7**

Study Resources

- Kuhad, U., Goel, G., Maurya, P. K., & Kuhad, R. C. (2021). Sukshmjeevanu in Vedas: The Forgotten Past of Microbiology in Indian Vedic Knowledge. Indian Journal of Microbiology, 61, 108-110.
- Sircar, N. N. (1991). Ancient Indian Bacteriology. Ancient Science of Life, 10(3), 180.
- Frend, C. (2006). Microbiology in the Veda. Vedic sciences, 8(4), 27-34.
- https://research.com/scientists-rankings/microbiology/in

T.Y. B.Sc. Microbiology (Major)
Semester-VI
MIB-DSC-366: Practical on Immunology and Enzymology

Total Hours: 60 **Credits: 2**

Course Objectives	▪ Develop Proficiency in Clinical Diagnostic Techniques ▪ Enhance Practical Skills in Enzymology and Bioprocessing ▪ Understand Laboratory Safety and Professional Practices	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Perform microscopic examinations, serological tests, and immunological reactions to detect microbial infections. ▪ Produce, extract, purify, and analyze enzymes ▪ Implement universal precautions while handling clinical samples	
Sr. No.	**Contents**	**Hours**
1	Study of various stages of malarial parasite in RBCs using permanent slides	**4**
2	Demonstration of Universal Precautions for handling blood and other body fluids	**4**
3	Preparation and confirmation of O and H antigens of *Salmonella*	**4**
4	Enzyme-linked immunosorbent assay (HIV DOT ELISA)	**4**
5	Venereal disease research laboratory (VDRL) test	**4**
6	Demonstration of precipitation reaction based on immunodiffusion	**4**
7	Widal Test qualitative and quantitative	**4**
8	Detection of Malarial parasite by a suitable test	**4**
9	Development of Inoculum, Production, and Recovery of enzyme e.g. Amylase.	**4**
10	Determination of enzyme activity and specific activity of crude enzyme	**4**
11	Determination of protein content of crude enzyme	**4**
12	Immobilization of yeast cells/enzyme and detection of immobilization activity	**4**
13	To demonstrate the salting in and salting out process for protein	**4**
14	To illustrate the enzyme separation using column chromatography	**4**
15	Visit Pathology Laboratory/Blood Bank	**4**
Study Resources	▪ Sharma Kanika (2007) Manual of Microbiology tools and techniques, Ane's Student Edition, New Delhi ▪ Reddy, M. G., Reddy, M. N.,Saigopal, D. V. R. and Mallaiah, K. V. (2008), Laboratory experiments in Microbiology, Himalaya Publishing House, Mumbai ▪ Tembhare D. B. (2008) Techniques in life science, Himalaya Publishing House, Mumbai ▪ Aneja, K. R. (2022), Experiments in Microbiology, Plant Pathology, Tissue culture and Mushroom cultivation, 2nd Ed., Wishwa Prakashan, New Delhi (New Age International, Pvt. Ltd.)	

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Microbiology (Major)
Semester-VI
MIB-DSC-367: Practical on Molecular and Environmental Biology

Total Hours: 60 **Credits: 2**

Course Objectives	▪ To provide hands-on training in the isolation, analysis, and characterization of microbial DNA ▪ To develop skills in microbial screening for environmental and industrial applications ▪ To familiarize students with advanced microbiological techniques for environmental monitoring
Course Outcomes	After successful completion of this course, students are expected to: ▪ gain proficiency in DNA isolation, electrophoresis, and bioinformatics tools for genetic analysis. ▪ isolate, characterize, and evaluate the role of microorganisms in the environment ▪ develop skills in environmental monitoring by analyzing microbial diversity, pollution indicators, and industrial wastewater quality.

Sr. No.	Contents	Hours
1	Isolation of genomic DNA from Yeast/ Fungi/ bacteria growth	4
2	Isolation of DNA from onion	4
3	Demonstration of agarose gel electrophoresis	4
4	Preparation of paper model of DNA	4
5	Sequencing data analysis using BLAST and databases like NCBI and SILVA.	4
6	Construction of phylogenetic trees using MEGA software.	4
7	Isolation of azo/aryl dye degrading bacteria from polluted soil sample by solid-phase decolorization method	4
8	Isolation of phosphate solubilizing microorganisms from rhizosphere soil	4
9	Isolation and primary screening of bacteria/fungi from soil samples for lignin dephenolization activity	4
10	Analysis of wastewater for determination of COD	4
11	Isolation and primary screening of bacteria/fungi from soil samples for lignin dephenolization activity	4
12	Study of Composting and Microbial Activity in Organic Waste Decomposition	4
13	Demonstration of biogas production	4
14	Analysis of wastewater of distillery/dairy/Pharma. industry- Determination of TS and TDS	4
15	Demonstration of air sampling devices for environmental monitoring	4

Study Resources

- Green, Michael R., and Joseph Sambrook. (2019) Molecular Biology: Principles and Practice. Cold Spring Harbor Laboratory Press, .
- Wilson, Kevin, and John Walker. (2010) Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, .
- Maier, Raina M., I. L. Pepper, & Charles P. Gerba (2009) Environmental Microbiology. Academic Press.
- Sharma, S. K., and A. K. Bhattacharya. (2012) Wastewater Treatment: Advanced Processes and Technologies. CRC Press, .
- Tiquia-Arashiro, Sonia M., & Deepak Pant. Microbial Electrochemical Technologies. CRC Press, 2019.

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Microbiology (Elective)
Semester-VI
MIB-DSE-361A: Agricultural Microbiology

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To learn concepts in soil microbiology ▪ To study plant microbial interactions. ▪ To know about biofertilizers ▪ To be acquainted with biofertilizers	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Aware of soil horizons, rhizosphere and biogeochemical cycles ▪ Understand the plant microbial interactions and plant diseases ▪ Learn types and preparation of biofertilizers ▪ Comprehend various biopesticides and their mode of actions	
Unit	**Contents**	**Hours**
Unit I	**Soil microbiology** ▪ Soil horizons, classification of soils and Rhizosphere microflora ▪ Winogradsky's column to study soil microflora ▪ Enumeration of soil microflora by different techniques ▪ Rhizosphere: concept, microorganisms, significance and Rhizosphere engineering	**7**
Unit II	**Plant-Microbe Interactions** ▪ Classification of plant diseases based on symptoms, crop and parts affected ▪ Terminology: Host, Alternate and Collateral host, Resistance, Susceptibility and Tolerance ▪ Disease Triangle (Host, environment and pathogen), ▪ Concept of Disease cycle **Plant diseases** Study with respect to causative agent, host, symptoms and control: Wilt of cotton, Citrus canker, Downy mildew of grapes, Whip smut of sugarcane, Tikka disease of groundnut, Banana Bunchy Top Viral disease	**8**
Unit III	**Biofertilizers** ▪ Advantages over chemical fertilizers ▪ Screening, isolation,characterization, production and field application of the following as biofertilizer o *Rhizobium* for legume/pulses plants o *Frankia* for non-leguminous crop o *Cyanobacteria/ Azolla*: for crop cultivation o Non-symbiotic nitrogen-fixing bacteria: *Azospirillum, Azotobacter* o PGPR, phosphate solubilizing bacteria and *Mycorrhizal* ▪ Application of biofertilizers: Liquid and preparation of carrier-based formulation, Seed bacterization, soil broadcasting ▪ Bio-efficacy and quality parameters	**8**
Unit IV	**Biopesticides** ▪ Microbes as biopesticides/bioinsecticides, advantages over synthetic pesticides ▪ Screening and isolation of bioagents ▪ Mode of action, mass production, formulation, Field applications of o *Bacillus thuringiensis, Pseudomonas fluorescence, Trichoderma viridae,* NPV and *Beauveria bassiana* ▪ Bio-efficacy and Quality parameters assessment	**7**

Study Resources

- SubbaRao, N.S. (1999) Soil Microbiology, 4th edn., Oxford and IBH Publ. Co., New Delhi.
- Coyne, M.S. (2001) Soil Microbiology: An Exploratory Approach, Delmar Thomson Learning.
- Alexander, M. (1977) Introduction to Soil Microbiology, John Wiley and Sons Inc. New York.
- Kannaiyan, S. (2003) Biotechnology of Biofertilizers, CHIPS, Texas.
- Rai, M. K. (2005) Handbook of Microbial Biofertilizers, The Haworth Press, Inc. New York.
- Reddy, S.M. et al. (2002) Bioinoculants for Sustainable Agriculture and Forestry, Scientific Publishers, New Delhi
- Subba Rao N.S (1995) Soil microorganisms and plant growth Oxford and I.B.H. Publishing Co. Pvt. Ltd., New Delhi.
- Saleem, F, and Shakoori, A. R. (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG
- Aggarwal, S. K. (2005) Advanced Environmental Biotechnology, A.P.H. Publication, New Delhi

T.Y. B.Sc. Microbiology (Elective)
Semester-VI
MIB-DSE-361B: Microbiology for Sustainable Food Systems
(NPTEL course: noc25-ag14)

Total Hours: 30 **Credits: 2**

Course Objectives	▪ To understand the Role of Microorganisms in the Food Industry ▪ To analyze Food Contamination and Pathogens ▪ To examine Food Spoilage and Preservation Techniques ▪ To evaluate Food Safety and Microbial Control Methods	
Course Outcomes	After successful completion of this course, students are expected to: ▪ identify and explain the role of microorganisms in food processing ▪ recognize sources of contamination, describe common foodborne pathogens ▪ analyze microbial spoilage mechanisms and implement appropriate preservation methods ▪ evaluate and apply physical, chemical, and biological methods for controlling microorganisms in food	
Unit	**Contents**	**Hours**
Unit I	**Introduction to Food Microbiology** o Microorganisms in the food industry (dairy, brewing, baking, etc.) o Natural microbiota of raw foods (e.g., meats, fruits, vegetables) • Fermented Foods and Beverages o Examples of fermented foods (yoghurt, cheese, pickles, sauerkraut) o Role of microorganisms in food flavour, texture, and preservation • Probiotics and Prebiotics o Definition and role of probiotics in human health o Prebiotics and their role in supporting beneficial microorganisms o Mechanisms of probiotics in the gut (e.g., gut flora balance)	**7**
Unit II	**Contaminants of Food** • Sources of Food Contamination o Contamination during processing, handling, storage, and transportation o Contamination from raw materials (e.g., contaminated water, soil, or animals) • Example of Foodborne Pathogens o *Salmonella, E. coli, Listeria, Campylobacter*, etc. • Intrinsic and Extrinsic Factors o Intrinsic factors: pH, moisture content, nutrients, and antimicrobial properties o Extrinsic factors: temperature, atmosphere, humidity, and packaging • Microbial Growth in Different Types of Food o Growth in dairy products, meats, vegetables, and beverage	**7**
Unit III	**Microbial Food Spoilage** • Spoilage Organisms o bacteria (e.g., P*seudomonas, Enterobacter*), o moulds (e.g., *Aspergillus*), yeasts (e.g., *Candida*) o Mechanisms of spoilage (e.g., acid production, gas formation, off-flavours) • Signs of Food Spoilage: Sensory changes and Microbial spoilage indicators • Prevention of Spoilage refrigeration, drying, acidification, fermentation, Role of preservatives: chemical vs. natural Diseases by Foodborne Microbes • Pathogenesis of Foodborne Illness o Mechanisms of foodborne infections, symptoms and treatment of foodborne diseases	**8**

Unit IV	**Controlof Microorganisms in Food**
	• Physical Methods: Heat, Cold storage, Radiation
	• Chemical Methods: preservatives, salt, sugar, acids, antimicrobial packaging and natural food preservatives
	• Biological method: e.g., bacteriophages, Lactic acid bacteria
	• Food Processing Technologies: High-pressure processing (HPP), pulsed electric fields (PEF)
	• Food Safety Regulations and Standards: WHO, FAO, FDA, HACCP, FSO
	• Food Packaging and Microbial Control
	  o Packaging materials and their influence on microbial growth
	  o Modified atmosphere packaging (MAP), vacuum packing, and active packaging
	• Foodborne Disease Control in the Supply Chain
		8

Study Resources

- Adams, M. R., & Moss, M. O. (2008). Food microbiology (3rd ed.). Royal Society of Chemistry.
- Doyle, M. P., & Buchanan, R. L. (Eds.). (2013). Food microbiology: Fundamentals and frontiers (4th ed.). ASM Press.
- Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). Modern food microbiology (7th ed.). Springer.
- Montville, T. J., Matthews, K. R., & Kniel, K. E. (2017). Food microbiology: An introduction (4th ed.). ASM Press.
- Ray, B., & Bhunia, A. (2014). Fundamental food microbiology (5th ed.). CRC Press.
- Robinson, R. K. (Ed.). (2014). Encyclopedia of food microbiology (2nd ed.). Academic Press.

T.Y. B.Sc. Microbiology (Elective)
Semester-VI
MIB-DSE-362A: Practical on Agricultural Microbiology

Total Hours: 60 **Credits: 2**

Course Objectives	▪ To develop practical skills in the isolation, identification, and characterization of agriculturally important microorganisms ▪ To evaluate the functional roles of beneficial microbes in plant growth promotion, disease suppression ▪ To enhance understanding of microbial interactions in agriculture by applying microbiological techniques	
Course Outcomes	After successful completion of this course, students are expected to: ▪ gain hands-on experience in isolating and identifying plant pathogens, biofertilizers, and biocontrol agents ▪ develop an understanding of the role of beneficial microbes in agriculture ▪ apply microbiological methods to evaluate microbial functions such as antifungal activity, siderophore production, and plant-microbe interactions	
Sr. No.	**Contents**	**Hours**
1	Isolation and identification of *Xanthomonas*from infected citrus fruit	**4**
2	Isolation and identification of *Rhizobium* sp. from root nodules	**4**
3	Isolation and identification of *Azotobacter* sp. From agricultural/ garden soil.	**4**
4	Isolation of actinomycetes from soil using selective media	
5	Isolation of mycorrhizal fungi from plant roots	**4**
6	Isolation of biocontrol agents like *Trichoderma*/*Pseudomonas*	**4**
7	Evaluation of the antifungal activity of bacterial biocontrol agent	**4**
8	Sampling of soil from different locations and depths followed by Isolation and enumeration of soil microbes (TVC)	**4**
9	Testing plant growth-promoting bacteria (PGPR) for IAA production	**4**
10	Demonstration of Koch's postulates in plants	**4**
11	Evaluation of efficacy of biofertilizer (*Azotobacter*/ *Rhizobium*/ *Trichoderma* sp.) by pot assay	**4**
12	Preparation of biofertilizer and testing for efficacy	**4**
13	Production of siderophore and its detection with suitable method	**4**
14	Examination of infected plant part for signs and symptoms of disease	**4**
15	Visit to agro-industry/ farm yard/ interaction with farmer / agricultural research station or college	**4**

Study Resources

- Harley, John P., and Lansing M. Prescott. (2002) Laboratory Exercises in Microbiology. McGraw-Hill, .
- Dhingra, Odile D., and James B. Sinclair. (1995) Basic Plant Pathology Methods. CRC Press,
- Rangaswami, G., and D. J. Bagyaraj. (2004) Agricultural Microbiology. PHI Learning Pvt. Ltd., .
- Aneja, K. R. (2003) Laboratory Manual of Microbiology, Biochemistry and Molecular Biology. New Age International, .
- Subba Rao, N. S. (1993) Soil Microorganisms and Plant Growth. Oxford & IBH Publishing, .
- Gupta, P. K. (2010) Practical Manual of Agricultural Microbiology. Agrobios (India), .
- Reddy, S. M. (2015) Microbial Biotechnology in Agriculture and Aquaculture. Scientific Publishers

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Microbiology (Elective)
Semester-VI
MIB-DSE-362B: Practical on Food Microbiology

Total Hours: 60 **Credits: 2**

Course Objectives	▪ To develop practical skills in isolating, identifying, and analyzing microorganisms associated with food ▪ To understand the microbial quality, safety, and shelf-life of various food products through microbiological and biochemical testing methods ▪ To gain hands-on experience in food microbiology techniques, including microbial enumeration
Course Outcomes	After successful completion of this course, students are expected to: ▪ acquire proficiency in isolating and identifying microorganisms from different food products and assessing their impact on food quality ▪ develop an understanding of factors affecting microbial growth in food, methods to prevent spoilage ▪ learn to evaluate food samples for contamination, determine microbial load, and assess the quality of dairy and processed food

Sr. No.	Contents	Hours
1	Isolation of halophilic microbes from pickles	4
2	Isolation of surface microflora from vegetables for fecal contamination	4
3	Isolation of microorganisms from spoiled food/fruit	4
4	Isolation and detection of fungus from spoiled bakery product	4
5	Dilution methods for liquid/solid/semisolid food samples	4
6	Determine the influence of various sugar/nitrogen concentrations on the growth of bacteria	4
7	Clarification of fruit juice using suitable enzymes	4
8	Determination of shelf life of given food item	4
9	Direct microscopic examination of spoiled food	4
10	Direct microscopic examination of frozen/liquid food	4
11	Sensory evaluation and physical characterization of different types of bread/ food	4
12	Examination of food for the presence of food-poisoning bacteria	4
13	Comparative microbial load determination of raw and pasteurized milk by SPC	4
14	To check the quality of milk using acidity / resazurin test	4
15	Visit to the food industry/ dairy industry/ food processing unit/ hotel kitchen	4

Study Resources

- Jay, James M., M. J. Loessner, & D. A. Golden. (2005) Modern Food Microbiology. Springer, .
- Harrigan, W. F. (1998) Laboratory Methods in Food Microbiology. Academic Press, .
- Frazier, William C., and Dennis C. Westhoff. (1995) Food Microbiology. McGraw-Hill, .
- Jay, James M. (2003) Foodborne Microorganisms of Public Health Significance. AIFST (NSW Branch), .
- Forsythe, Stephen J. (2010) The Microbiology of Safe Food. Wiley-Blackwell, .
- Brown, Margaret H.(2000) Microbiological Quality of Foods. Springer, .
- Montville, Thomas J., Karl R. Matthews, and Kalmia E. Kniel. (2017) Food Microbiology: An Introduction. ASM Press,

***Mandatory to perform any 12 practical from above.**

T.Y. B.Sc. Microbiology (Vocational)
Semester-VI
MIB-VSC-361: Pharmaceutical Microbiology

Total Hours: 30 **Credits: 2**

Course Objectives	• To acquire knowledge about large-scale production of commercially valuable products. • To acquaint with the chronological development in fermentation. • To introduce fundamentals of pharmaceutical microbiology and the role of microbiologists.	
Course Outcomes	After successful completion of this course, students are expected to: • Understand fermentation processes involved in the production of various fermentation products. • Get acquainted with the needs of a fermentation process in pharmaceutical and other industries. • Familiar with concepts in the pharmaceutical industry and know the contribution of microbiologists to it.	
Unit	**Contents**	**Hours**
Unit I	**Basics to Pharmaceutical Microbiology** ▪ Concept of pharmaceutical microbiology ▪ Microbiological test methods for Raw materials, In process and finished items, Environmental Monitoring ▪ Application of pharmaceutical microbiology ▪ Basics of the pharmaceutical sector: Significance of Research & Development, Cost, Generic drug products, allied satellite sectors/ contractors. ▪ Role of the microbiologist	**7**
Unit II	**Industrial Fermentations of Antimicrobials** (Following products w.r.t. organism, inoculums preparation, fermentation media, fermentation process, flow chart and recovery): ▪ Antibiotics: Streptomycin and Penicillin ▪ Vaccine (bacterial and viral), Immune sera, toxoid ▪ Interferon ▪ Biopharmaceuticals viz. streptokinase& streptodornase ▪ Bio-Insecticide	**7**
Unit III	**Industrial Fermentations of acids and solvent** (Following products w.r.t. organism, inoculums preparation, fermentation media, fermentation process, flow chart and recovery): ▪ Organic acids: Citric acid, Vinegar and Lactic acid ▪ Amino acids: L- Lysine and L- Glutamic acid ▪ Organic solvent: Ethanol	**8**
Unit IV	**Industrial Fermentations of Bio-products** (Following products w.r.t. organism, inoculums preparation, fermentation media, fermentation process, flow chart and recovery): ▪ Vitamin: Cyanocobalamin, Riboflavin ▪ Beverage: Beer & Wine ▪ Single cell protein (SCP) ▪ Enzyme: Amylase ▪ Microbial polysaccharides – xanthan-gum, dextran.	**7**

Study Resources

- Sandle Tim (2016), Pharmaceutical Microbiology: Essentials for Quality Assurance and Quality Control, Woodhead Publishing Limited by Elsevier, UK.
- Okafor N, Okeke B.C., (2021), Modern Industrial Microbiology and Biotechnology, 2nd Edition, CRC Press, Taylor and Francis Group, US.
- Casida, L.E (2019) Industrial Microbiology, 2nd Edition, ISBN: 9788122438024, New Age

International Pvt Ltd Publishers, New Delhi
- Hugo W.B., Russell A.D., (1998), Pharmaceutical Microbiology, 6th Edition, Blackwell Science Ltd.
- Gilmore B.F., Denyer S.P. (2023), Hugo and Russell's Pharmaceutical Microbiology, 9th Edition, John Wiley & Sons Ltd, UK.
- Crueger, W., Crueger, A., Aneja K.R.(2017), Crueger's Biotechnology: A Textbook of Industrial Microbiology, 3rd Edition, ISBN: 9789385998638, Medtech Publishers, New Delhi.

T.Y. B.Sc. Microbiology (Vocational)
Semester-VI
MIB-VSC-362: Practical on Pharmaceutical Microbiology

Total Hours: 60 **Credits: 2**

Course Objectives	▪ To develop Skills in Pharmaceutical Microbial Testing ▪ Enhance Competency in Microbiological Assays and Environmental Monitoring ▪ Understand Laboratory Safety and Regulatory Compliance	
Course Outcomes	After successful completion of this course, students are expected to: ▪ Perform sterility testing, microbial limit tests, and bio-burden estimation for pharmaceutical products ▪ Successfully conduct potency determination of antibiotics and vitamins, evaluate bacterial thermal resistance ▪ Demonstrate safe handling of hazardous chemicals, interpret MSDS and SOPs,	
Sr. No.	**Contents**	**Hours**
1	Sterility testing of injectables by membrane filter technique	**4**
2	Bio-burden estimation of pharmaceutical finished product	**4**
3	Environmental monitoring of the laboratory to enumerate the microflora by settling velocity method.	**4**
4	Determination of potency of Penicillin/Streptomycin by bioassay.	**4**
5	Determination of potency of Vitamin B12 by bioassay/chemical assay.	**4**
6	Determine the Thermal Death Time (TDT) of given bacteria	**4**
7	Determine the Thermal Death Point (TDP) of given bacteria	**4**
8	Detection and isolation of recently reported microorganisms from pharmaceutical products. e.g. *Bulkholderia cepecia*	**4**
9	Microbial Limit test for Finish pharmaceutical product	**4**
10	Testing of water for microbial analysis using a suitable technique	**4**
11	Performed Growth Promotion test for nutrient media	**4**
12	Testing of controlled environment for microbial contamination using surface sampling	**4**
13	Demonstration of safe handling of hazardous chemicals and awareness of Material Safety Data Sheet (MSDS)	**4**
14	Preparation of SOP of any laboratory instrument	**4**
15	Industrial visit to the pharmaceutical industry	**4**

Study Resources

- Dubey, R.C. and Maheshwari, D.K. (2004), Practical Microbiology, S.Chand and Co. Delhi.
- Dubey, Akhilesh, Mishra, Neeraj, Singh, Deb, Neha, Abhinav and Verma, Shivendra. (2010), Isolation of dye degrading microorganism. Electronic Journal of Environmental, Agricultural and Food Chemistry.
- Parija, S. C., (2007), Textbook of Practical Microbiology, Ahuja Publishing House New Delhi.
- Reddy, M. G., Reddy M. N., Saigopal, D. V. R. and Mallaiah, K. V. (2008), Laboratory experiments in Microbiology, Himalaya Publishing House, Mumbai
- Roy, D. C. et al., (2018), Biodegradation of Crystal Violet dye by bacteria isolated from textile industry effluents, PeerJ.; Vol. 6, doi: 10.7717/peeij.5015
- Sharma, Kanika, (2007), Manual of Microbiology Tools and Techniques, 2nd Ed. Ane's Book India, New Delhi.

***Mandatory to perform any 12 practical from above.**

Skills acquired and Job prospects for the Microbiology students

Microbiology is one of the most significant subjects, exhibiting its impact on human health, the industrial production of antibiotics, vaccines, enzymes, fine chemicals, the energy sector, and the social sector, such as waste treatment. The degree program in Microbiology teaches students about the role of microorganisms in human life and their applications in various fields. A significant attraction of the course is its combination of in-depth scientific knowledge with practical laboratory skills and career opportunities across all sectors.

After completing a three-year degree course in Microbiology, students will be well-versed in laboratory skills and possess transferable skills essential for working in the industrial sector, including laboratory settings and pursuing higher studies.

Laboratory Skills:

- Laboratory safety practices
- Skillful handling of microbial cultures and aseptic techniques
- Proficient handling of fermenters and their parts
- Molecular kit-based and protocol-based analysis
- Advanced techniques like- Chromatography, Electrophoresis, Spectrometry
- Some medical diagnostic techniques like the Widal test, microbial analysis of food and dairy products
- Analysis and interpretation of results and logical thinking

Transferable Skills:

During the course, students will develop skills beyond laboratory skills, which are transferable across multiple career areas. These are:

- Analytical skill, Observational skill
- Planning and Time management
- Mathematical and IT skills
- Creative thinking, Problem-solving
- Report writing skill, Presentation skill

Job Opportunities:

Private Sector:

Microbiologists can work in the quality control, quality assurance, and R&D divisions of companies such as pharmaceutical companies, Chemical manufacturing companies, Food and Beverage (including brewing), Health and Beauty Care, and medical instrument companies, as well as agricultural industries and research laboratories.

Public Sector:

It includes the National Blood Service, Cancer research institutes, Environmental Pollution Control, Forensic Science, Hospitals, Overseas Development, Public Health Entities, Public Health Laboratories, Agriculture, and fisheries, among others.

Job profiles:

The industrial job profiles may include Microbiologist, Biologist, Biotechnologist, Laboratory Technician, Quality Control and Assurance, and Research and Development, among others. They may also work as scientists, research associates, or officers in clinical biology, pharmaceuticals, biomedicine, forensic science, food and dairy, breweries, and wineries.

Opportunities in higher studies

After completing a B.Sc. in Microbiology, students may continue their studies with an M.Sc. in Microbiology, Biotechnology, or Biochemistry, and pursue further higher education. Even students can pursue other courses where graduation is essential.