

SAVITRIBAI PHULE PUNE UNIVERSITY
(Formerly University of Pune)

B. Sc. Degree Course in
MICROBIOLOGY

Choice Based Credit System [CBCS]2019 Pattern

Syllabus for Third Year
(To be implemented from Academic Year 2021-22)

Board of Studies (Microbiology)
Savitribai Phule Pune University [SPPU]
Pune-411007

GENERAL INFORMATION

Eligibility at third year B. Sc. Microbiology:

Student shall clear all First Year B. Sc. Microbiology courses and satisfactorily keep terms of Second Year of B. Sc. with Microbiology as one of the subjects.

Course Structure: T. Y. B. Sc. Microbiology course includes 12 theory papers (DSEC-Discipline Specific Elective Course), 06 practical courses and 04 skill enhanced courses (SEC). The 06 theory papers, 03 practical courses and 02 skill enhanced courses (SEC) will be taught in semester V and the remaining 06 theory papers, 03 practical courses and 02 skill enhanced courses (SEC) will be taught in semester VI. The examination will be held semester-wise for theory and practical papers.

Note:

- i. Each lecture (L) will be of 50 minutes.
- ii. Each practical of 4 hours 20 minutes and 12 practical sessions per semester
- iii. 12 weeks for teaching 03 weeks for evaluation of students (theory as well as practical).
- iv. For details refer UG rules and regulations (CBCS for Science program under Science and Technology) published on SPPU website.

Evaluation Pattern (As per CBCS rules, SPPU 2019 Pattern)

1. Each theory and practical course carry 50 marks equivalent to 2 credits.
2. Each course will be evaluated with Continuous Assessment (CA) and University Assessment (UA) mechanism.
3. Continuous assessment shall be of 15 marks (30%) while university Evaluation shall be of 35 marks (70%).
4. To pass each course, a student has to secure 40% mark in continuous assessment as well as university assessment i.e. 6 marks in continuous assessment and 14 marks in university assessment for the respective course.
5. For Continuous Assessment (internal assessment) minimum two tests per paper must be organized, of which one must be written test of 10 marks.
6. Method of assessment for internal exams: Viva-Voce, Project, survey, field visits, tutorials, assignments, group discussion, etc.

2.2 Mandatory Credit courses for award of B.Sc. Degree:

In addition to the compulsory credits of 132, the student has to earn additional 8 credits from following groups by taking/participating/conducting respective activities.

Courses in Group I are compulsory.

The student can earn **maximum 04 credits from an individual group from Group 2 to Group -9.**

These extra credits will not be considered for GPA calculation, however these are mandatory for the completion and award of B. Sc. Degree.

Group 1: Physical Education (at F. Y. B. Sc. Sem. I) -01 credit

Physical Education (at F. Y. B. Sc. Sem. II) - 01 credit

(Note: Group I is compulsory for all the students as stated above.)

Group 2: Sport representation at College level - 01 credit

Sport representation at University/Statelevel - 02 credits

Group 3: National Social Service Scheme (participation in Camp): 01 credits

N.C.C.(with participation in annual camp) -01 credit

N. C. C. (with B certificate/C certificate award)- 02 credits

N.S.S./N.C.C. Republic day parade participation - 04 credits

Group 4: Avishkar participation; Extension activity participation, Cultural activity participation -01 credit

Avishkar selection at University level - 02 credits

Avishkar winner at state level - 04 credits

Group 5: Research paper presentation at State/National level - 01credits

Research paper presentation at International level - 02 credits

Group 6: Participation in Summer school/programme; Short term course (not less than 1-week duration) - 03 credit.

Group 7: Scientific Survey, Societal survey, - 02 credits.

Group 8: Field Visits; Study Tours; Industrial Visits; Participation in curricular/ cocurricular competitions- 01 Credit.

Group 9: Online certificate Courses /MOOC Courses/ Career Advancement Course up to 04 credits (Minimum 10 Hrs. / credit)

**Equivalences for the New Courses (w. e. f. from 2021-22) with
Old Courses (2013 Pattern) in Microbiology
T. Y. B. Sc. Microbiology
Semester - V**

Theory/ Practical/ Skill Enhancement	Old Course Semester-III		New Course Semester-V (CBCS 2019 Pattern)	
	Course Number	Course Title	Course Number	Course Title
Discipline Specific Elective Course (DSEC) Theory	MB 331	Medical Microbiology-I	MB 351	Medical Microbiology-I
	MB 334	Immunology-I	MB 352	Immunology-I
	MB 333	Enzymology	MB 353	Enzymology
	MB 332	Genetics and Molecular Biology-I	MB 354	Genetics
	MB 335	Fermentation Technology -I	MB 355	Fermentation Technology-I
	MB 346	Agricultural and Environmental Microbiology	MB 356	Agricultural Microbiology
Discipline Specific Elective Course (DSEC) Practical	MB 349	Practical Course-III Diagnostic Microbiology and Immunology	MB 357	Practical course-I based on: MB 351 Medical Microbiology-I MB 352 Immunology I
	MB 348	Practical Course-II Biochemistry and Genetics	MB 358	Practical course-II based on MB 353 Enzymology MB 354 Genetics
	MB 347	Practical Course I Applied Microbiology	MB 359	Practical course-III based on: MB 355 Fermentation Technology-I MB 356Agricultural Microbiology
Skill Enhancement course	-	-	MB 3510	Marine Microbiology
	-	-	MB 3511	Dairy Microbiology

Equivalences for the New Courses (w. e. f. from 2021-22)

With old Courses (2013 Pattern) in Microbiology

T. Y. B. Sc. Microbiology Semester-VI

Theory/ Practical/ Skill Enhancement	Old Course Semester-III		New Course Semester-VI (CBCS 2019 Pattern)	
	Course Number	Course Title	Course Number	Course Title
Discipline Specific Elective Course (DSEC) Theory	MB 341	Medical Microbiology-II	MB 361	Medical Microbiology II
	MB 344	Immunology-II	MB 362	Immunology II
	MB 343	Metabolism	MB 363	Metabolism
	MB 342	Genetics and Molecular Biology-II	MB 364	Molecular Biology
	MB 345	Fermentation Technology-II	MB 365	Fermentation Technology II
	MB 346	Food and Dairy Microbiology	MB 366	Food Microbiology
Discipline Specific Elective Course (DSEC) Practical	MB 349	Practical course-III Diagnostic Microbiology and Immunology	MB 367	Practical course-I. Based on: MB 361 Medical Microbiology II and MB 362 Immunology II
	MB 348	Practical course-II Biochemistry and Genetics	MB 368	Practical course-II. Based on: MB 363 Metabolism and MB 364 Molecular Biology
	MB 347	Practical course-I Applied Microbiology	MB 369	Practical course III. Based on: MB 365 Fermentation technology-II and MB 366 Food Microbiology
Skill Enhancement course	-	-	MB 3610	Waste management
	-	-	MB 3611	Nano biotechnology

Evaluation Pattern
T. Y. B. Sc. Microbiology

Courses							
Semester-V				Semester-VI			
Paper	Course Title	Internal examination Marks	University examination Marks	Paper	Course Title	Internal Exam Marks	University examination Marks
MB 351	Medical Microbiology I	15	35	MB 361	Medical Microbiology II	15	35
MB 352	Immunology I	15	35	MB 362	Immunology II	15	35
MB 353	Enzymology	15	35	MB 363	Metabolism	15	35
MB 354	Genetics	15	35	MB 364	Molecular Biology	15	35
MB 355	Fermentation technology I	15	35	MB 365	Fermentation Technology II	15	35
MB 356	Agricultural Microbiology	15	35	MB 366	Food Microbiology	15	35
MB 357	Practical course-I Based on: MB351 and MB 352	15	35	MB 367	Practical course I Based on: MB 361 and MB 362	15	35
MB 358	Practical course-II Based on MB 353 and MB 354	15	35	MB 368	Practical course II Based on: MB 363 and MB 364	15	35
MB 359	Practical course-III Based on:MB 355 and MB 356	15	35	MB 369	Practical course III Based on: MB 365 Fermentation technology II, MB 366 Food Microbiology	15	35
MB 3510	Marine Microbiology	15	35	MB 3610	Waste Management	15	35
MB 3511	Dairy Microbiology	15	35	MB 3611	Nano biotechnology	15	35

Semester V

DSEC-MB 351: Medical Microbiology- I

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Course Outcomes:

- Understand the human anatomy, pathogens associated with diseases.
- Acquire knowledge of principles underlying establishment of pathogens in human body.
- Comprehend of pathogenesis of specific pathogens causing microbial diseases.
- Assess epidemiological patterns of microbial disease transmission as various modes, intensity at local and global level.
- Gain Knowledge principles of chemotherapy of microbial diseases and development of drug resistance among pathogens and strategies to mitigate.
- Develop identification systems for microbial disease diagnosis, disease treatment and prevention measures.

Credit No.	Topics	No. of Lectures
	Introduction to infectious diseases and Epidemiology	18
Credit I	1. Introduction to infectious diseases of following human body systems: (Brief anatomy and Physiology, Diseases, Pathogens, common symptoms)	
	a. Respiratory system	2
	b. Gastrointestinal system and liver	2
	c. Urogenital system	2
	d. Central nervous system	2
	2. Epidemiology:	
	a. Case control and cohort studies – Study design and application	2
	b. Principle and methods – Clinical trials of drugs and vaccines (Randomized control trials Concurrent parallel and cross-over trials)	3
	c. Epidemiology of infectious diseases	
	i. Sources and Reservoirs of Infection	1
ii. Modes of Transmission of Infections	1	
iii. Disease Prevention and Control Measures, Vaccine-preventable bacterial diseases and nonvaccine-preventable bacterial diseases	3	

Credit II	Study of bacterial pathogens:	18
	3. Study of following groups of bacterial pathogens: (With respect to- Classification and Biochemical characters, Antigenic structure, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis, Epidemiology, Prophylaxis and Chemotherapy):	
	a. <i>Salmonella, Vibrio</i>	2
	b. <i>Streptococcus pneumoniae, Streptococcus pyogenes, Neisseriameningitidis and Neisseria gonorrhoeae</i>	4
	c. <i>Pseudomonas aeruginosa</i>	2
	d. <i>Treponema, Leptospira</i>	2
	e. <i>Clostridium tetani</i>	2
	f. <i>Mycobacterium tuberculosis</i> and <i>Mycobacterium leprae</i>	4
g. Rickettsial diseases - Scrub typhus, Spotted fevers	2	

Semester VI

DSEC-MB 361: Medical Microbiology II

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Credit No.	Topics	No. of lectures
Credit I	Chemotherapy	18
	1. Routes of drug administration.	1
	2. Mode of action of antimicrobial agents on:	
	a. Bacteria:	
	i. Cell wall: Beta lactams: 1 st to 6 th Generation- e.g. Meropenem, Imipenem, Piperacillin, Tazobactam	2
	ii. Cell membrane: Polymyxin	1
	iii. Protein synthesis: Streptomycin, Tetracycline	1
	iv. Nucleic acids: Fluroquinolones, Rifamycin	1
	v. Enzyme inhibitors: Trimethoprim, Sulfomethaxazole	1
	b. Fungi: Griseofulvin, Amphotericin B, Anidulafungin, Vericonazole	3
c. Viruses: Acyclovir, Oseltamivir, Remdecivir	1	
d. Protozoa: Metronidazole, Chloroquine	1	

	<p>3. Mechanisms of drug resistance on:</p> <p>a. Genetic basis:</p> <p>i. Mutations in gene(s)</p> <p>ii. Acquisition of foreign DNA coding for resistance determinantsthrough horizontal gene transfer.</p> <p>b. Mechanisms of drug resistance by:</p> <p>i. Limiting uptake of a drug.</p> <p>ii. Modification of a drug target.</p> <p>iii. Inactivation of a drug.</p> <p>iv. Active efflux of a drug.</p>	3
	<p>4. Introduction to cultivation of viruses</p> <p>5. Study of following groups of viral pathogens:</p> <p>a. Human viruses (with respect to – Virion, Characteristics, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis including serological diagnosis, Epidemiology, Prophylaxis and Chemotherapy):</p> <p>i. Respiratory Viruses: Influenza Virus, Corona Virus</p> <p>ii. Hemorrhagic Virus: Dengue</p> <p>iii. Hepatic Virus: Hepatitis A Virus</p> <p>iv. Gastrointestinal Virus: Rotavirus</p> <p>v. Cutaneous Viruses: Human papillomavirus</p> <p>vi. Neurological Viruses: Japanese Encephalitis Virus</p> <p>b. Animal Viruses: FMD Virus and Rinderpest Virus</p> <p>6. Study of following groups of parasites (with respect to – Classification, Lifecycle, Morphological characteristics, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis (Serological diagnosis wherever applicable), Epidemiology, Prophylaxis and Chemotherapy):</p> <p>a. <i>Plasmodium</i></p> <p>b. <i>Entamoeba</i></p> <p>7. Study of following groups of yeast and fungal pathogens (With respect to – Morphological and cultural characteristics, Classification, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis,</p>	18
Credit II		2
		2
		1
		1
		1
		1
		2
		1
		2
		1

	Epidemiology, Prophylaxis and Chemotherapy)	
a.	<i>Aspergillus</i> species (Pathogenic)	1
b.	<i>Cryptococcus neoformans</i>	1
c.	<i>Histoplasma capsulatum</i>	1

References: MB 351 Medical Microbiology-I and MB 361 Medical Microbiology- II

1. Chakraborty P. (2013). A Textbook of Microbiology. 3rd edition. New Central Book Agency. India. ISBN-13: 978-8173818769
2. Champoux J. J., Neidhardt F. C., Drew W. L. and Plorde J. J. (2004). Sherris Medical Microbiology: An Introduction to infectious diseases. 4th edition. Ryan K. J. and Ray C. G. (editors). McGraw-Hill Companies. DOI: 10.1036/0838585299
3. Dey N. C., Dey T. K. and Sinha D. (2013). Medical Bacteriology Including Medical Mycology and AIDS. 17th Edition. New Central Book Agency (P) Ltd (Publisher). India
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- Antimicrobial Drug Resistance: Clinical and Epidemiological Aspects. Volume 2. Edition 2. Springer. ISBN 978-3-319-47266-9
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 15. Mukherjee K. L. and Ghosh S. (2010). Medical Laboratory Technology. Volume II: Procedure Manual for Routine Diagnostic Tests. 2nd edition. McGraw Hill Education (India) Private Limited. ISBN-13: 978-1259061240
 16. Mukherjee K. L. and Ghosh S. (2010). Medical Laboratory Technology. Volume III: Procedure Manual for Routine Diagnostic Tests. 2nd edition. McGraw Hill Education (India) Private Limited. ISBN-13: 978-1259061257
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 22. Tortora G. J., Funke B. R. and Case C. L. (2016). Microbiology: An introduction 12th Edition, Pearson. ISBN-13: 9780321929150

Links:

1. <https://www.who.int/travel-advice/disease-information>
2. <https://Microbenotes.Com/Remdesivir/#Mechanism-Of-Action-Of-Remdesivir>
3. *Aspergillus* <https://www.cdc.gov/fungal/diseases/aspergillosis/index.html>
4. *Histoplasma capsulatum* <https://www.cdc.gov/fungal/diseases/histoplasmosis/>
5. *Cryptococcus neoformans* www.cdc.gov/fungal/diseases/cryptococcosis-neoformans/

Semester V

DSEC-MB-352 Immunology- I

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Course Outcomes

- Understand immune system structure, composition, function and comparison of different types of immunity.
- Acquire knowledge about antigens, Recognition of pathogens; antigen processing and presentation; Immunity to infection and pathological consequences of immunodeficiencies.
- To learn the applications of Immunology in monoclonal antibodies, vaccines production and Immunotherapy.
- Understand abnormal working of Immune system in hypersensitivity, auto immune diseases, immune tolerance and transplantation immunology.
- To develop strategies for Diagnosis of diseases based on antigen and antibody reactions with emphasis on prevailing communicable diseases.

Credit No.	Topics	No. of Lectures
Credit I	Organs of immune system, Innate immunity, Antigen and Immunoglobulins	18
	1. Organs of immune system:	
	a. Primary lymphoid organs (Thymus and Bone Marrow): Thymus – structure, thymic education (positive and negative selection) Bone marrow –Structure and Negative selection	2
	b. Secondary lymphoid organs – structure and function of spleen and lymph node, mucous associated lymphoid tissue, lymphatic system and lymph circulation	2
	2. Innate immunity: Non-specific mechanisms of defense: Second line of defense:	
a. Humoral components: Defensins, pattern recognition proteins (PRP) and pathogen associated molecular patterns (PAMPs), complement, kinins, and acute phase reactants.	1	
b. Cellular components: Phagocytic cells – PMNL, macrophages (reticulo-endothelial cell system) and dendritic cells	1	
c. Phagocytosis (oxygen dependent and independent systems), Complement activation (Classical, Alternative and lectin pathway), Inflammation (cardinal signs, mediators, vascular and cellular changes, role of Toll-like receptors)	5	

	3. Antigen: a. Factors affecting immunogenecity b. Antigenic determinants, haptens and cross-reactivity, Carrier, Adjuvants c. Types of antigens: Thymus-dependent and thymus-independent antigens, Synthetic antigens, Soluble and particulate antigens, Autoantigens, Isoantigens	1 1 1
	4. Immunoglobulins: a. Characteristic of domain structure, functions of light and heavy chain domainsand antigenic nature of immunoglobulin molecules b. Molecular basis of antibody diversity (kappa, lambda and heavy chain)	2 2
	Antigen- Antibody Interactions, Major Histocompatibility Complex, Transplantation and Immunity and Hybridoma Technology and Monoclonal Antibodies	18
Credit II	5. Antigen- Antibody Interactions: A. Principles of interactions: Antibody affinity and avidity, ratio of antigen antibody, lattice hypothesis and two stage theory, antigen-antibody reactionkinetics (dialysis equilibrium experiment) B. Visualization of antigen antibody complexes: a. Precipitation reactions: in fluid and in gel, immunoelectrophoresis b. Agglutination reactions: hemagglutination, bacterial agglutination, passiveagglutination and agglutination-inhibition c. Immunofluorescence techniques: direct and indirect, fluorescence-activated cell sorting (FACS) d. Enzyme-linked immunosorbent assay (ELISA), biotin-avidin system and enzyme-linked immune absorbent spot (ELISpot) assay e. Radioimmunoassay RIA	2 1 1 2 2 1
	6. Major Histocompatibility Complex: a. Structure of MHC in man and mouse b. Structure and functions of MHC class-I and class-II molecules c. MHC antigen typing (microcytotoxicity and mixed lymphocyte reaction)	1 1 1
	7. Transplantation and Immunity; a. Types of Grafts, Allograft rejection mechanisms b. Prevention of allograft rejection	2 1

	8. Hybridoma Technology and Monoclonal Antibodies;	
	a. Preparation, HAT selection and propagation of hybridomas secreting monoclonal antibodies	2
	b. Applications of monoclonal antibodies	1

Semester VI

DSEC-MB 362 Immunology– II

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Credits	Topics	No. of Lectures
Credit I	Cytokines, Adaptive / Acquired Immunity, Hypersensitivity, Autoimmunity and Autoimmune diseases and Immunodeficiency	18
	1. Cytokines:	
	a. Concept- Cytokines, lymphokines, monokines, interleukines, chemokines, interferons and tumor necrosis factor	1
	b. Properties, Attributes and biological functions of cytokines	2
	2. Adaptive / Acquired Immunity (Third line of defense):	
	A. Humoral Immune Response	
	i. Primary and secondary response kinetics, significance in vaccination programs	2
	ii. Response of secondary lymphoid organs to antigen	1
	iii. Antigen processing and presentation (Major Histocompatibility class I and class II restriction pathways), cell-cell interactions and adhesion molecules, response to super-antigens, role of cytokines in activation and differentiation of B-cells	5
	B. Cell Mediated Immune Response	
i. Activation and differentiation of T cells, role of cytokines in activation		
ii. Mechanism of Cytotoxic T lymphocytes (CTL) mediated cytotoxicity, Antibody-dependent cellular cytotoxicity (ADCC)	2	
iii. Significance of Cell Mediated Immune Response (CMI)	3	
iv. Immune response against tumors and foreign transplanted cells		
	1	
	1	

Credit II	Hypersensitivity, Autoimmunity and Autoimmune diseases and Immunodeficiency	18
	3. Hypersensitivity	
	a. General principles of different types of hypersensitivity reactions	2
	b. Gell and Coomb's classification of hypersensitivity – mechanism with examples for type I (Immediate), II, III and IV (delayed)	5
	4. Autoimmunity and Autoimmune diseases:	
	a. Immunological tolerance	1
b. Types of autoimmune diseases	1	
c. Factors contributing development of autoimmune diseases	1	
d. Immunopathological mechanisms	1	
e. Diagnosis and treatment of autoimmune diseases: Myasthenia gravis and Rheumatoid arthritis	2	
f. Therapeutic immunosuppression for autoimmunity	1	
5. Immunodeficiency:		
i. Complement deficiencies	2	
ii. Introduction to congenital immunodeficiency disorders: Common Variable Immune Deficiency (CVID) and acquired immunodeficiency: Immune mechanisms in AIDS	2	

References: MB-352 Immunology- I and MB 362- Immunology-II

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- MBL are pattern recognition molecules that signal immediate and long-term protective immune functions. *Mol. Immunol.* 44: 33–43.
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 23. Talwar G. P. (1983) *Handbook of Immunology*, Vikas Publishing Pvt. Ltd. NewDelhi.
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Semester V

DSEC-MB 353: Enzymology

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Course Outcomes

- To understand methods of active site determination, role of enzymes and its cofactors in microbial physiology.
- To learn to perform enzyme assay, purification and quantification of enzymes activity, enzyme kinetics in terms of initial, final velocity, mathematical expression of enzyme kinetic parameters.
- To correlate regulation of metabolism at enzymatic levels and apply, methodology for commercial applications of enzymes
- To learn mechanisms of transport of solutes across the membrane
- To get acquainted with mechanism of biosynthesis and degradation of bio molecules
- To comprehend basic concept of autotrophic mode of metabolism of prokaryotes

Credit No.	Topics	No. of lectures
	Enzymes:	18
Credit I	1. Structure of enzymes:	
	a. Methods to determine amino acid residues at active site (Physical method e.g. x-ray crystallography and chemical methods such as trapping of ES complex, use of inhibitors, use of pseudo-substrate, change of pH)	3
	b. Role of vitamins in metabolism: Occurrence, Structure and Biochemical functions of the following:	2
	i. Thiamine (Vitamin B1) and Thiamine Pyrophosphate ii. Vitamin D	
	2. Enzyme assays:	
	a. Principles of enzyme assays and calculation of enzyme unit, specific activity	1
	b. Enzymes assays with examples by:	2
	i. Spectrophotometric methods	
	ii. Radioisotope assay	

	3. Principles and Methods of Enzyme purification:	
	a. Methods of cell fractionation	2
	b. Principles and methods of enzyme purification:	
	i. Based on molecular size	2
	ii. Based on charge	2
	iii. Based on solubility differences	2
	iv. Based on specific binding property and selective adsorption	1
	c. Construction of enzyme purification chart	1
	Enzyme Kinetics, metabolic regulation and Immobilized Enzymes:	18
Credit II	4. Enzyme Kinetics:	
	a. Concept and use of initial velocity	2
	b. Michaelis Menton equation for the initial velocity of single substrate enzyme catalyzed reaction. Brigg's Haldane modification of Michaelis Menton equation. Michaelis Mentonplot, Lineweaver and Burk plot. Definition with significance of Km, Ks, Vmax	5
	5. Metabolic Regulations:	
	a. Enzyme compartmentalization at cellular level	1
b. Allosteric enzymes	1	
c. Feedback mechanisms	2	
d. Covalently modified regulatory enzymes (Glycogenphosphorylase)	1	
e. Proteolytic activation of zymogens	1	
f. Isozymes - concept and examples	1	
g. Multienzyme complex e.g. Pyruvate dehydrogenasecomplex(PDH)	1	
	6. Immobilization of enzymes:	3
	Concept, methods of immobilization and applications	

Semester VI

DSEC-MB 363: Metabolism

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Credit No.	Topics	No of lectures
Credit I	Membrane transport and Bioenergetics	18
	1. Membrane transport mechanisms: i. Passive transport - Diffusion, Osmosis, Facilitated transport ii. Active transport - Active transport systems in bacteria iii. Group translocation of sugars in bacteria iv. Ionophores: Mechanism and examples	6
	2. Bioenergetics: i. Laws of thermodynamics- first and second law	1
	ii. Concepts of free energy, entropy, high energy compounds: Pyrophosphate, enolic phosphates, acyl phosphates, thioester compounds, and guanidinium compounds iii. Mitochondrial electron transport chain: components, arrangement of different components in the inner membrane, structure and function of ATP synthetase, inhibitors and uncouplers of ETC and oxidative phosphorylation, energetics of mitochondrial electron transport chain	4 7
Credit II	Metabolic pathways and Autotrophy	18
	3. Biosynthesis and Degradation: a. Chemistry, concept of polymerization of macromolecules: Polysaccharides. (Starch, and peptidoglycan) and Lipids (Fatty acids, triglycerides and phospholipids)	6
	b. Degradation of macromolecules – Polysaccharides (starch), Lipids (fatty acids oxidation e.g. β oxidation), Proteins (urea cycle)	6
	4. Bacterial Photosynthesis: Photosynthetic bacteria with referenceto photosynthetic apparatus, energy generation, and CO₂ fixation a. Cyanobacteria,	2
	b. Purple bacteria	2
5 Chemolithotrophy: Concept and one example, Iron oxidizing bacteria	2	

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	3. Regulation of transcription: Concept and components of operon: Lac operon: Inducible operon	2
	4. Translation in prokaryotes and eukaryotes a. Structure and role of m-RNA, t-RNA and Ribosomes in Translation b. Role of Aminoacyl t-RNA synthetase in translation c. Steps in translation: Initiation, elongation, translocation and termination of protein synthesis d. Salient features of Eukaryotic translation	5
	Gene transfer and mapping techniques	18
Credit II	5. Gene transfer by Transformation a. Discovery of Transformation b. Natural transformation Systems- <i>Streptococcus pneumoniae</i> and <i>Haemophilus influenzae</i> . c. Factors affecting transformation i. Competence development ii. Size of DNA iii. Concentration of DNA	4
	6. Gene transfer by Conjugation a. Discovery of Conjugation, b. Properties of F plasmid, F ⁺ , F ⁻ , Hfr and F' strains c. Process of conjugation between F ⁺ and F ⁻ , Hfr and F ⁻ , F' and F ⁻	4
	7. Gene transfer by Transduction a. Discovery of Transduction b. Generalized transduction mediated by P22 c. Specialized transduction mediated by lambda phage	4
	8. An introduction to Gene mapping a. Gene linkage and concept of genetic recombination b. Recombination mapping: Map unit, recombination frequency c. Mapping of genes by co-transformation d. Mapping of genes by co-transduction e. Mapping by interrupted mating experiment f. Numerical problems based on co-transformation, co-transduction and interrupted mating	6

Semester VI

DSEC -MB-364: Molecular Biology

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Credit No	Topics	No. of lectures
Credit I	Genetic Recombination and Bacteriophage Genetics.	18
	1. Gene linkage and crossing over a. Mendel's laws: Eukaryotic Cell cycle, Mitosis, Meiosis b. Holliday model for Homologous recombination, Role of Rec and Ruvproteins c. Genetic mapping by Tetrad analysis in <i>N. crassa</i> (Numerical Calculations using PD, TT and NPD) d. Genetic Mapping by Parasexual cycle in <i>A. nidulans</i>	9
	2. Bacteriophage Genetics a. Lytic cycle: Virulent phages, T-series phages, Concept and formation of plaque, Lysogenic cycle: Temperate phage (λ phage) b. Bacteriophage mutants: Plaque morphology (r type), Host range, Conditional lethal mutants (Ts and Am) c. Concept of Genetic Complementation and Cis-trans test of genetic function. (Intergenic- rII locus of T4 phage, Mechanism of Intragenic complementation.) d. Fine structure mapping of rII locus of T4 phage using Benzer's spot tests and deletion mapping	9
Credit II	DNA damage and repair mechanisms, Recombinant DNA technology	18
	3. DNA damage and Repair mechanisms a. DNA damage by hydrolysis, deamination, alkylation, oxidation, Radiation (X rays and UV rays) b. DNA repair by Photo reactivation c. DNA repair by Mismatch repair mechanism d. DNA repair by Excision repair mechanisms (BER/NER)	5

	<p>4. Recombinant DNA Technology Tools and basics of recombinant DNA technology</p> <p>a. Introduction to recombinant DNA technology</p> <p>b. Restriction enzymes: Concept, Nomenclature, properties and types with examples (Eco R1, Sma I, Pst I).</p> <p>c. Vectors: Features of an ideal vector</p> <p>i. Plasmids: pBR322</p> <p>ii. Bacteriophage vectors: Lambda</p> <p>iii. Cosmids</p> <p>iv. High capacity vectors: YACs, BACs</p> <p>v. Expression vectors</p> <p>d. Joining of DNA molecules- DNA Ligases (<i>E. coli</i> and T4 phage), Use of Linker / Adaptor / Homopolymer tailing</p> <p>e. Methods to transfer recombinant DNA into bacterial host cells (Physical – Electroporation, Gene gun, Chemical –CaCl₂ mediated, liposome mediated)</p> <p>f. Methods of screening recombinants using selective markers and Blue-whitescreening</p>	10
	<p>5. Molecular techniques used in RDT</p> <p>a. Isolation of genomic DNA</p> <p>b. Principle and methodology of Agarose gel electrophoresis and its applications</p> <p>c. Concept, Methodology and applications of Southern, Northern and Western blotting</p>	3

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2. National Academies Press: Introduction of Recombinant DNA-Engineered Organisms Into theEnvironment: Key Issues: <https://www.nap.edu/download/18907#>
3. Guidelines and Handbook for Institutional Biosafety Committees (DBT, Govt. of India and BCIL):<https://thsti.res.in/pdf/IBG.pdf>
4. University of North Carolina’s Biosafety Guidelines (Principles, Risk assessment, Biosafety levels, Guidelines):
<https://ehs.unca.edu/laboratory-safety/biological-safety/>
<http://www.informatics.jax.org/silver/chapters/7-1.shtml>

Semester V

DSEC -MB 355 Fermentation Technology– I

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Course Outcomes

- To impart technical understanding of commercial fermentations.
- To apply classical, advanced strain improvement and isolation techniques for fermentation processes.
- To optimize and sterilize media used in fermentation industry for commercially economical and efficient fermentations.
- To recover the product using suitable methods and ensuring quality of the finished product by quality assurance tests.
- To acquaint fermentation economics, process patentability, process validation.
- To comprehend the large scale productions of commercially significant fermentation products of classical and recent significance.

Credit No.	Topics	No. of lectures
Credit I	Upstream processes of fermentations	18
	1. Strain Improvement:	
	a. Objectives of strain improvement	1
	b. Methods for strain improvement:	
	i. Types of mutants used in strain improvement (altered cell permeability mutants, auxotrophs, analogue resistant mutants, revertants)	1
	ii. Selection of different types of mutants (replica plate method, filtration enrichment, penicillin enrichment method, gradient plate technique)	2
	iii. Application of rDNA technology (significance, technique for commercial recombinant products like insulin)	1
	2. Media optimization	
	a. Objectives of media optimization	1
	b. Methods of media optimization:	
	i. Classical approach – One factor at a time, Full factorial design	1
	ii. Plackett and Burman Design (with example) (Numerical problems of PBD can be discussed using software)	2
	iii. Response Surface Methodology (RSM)	1

	<p>3. Sterilization of Media:</p> <p>a. Methods of sterilization 1</p> <p>b. Batch sterilization and Continuous sterilization (direct and indirect methods) 1</p> <p>c. Concept and derivation of Del factor 1</p> <p>d. Filter sterilization of liquid media 1</p>	
	<p>4. Scale-up and Scale-down:</p> <p>a. Objectives of scale-up 1</p> <p>b. Levels of fermentation (laboratory, pilot-plant and production level – flow sheet to explain scale up) 1</p> <p>c. Criteria of scale-up for critical parameters [Aeration (kLa Volumetric Mass transfer coefficient), Agitation (P/V ratio, N_{Re} Reynolds number, N_p Power number, N_{Fr} Froudes number), Sterilization and broth rheology (Newtonian and non Newtonian fluids - bacterial and mycelia fungal fermentations)] 1</p> <p>d. Scale-down (example of any one commercial fermentation) 1</p>	
	Downstream processing and Quality assurance of fermentation products	18
Credit II	<p>5. Downstream processing of fermentation products: (method, principle, types, examples of fermentations, factors affecting, merits and demerits at large scale operation)</p> <p>a. Cell disruption methods 1</p> <p>b. Filtration 1</p> <p>c. Centrifugation 1</p> <p>d. Liquid-liquid extraction 1</p> <p>e. Distillation 1</p> <p>f. Drying 1</p>	
	<p>6. Quality assurance of fermentation products (as per IP, USP)</p> <p>a. Methods of detection and Quantification of the fermentation product: physicochemical, biological and enzymatic methods 2</p> <p>b. Sterility testing (direct inoculation method, membrane filtration method) 1</p> <p>c. Bioburden test 1</p>	

d. Microbial limit test	1
e. Pyrogen testing: Endotoxin detection (LAL test)	1
f. Ames test and modified Ames test	1
g. Toxicity testing (Acute toxicity)	1
h. Shelf life determination	1
7. Fermentation economics:	
a. Contribution of various expense heads to a process (Recurring and nonrecurring expenditures) citing any suitable example.	1
b. Introduction to Intellectual Property Rights – Types of IPR (patenting in fermentation industry)	1
c. Concept of validation (significance of SOPs)	1

Semester VI

DSEC - MB 365 Fermentation Technology – II

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Credit No.	Topics	No. of lectures
Credit I	Solid state and Submerged state fermentations and Large scale fermentations	18
	1. Introduction to Solid State Fermentation and Submerged Fermentation: Process, production strains, media, fermentor design, fermentation conditions, applications, merits and demerits	1
	2. Large scale production of (process with flow sheet, nature of the product, production pathway, applications, production strains, media, fermentation process, parameters, product recovery)	3 3 4
	a. Primary Metabolites: i. Vitamins (B12 and B2)	1
	ii. Amino acids - Glutamic acid, Lysine iii. Organic acids (Citric acid, Vinegar and Lactic acid)	3
	b. Secondary metabolites: i. Bioethanol	

	<ul style="list-style-type: none"> ii. Alcoholic Beverages - <ul style="list-style-type: none"> a. Beer (Lagering, Maturation, Types of beer) b. Wine (Aging, Malo-lactic acid fermentation, types of wine, wine defects, comparison of white and red wine) iii. Antibiotics [Penicillin (natural and semi synthetic) and Streptomycin] 	3
Credit II	Large scale production of enzymes, steroids, biomass based products, milk products, vaccines, immune sera and Modern trends in microbial production	18
	3. Enzymes	
	<ul style="list-style-type: none"> i. Amylase ii. Esterases iii. Proteases 	1 1 1
	4. Microbial transformation of steroids	2
	5. Biomass based products:	
	<ul style="list-style-type: none"> i. Yeast: Baker's and Distiller's yeast ii. Probiotics: <i>Lactobacillus sporogenes</i> 	2 1
	6. Milk products:	
	<ul style="list-style-type: none"> i. Cheese (Processed, soft, semi-hard, hard ripened types- bacterial and mold) ii. Yogurt (plain, flavoured, fruit, sundae style. Stirred type, set type, probiotic yoghurt) 	2 2
	7. Vaccines	
	<ul style="list-style-type: none"> i. Polio – Inactivated Polio Vaccine, Oral Polio Vaccine ii. Tetanus – Tetanus toxoid (TT) iii. Rabies – HDCC, Chick embryo cell line, Vero cell line 	1 1 1
8. Immune sera		
<ul style="list-style-type: none"> i. Anti tetanus serum (ATS) ii. Anti rabitic serum (ARS) 	1 1	
9. Modern trends in microbial production:		
Biosurfactant and bioemulsifier	1	

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https://www.who.int/biologicals/vaccines/Tetanus_Recommendations_TRS_980_Annex_5
<https://academic.oup.com/jimb/article-pdf/18/5/340/34773995/jimb0340.pdf>
25. Large scale production of rabies vaccine:
26. Large scale production of tetanus vaccine:
<http://nopr.niscair.res.in/bitstream/123456789/26533/1/JSIR%2060%2810%29%20773-778.pdf>
27. USA Clinical Laboratory Standards Institute (CLSI) Guidelines 2021: <https://clsi.org/>

Semester V

DSEC - MB 356: Agricultural Microbiology

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Course Outcomes

- To understand plant growth improvement with respect to disease resistance, environment tolerance.
- To correlate stages of plant disease development, epidemiology, symptom based classification, control methods.
- To understand the importance of microorganisms in sustainable agriculture, biotechnological application of bio films, edible vaccines.
- To correlate Soil Micro biome and Role of microorganisms in soil health
- To determine the use of Microorganisms as tools in plant genetic engineering.

Credit No.	Topics	No. of lectures
Credit I	Plant Pathology	18
	1. Plant growth improvement and Stages in development of a disease a. Plant growth improvement with respect to disease resistance b. Stages in development of a disease: Infection, invasion, colonization, dissemination of pathogens andperennation	3
	2. Classification of disease based on symptoms (with one example of the following): Canker, Downy mildew, Mosaic	3
	3. Plant disease epidemiology Concepts of monocyclic, polycyclic and polyetic diseases withone example of each, disease triangle and forecasting of plant diseases.	6
	4. Methods of plant disease control i. Eradication ii. Chemical control iii. Biological control (employing bacterial and fungal cultures) iv. Integrated pest management v. Genetic engineering for disease resistant plants	6

	Microorganisms in sustainable Agriculture and tools in plant genetic engineering	18
Credit II	5. Microorganisms in sustainable Agriculture	
	a. Soil Micro biome (plant Micro biome)	2
	b. Concept, Composition, functioning and methods to study:	
	i. Conservation of soil health: Role of microorganisms in soil health	1
	ii. Phytonutrient availability by soil microorganisms Mechanism of diazotrophy, Phosphate solubilization, Potassium mobilization, micronutrient availability	4
	iii. Biofilm in plant surfaces, Biofilm formation; Biofilm in Phyllosphere and rhizosphere, Examples of plant- microbe interactions in biofilms, Biotechnological applications of plant biofilms	3
	6 Microorganisms in plant genetic engineering:	
	a. Concept of GM crops (Transgenic crops) w.r.t. to edible vaccines, insecticide resistance, herbicide resistance, improved varieties, new variants, disease resistance	2
	b. Tools and techniques:	
	i. Microorganisms as tools in plant genetic engineering (Shuttle vectors)	1
	ii Technology of BT resistant crops	1
	iii. Concept of edible vaccines	1
	iv Technique of use of plant viruses in genetic engineering	1
	c. RNAi Technology and antisense RNA technology in disease resistant plant varieties	2

References: MB 356 Agricultural Microbiology

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11. Peter K. (2018). *Genetic Engineering of Horticultural Crops*. United Kingdom: Elsevier Science. ISBN: 9780128104408
12. Rangaswami G. (2005). *Diseases of Crop Plants in India*. 4th edition. Prentice Hall of India Private Limited., New Delhi.
13. Rudrappa T., Biedrzycki M. L. and Bais H. P. (2008). Causes and Consequences of plant associated biofilms. *FEMS Microbiology and Ecology*. 64 (2): 153-166.
14. Singh R. S. (1998). *Plant Diseases Management*. 7th edition. Oxford and IBH, New Delhi.
15. Stewart C. N. (2008). *Plant Biotechnology and Genetics: Principles, techniques and applications*. John Wiley and Sons. Inc. New York.
16. Thind B. (2019). *Phytopathogenic Bacteria and Plant Diseases*. United Kingdom: CRC Press. ISBN: 9780429512506

Semester VI

DSEC - MB 366: Food Microbiology

[2 Credits; 36 Lectures]

[1 credit=15hrs x 60 mins = 900mins/50mins=18 lectures]

Course Outcome

- To describe food safety problems and solutions in India and global scale.
- Identify and classify types of microorganisms in food processing and compare their Characteristics and behavior
- To learn food classification based on their perishability, intrinsic and extrinsic factors affecting the growth of microbes in foods, role of microorganisms in food fermentation.
- To acquire knowledge about food spoilage, food borne diseases, predisposition and preventive and control measures.
- To apply principles of sanitation, heat treatment, irradiation, modified atmosphere, antimicrobial preservatives and combination of method (hurdle concept) to control microbial growth with emphasis on HACCP guidelines.

Credit No	Topics	No. of lectures
Credit I	Introduction to properties of food and spoilage of food	18
	1. Classification of food- Perishable, non-perishable, and stable. Sensory characters of food- a. Definition of food b. Sensory or organoleptic factors- appearance factors-(size,shape, color, gloss, consistency, wholeness) c. Textural factors-texture changes d. Flavor factors (taste, smell, mouthfeel, temperature)	4
	2. Factors affecting Microbial growth in food a. Intrinsic factors- pH, water activity, O-R potential, nutrient content, biological structure of food, inhibitory substances in food. b. Extrinsic factors-Temperature of storage, Relative humidity, concentration of gases.	5
	3. Sources of food spoilage microorganisms a. Contamination and spoilage of perishable foods- vegetables and fruits, Meat and meat products, Fish and other sea food, Egg and poultry products. b. Contamination and spoilage of canned foods c. Contamination and spoilage of- cereals and cereal products, sugar and sugar products, salad dressings, spices andcondiments.	9

Credit II	Food Preservation and food in relation to disease	18
	4. Principles of food preservation a. Importance of TDP, TDT, D, F, Z values b. Use of low and high temperature for food preservation. c. Use of chemicals and antibiotics in food preservation, d. Canning e. Dehydration f. Use of radiation g. Tetra pack technology h. Food grade bio preservatives	10
	5. Microbial food poisoning and food infection a. Food poisoning - <i>Clostridium botulinum</i> , <i>Aspergillus flavus</i> b. Food infection- <i>Salmonella typhimurium</i> , <i>Vibrio parahaemolyticus</i>	4
	6. Concept of Prebiotic and Probiotic and fermented food- definition, Health effects, Quality assurance, Safety, side effects and risk. Potential applications of Prebiotic, Probiotic and fermented food	2
	7. Food sanitation and regulatory authorities (ISO, FDA, WHO)	2

References: MB 366 Food Microbiology

1. Alias A K., Paliyath G. and Bhat R. (2012). Progress in Food Preservation. United Kingdom: Wiley. ISBN: 9780470655856
2. Banwart G. J. (1989). Basic Food Microbiology. 2nd edition. Chapman and Hall. International Thompson Publishing.
3. Bozoglu T. F. and Erkmen O. (2016). Food Microbiology. 2 Volume Set: Principles into Practice. United Kingdom: Wiley. ISBN: 9781119237761
4. Coles R. and Kirwan M. J. (2011). Food and Beverage Packaging Technology. Germany: Wiley. ISBN: 9781444392173
5. Early R. (2012). Guide to quality management for the food Industry. Blackie Academic and Professional. ISBN-13: 978-1461358879
6. Frazier W. C., Westhoff D. C. and Vanitha N. M. (2013). Food Microbiology. 5th edition. McGraw Hill education, India.
7. Garbutt J. (1997). Essentials of Food Microbiology. Taylor and Francis. ISBN: 9780340677018
8. Gupta V. (2017). The food safety and standards act 9th edition. Commercial Law Publishers (India) Private Limited

9. Jay J. M. (2012). Modern Food Microbiology. Netherlands: Springer Netherlands. ISBN: 9789401164818
10. Jay J. M. and Loessner M. J. (2005). Modern Food Microbiology. 7th edition. Springer. ISBN 978-0-387-23413-7
11. Mahindru S. N. (2010). Encyclopedia of Food Analysis. 3 Volumes. APH Publishing Corporation. ISBN-13: 9788131308806
12. Makun H. A. (2016). Significance, Prevention and Control of Food Related Diseases. Croatia: IntechOpen. ISBN: 9789535122777
13. Peñas. E., Frias J. and Villaluenga C. M. (2016). Fermented Foods in Health and Disease Prevention. Netherlands: Elsevier Science. 9780128025499
14. Preedy V. R. (2015). Probiotics, Prebiotics, and Synbiotics: Bioactive Foods in Health Promotion. Netherlands: Elsevier Science. ISBN: 9780128023716
15. Ray B. (2019). Food Biopreservatives of Microbial Origin. United States: CRC Press. ISBN: 9781351080514
16. Sivasankar B. (2009). Food processing and preservation. PHI Learning Pvt. Limited

Semester V

Practical Course-I

DSEC-MB – 357: Diagnostic Microbiology and Immunology

[2 Credits; 78 Lectures]

[1 credit=15hrs x 130 mins = 1950 mins/50 mins=39 lectures]

78 L distributed as 60 L for performing practicals and 18 L for internal evaluation

12 Practical x 5 lectures = 60 Lectures

Sr. No	Practical	No. of Practical
1.	Clinical microbiology: Physical, Chemical and Microscopic examination of Clinical samples - Urine, stool and pus	2
2.	Isolation, identification of following pathogens from clinical samples: i. <i>Klebsiella</i> spp. ii. <i>Salmonella</i> spp. iii. <i>Pseudomonas</i> spp iv. <i>Streptococcus</i> spp. v. <i>Enterococcus</i> spp. (for identification use of keys as well as Bergey's Manual is recommended)	5
3.	Agglutination tests: Widal test (Slide test and Tube Test) and Rapid Plasma Reagin (RPR) test	1
4.	Epidemiological survey: Development of hypothesis, Data collection, organization, statistical analysis, graphical representation using computers and interpretation, Preparation of report	2
5.	Hemogram: a. Estimation of hemoglobin (Acid hematin and Cyan-methemoglobin method) b. ESR and PCV determination, c. White blood cell differential count from peripheral blood d. Counting of RBCs and WBCs using counting chamber e. Calculation of hematological indices	2

Semester VI

Practical Course-I

DSEC-MB – 367: Diagnostic Microbiology and Immunology

[2 Credits: 78 Lectures]

[1 credit=15hrs x 130 mins = 1950 mins/50 mins=39 lectures]

78 L distributed as 60 L for performing practicals and 18 L for internal evaluation

12 Practical x 5 lectures = 60 Lectures

Sr. No.	Practicals	No. of Practical
1.	Study of permanent slides of following microbial pathogens: a) <i>Entamoeba histolytica</i> b) <i>Giardia</i> spp. c) <i>Plasmodium</i> spp. d) <i>Mycobacterium</i> (tuberculosis and leprae) e) <i>Trichophyton</i> spp. f) <i>Epidermophyton</i> spp. g) <i>Microsporum</i> spp.	3
2.	Isolation and identification of following yeast and fungal pathogens: <i>Cryptococcus neoformans</i> / <i>Histoplasma capsulatum</i>	1
3.	Antibiotic sensitivity testing of the bacterial pathogens (for Gram negative and Gram Positive)	1
4.	Immunoematology: Cross-matching (Major and Minor) and Coomb's test (Direct and Indirect)	2
5.	Immuno chromatographic test: The qualitative differential detection of IgM and IgG antibodies to dengue virus in Human serum /Plasma Or Advantage Mal Card visual immunoassay: The qualitative diagnosis of <i>Plasmodium</i> spp	1
6.	Immunoprecipitation: Double diffusion (Ouchterlony) technique	1
7.	Demonstrations of: a. Serum protein separation by electrophoresis b. ELISA (Antigen/ Antibody detection)	2

	c. Egg inoculation technique	
8.	Visit to blood bank and preparation of visit report	1

References: MB 357 and MB 367: Diagnostic Microbiology and Immunology

1. Abramson J. and Abramson Z. H. (2011). Research Methods in Community Medicine: Surveys, Epidemiological Research, Programme Evaluation, Clinical Trials. Sixth Edition. Wiley. ISBN: 978-0-470-98661-5
2. Baveja C. P. and Baveja V. (2019). Text and Practical Microbiology for MLT. 3rd Edition. Arya Publishing Company. ISBN-13: 9788178558387
3. Bergey's Manual of Systematic Bacteriology. (2005). Volume Two: The Proteobacteria, Part A: Introductory Essays. Garrity G. editor. Springer. ISBN 978-0-387-24143-2
4. Bergey's Manual of Systematic Bacteriology. (2005). Volume Two: The Proteobacteria, Part B: The Gammaproteobacteria. Garrity G. Brenner D. J., Krieg N. R., and Staley J. R. (Eds.). Springer. ISBN 978-0-387-24144-9
5. Bergey's Manual of Systematic Bacteriology. (2005). Volume Two: The Proteobacteria, Part C: The Proteobacteria. Garrity G. Brenner D. J., Krieg N. R., and Staley J. R. (Eds.). Springer. ISBN 978-0-387-24145-6
6. Bergey's Manual of Systematic Bacteriology. (2009). Volume Three: The Firmicutes. Part C: The Proteobacteria. Vos, P., Garrity, G., Jones, D., Krieg, N.R., Ludwig, W., Rainey, F.A., Schleifer, K.-H., Whitman, W. (Eds.). Springer. ISBN 978-0-387-95041-9
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9. Maheshwari N. (2017). Clinical Pathology Hematology and Blood Banking (For Dmlt Students). 3rd edition. Jaypee Brothers Medical Publishers. ISBN-13: 978- 9386261182
10. Mukherjee K. L. and Ghosh S. (2010). Medical Laboratory Technology, Volume I: Procedure Manual for Routine Diagnostic Tests. 2nd edition. McGraw Hill Education (India) Private Limited. ISBN-13: 978-1259061233
11. Mukherjee K. L. and Ghosh S. (2010). Medical Laboratory Technology, Volume II: Procedure Manual for Routine Diagnostic Tests. 2nd edition. McGraw Hill Education (India) Private Limited. ISBN-13: 978-1259061240

12. Mukherjee K. L. and Ghosh S. (2010). Medical Laboratory Technology, Volume III: Procedure Manual for Routine Diagnostic Tests. 2nd edition. McGraw Hill Education (India) Private Limited. ISBN-13: 978-1259061257
13. Talib V. H. (2019). Handbook Medical Laboratory Technology. 2nd edition. CBS Publishers and Distributors Pvt. Ltd. ISBN-13: 978-8123906775

Links:

1. *Candida*: <https://www.slideshare.net/Sciblack/candidiasis-clinical-manifestations-and-lab-diagnosis-of-oral-candidiasis>
2. *Cryptococcus neoformans*:
 - i) (<https://www.cdc.gov/fungal/diseases/cryptococcosis-neoformans/symptoms.html>)
 - ii) *Rev. Inst. Med. Trop. Sao Paulo*, 57(4):295-298, July-August, 2015, <http://dx.doi.org/10.1590/S0036-46652015000400004>, isolation of *cryptococcus neoformans* from environmental samples collected in southeastern Nigeria, emeka i. nweze(1), fred a. kechia(2,3), uju e. dibua(1), charles eze(4) and uwakwe s. onoja(5)
 - iii) <https://academic.oup.com/mmy/article/43/6/565/1008990>
3. *Histoplasma*: https://www.slideshare.net/shahmanthan24/histoplasma-is-mycology-epidemiology-laboratory-diagnosis?from_action=save

Semesters V

Practical Course – II

MB 358: Enzymology and Genetics

[2 Credits; 78 Lectures]

[1 credit=15hrs x 130 mins = 1950 mins/50 mins=39 lectures]

78 L distributed as 60 L for performing practicals and 18 L for internal evaluation

12 Practical x 5 lectures = 60 Lectures

Sr. No.	Practical	No. of Practical
1.	Determination of absorption spectra and molar extinction co-efficient of two different dyes(by colorimetry /spectrophotometry)	1
2.	Qualitative analytical tests using flow charts for i. Proteins (tests for aromatic amino acids, sulfur containing amino acids, different amino acids) ii. Carbohydrates (tests for monosaccharides, disaccharides, and polysaccharides)	2
3.	Preparation of buffers and calibration of pH meter	1
4.	Paper Chromatography i. Separation and Identification of amino acids from mixture by paper chromatography ii. Separation and Identification of sugars from mixture by paper chromatography	1
5.	Extraction and quantitative estimation of total carbohydrate /proteins from natural sample: i. Estimation of total carbohydrates from natural sources by Lane-Eynon method ii. Estimation of reducing sugar from natural sources by DNSA method iii. Estimation of proteins from natural sources by Folin Lowry method	3
6.	Isolation of genomic DNA from bacteria	1
7.	Determination purity of DNA and its quantification: a. Estimation of DNA by UV- spectrophotometric method, 260/280 ratio b. Estimation of DNA by the diphenylamine	1
8.	Bacterial Conjugation	1
9.	Chromosome Staining (G-banding) Giemsa staining of chromosome from eukaryotic cell extract	1

References: MB 358 Enzymology and Genetics

1. Ausubel F. M., Brent R., Kingston R. E., Moore D. D., Seidman J.G., Smith J. A. and Struhl K. (Editors.). (2003). *Current Protocols in Molecular Biology*. Copyright © John Wiley and Sons, Inc. ISBN: 047150338X
2. Bollet C., Gevaudan M.J., de Lamballerie X., Zandotti C. and de Micco P. (1991). A simple method for the isolation of chromosomal DNA from Gram positive or acid-fast bacteria. *Nucleic Acids Research*. 19(8): 1955. <https://doi.org/10.1093/nar/19.8.1955>
3. Burton K. (1968). Determination of DNA concentration with diphenylamine. *Methods in Enzymology*. Volume12. Part B: 163-166. [https://doi.org/10.1016/0076-6879\(67\)12127-7](https://doi.org/10.1016/0076-6879(67)12127-7)
4. Howe B., Umrigar A. and Tsien F. (2014). Chromosome Preparation from Cultured Cells. *J.Vis. Exp.* 83: e50203. doi:10.3791/50203
5. Jayaraman J. (2011). *Laboratory Manual in Biochemistry*. New Age International Private Limited. ISBN-13: 978-8122430493
6. Jørgensen N. O. G., Sørensen J. and Nybroe O. (2010). *Microbiology 2010: Block 3: manual of laboratory exercises*. Department of Agriculture and Ecology, University of Copenhagen.
7. Katoch R. (2011). *Analytical Techniques in Biochemistry and Molecular Biology*. Springer New York Dordrecht Heidelberg London. ISBN: 978-1-4419-9784-5.
8. Martzy R., Bica-Schröder K., Pálvölgyi, Á.M., Kolm C., Jakwerth S., Kirschner A. K. T., Sommer R., Krska R., Mach R. L., Farnleitner A. H. and Reischer G. H. (2019). Simple lysis of bacterial cells for DNA-based diagnostics using hydrophilic ionic liquids. *Sci Rep.* 9: 13994 <https://doi.org/10.1038/s41598-019-50246-5>
9. Plummer D. T. (2001). *Introduction to Practical Biochemistry*. Tata McGraw Hill Publishing Company. ISBN-13: 978-0070994874
10. Sadashivam S. and Manickam A. (2018). *Biochemical Methods*. Third edition. NewAge International Publication. ISBN-13: 978-8122421408
11. Wilson K. and Walker J. (Editors). (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. 7th edition. Cambridge University Press, New York. ISBN-13: 978-0521731676
12. Wright M. H., Adelskov J. and Greene A. C. (2017). Bacterial DNA Extraction Using Individual Enzymes and Phenol/Chloroform Separation. *Journal of microbiology and biology education*. 18(2): 18.2.48.<https://doi.org/10.1128/jmbe.v18i2.1348>

Semester VI

Practical Course – II

SEC-MB 368: Metabolism and Molecular Biology

[2 Credits: 78 Lectures]

[1 credit=15hrs x 130 mins = 1950 mins/50 mins=39 lectures]

78 L distributed as 60 L for performing practicals and 18 L for internal evaluation

12 Practicals x 5 lectures = 60 Lectures

Sr. No.	Practicals	No. of Practical
1.	Clinical Biochemistry - Estimations of i. Blood sugar ii. Blood urea iii. Serum cholesterol iv. Serum proteins and albumin	3
2.	Enzyme production, purification, quantification and Immobilization: i. Lab scale production of amylase using isolates ii. Precipitation of amylase from fermentation broth (salt/solvent) iii. determination of specific activity of crude and purified amylase iv. Immobilization of Amylase using calcium alginate	4
3.	Enrichment, Isolation and Enumeration of Bacteriophages (Principle , Methodology and Calculations of phage titer in PFU/ml)	2
4.	Isolation of Plasmid DNA and Agarose Gel Electrophoresis (Demonstration/hands on as per infrastructure availability)	1
5.	Study of Mitotic cell division from onion root tips	1
6.	Visit to a Biotechnology/ Biochemistry institute	1

References: MB 368 Metabolism and Molecular Biology

1. Ausubel F. M., Brent R., Kingston R. E., Moore D. D., Seidman J.G., Smith J. A. and Struhl K. (Editors.). (2003). Current Protocols in Molecular Biology. Copyright © John Wiley and Sons, Inc. ISBN: 047150338X
2. Bhatta P. and Sakya S. R. (2008). Study of mitotic activity and chromosomal behaviour in root meristem of *Allium cepa* L. treated with magnesium sulphate. Ecoprint. 15: 83-88. ISSN 1024-8668. Ecological Society (ECOS), Nepal. www.ecosnepal.com.
3. Birnboim H. C. and Doly J. (1979). A rapid alkaline extraction procedure for screening of recombinant plasmid DNA. Nucleic acid Research. 7(6):1513-1523.

4. Clokie M. R. J. and Kropinski A. M. (editors): Bacteriophage: Methods and Protocols. Volume 1. Isolation, Characterization and Interactions. Series Volume 501. Humana Press, New York
5. Freitas A.R., Novais C., Peixe L. and Coque T.M. (2020). Isolation and Visualization of Plasmids from Gram-Positive Bacteria of Interest in Public Health. In: de la Cruz F. (editors). Horizontal Gene Transfer. Methods in Molecular Biology. Volume-2075. Humana, New York, NY. https://doi.org/10.1007/978-1-4939-9877-7_2
6. Hyman P. and Abedon S.T. (2009). Practical methods for determining Phage growth parameters. Methods Mol Biol. 501:175-202. doi: 10.1007/978-1-60327-164-6_18. PMID: 19066822
7. Katoch R. (2011). Analytical Techniques in Biochemistry and Molecular Biology. Springer New York Dordrecht Heidelberg London. ISBN: 978-1-4419-9784-5
8. Kusumaningrum H. P., Lunggani A. T. and Nurhakim M. A. (2012). Chromosomes and Mitotic Cell Division Phase in Onion Roots After 24 Hours Acetoorcein Soaking Time. Bioma: Berkala Ilmiah Biologi. 14 (2): 46-48. <https://doi.org/10.14710/bioma.14.2.46-48>
9. Wilson K. and Walker J. (Editors). (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7th edition. Cambridge University Press, New York. ISBN-13: 978-0521731676

Semester V

Practical course-III

DSEC-MB 359 Fermentation Technology- I and Agricultural Microbiology

[2 Credits; 78 Lectures]

[1 credit=15hrs x 130 mins = 1950 mins/50 mins=39 lectures]

78 L distributed as 60 L for performing practicals and 18 L for internal evaluation

12 Practical x 5 lectures = 60 Lectures

Sr. No	Title of the Practical	No. of Practical
1.	Sterility Testing of pharmaceuticals (non-biocidal injectables): Direct inoculation method, membrane filtration method, using control test cultures as per IP guidelines (availability at the center).	2
2.	Minimum inhibitory concentration and minimum bactericidal concentration of antibacterial compounds (MIC and MBC)	2
3.	Antibiotic and growth factor assay (agar gel diffusion technique)	2
4.	Isolation and identification of <i>Xanthomonas</i> spp. from citrus canker	1
5.	Isolation of <i>Aspergillus niger</i> from black rot of onion	1
6.	Collection of plant disease specimens and study of symptoms/ Project based on digital record of plant diseases(Group Activity)	1
7.	Isolation of PGPR with phosphate solubilization potential/Vesicular-Arbuscular Mycorrhiza (VAM), Preparation of liquid bioinoculants	2
8.	Validation of commercial formulations of bioinoculants based on BIS standards, Pot studies to check effect of bioinoculants on plant growth	1

References: MB 359 Fermentation Technology- I and Agricultural Microbiology

1. British Pharmacopeia. (2021). The Stationery Office Ltd (TSO), PO Box 29, Norwich, NR3 1PD. <https://www.pharmacopoeia.com/Catalogue/Products>
2. Indian Pharmacopeia. (2018 Addendum 2021). <https://www.indianpharmacopoeia.in/index.php>
3. USA Clinical Laboratory Standards Institute(CLSI) Guidelines 2021 on <https://clsi.org/>
4. Sterility Testing: https://www.who.int/medicines/publications/pharmacopoeia/TestForSterility-RevGenMethod_QAS11-413FINALMarch2012.pdf.
5. Microbiological assay of antibiotics: <https://apps.who.int/phint/pdf/b/7.3.1.3.1-Microbiological-assay-of-antibiotics.pdf>

http://www.uspbpep.com/usp29/v29240/usp29nf24s0_c81.html.

6. Microbiological assay of vitamins:

<https://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=14117andcontext=rtd>.

<https://www.pharmaguideline.com/2011/09/microbiological-assay-of-cyanocobalamin.html>.

7. Isolation of *Xanthomonas citri* from citrus canker:

<https://www.plantbiosecuritydiagnostics.net.au/app/uploads/2018/11/NDP-9-Asiatic-citrus-canker-Xanthomonas-V1.2.pdf>.

https://assets.ippc.int/static/media/files/publication/en/2016/01/DP_06_2014_En_201_5-12-22_PostCPM10_InkAmReformatted.pdf.

http://www.asianjournalofchemistry.co.in/User/ViewFreeArticle.aspx?ArticleID=231_67.

8. Plant disease study based on symptoms:

▪ Dube H. C. and Bilgrami K.S. 1976 Text book of modern pathology. Vikas Publishing House. New Delhi.

▪ Mehrotra R. S. (1994). Plant Pathology. Tata McGraw-Hill Limited.

▪ Rangaswami G. (2005). Diseases of Crop Plants in India. 4th edition. Prentice Hall of India Pvt. Ltd., New Delhi.

9. Isolation of *Aspergillus niger* from black rot of onion:

<http://archive.sciendo.com/AGRO/agro.2012.29.issue-1/v10146-012-0003-5/v10146-012-0003-5.pdf>.

10. Validation of standards of biofertilizers:

▪ Manual - <https://law.resource.org/pub/in/bis/S06/is.6092.3.2.2004.pdf>

▪ Rhizobial and azotobacterial biofertilizers: <https://bio-fit.eu/q8/lo6-quality-control-of-biofertilizers?start=4>.

▪ Organic Farming: Organic Inputs and Techniques:

http://agritech.tnau.ac.in/org_farm/orgfarm_biofertilizertechnology.html.

▪ Borkar S. G. (2015). Microbes as Biofertilizers and their Production Technology. Woodhead Publishing India Private Limited., New Delhi.

▪ Yadav A. K. and Chandra K. (2014). Mass Production and Quality Control of Microbial Inoculants. Proc Indian Natn Sci Acad. 80 (2): 483-489.

11. Isolation of PGPR with PSB:

▪ <https://www.ijnpnd.com/article.asp?issn=2231-0738;year=2013;volume=3;issue=1;spage=29;epage=33;aulast=Ranjan>.

▪ <https://scielo.conicyt.cl/pdf/jssp/v16n2/aop4316.pdf>.

Semester VI

Practical Course-III

DSEC-MB 369 Fermentation Technology- II and Food Microbiology

[2 Credits; 78 Lectures]

[1 credit=15hrs x 130 mins = 1950 mins/50 mins=39 lectures]

78 L distributed as 60 L for performing practicals and 18 L for internal evaluation

12 Practical x 5 lectures = 60 Lectures

Sr. No	Title of the practical	No. of practicals
1.	Lab Scale production of the fermentation products: a. Ethanol (fermentation, recovery by simple distillation, estimation of end product by CAN method and fermentation efficiency) or b. Citric acid (fermentation, recovery by acid base precipitation and estimation of product by titrometry)	2
2.	Solid state fermentation for production of any one fermentation product (<i>Trichoderma sp.</i> / mushrooms / enzymes)	1
3.	Isolation and identification of Probiotic microflora from natural sources or any commercial formulation.	2
4.	Study of SOPs for pharmaceutical industry a. disinfectant efficacy testing b. Physical monitoring of microbiology section c. Handling of biological indicators d. Microbiological testing of vials e. Identification of contaminant in sterile area	1
5.	Detection of aflatoxin	1
6.	Determination of TDP and TDT value	2
7.	Determination of TDR and D value	1
8.	HACCP guidelines for food industry (activity based)	1
9.	Visit to any food industry or a fermentation industry	1

References: MB 369 Fermentation Technology- II and Food Microbiology

1. Lab scale fermentations:

- Casida L. E., Jr. (2019). Industrial Microbiology, New Age International Publishers, New Delhi. ISBN- 9788122438024

- Patel A. H. (2016). Industrial Microbiology. Trinity Press (Publisher). ISBN-13-9789385750267
<https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1541-4329.2005.tb00060.x>
2. Solid state fermentation:
 - <https://iopscience.iop.org/article/10.1088/1757-899X/612/2/022111/pdf>.
 - <https://www.scielo.br/j/babt/a/vDHdsFscjRYsW6jkRfKQCDM/?lang=en>.
 - Meshram S. U. and Shinde G. B. (2009). Applied Biotechnology. I.K. International Publishing House Pvt. Ltd., New Delhi.
 3. Isolation of Probiotic bacteria:
 - <https://www.frontiersin.org/articles/10.3389/fmicb.2019.01382/full>.
 - <https://www.hindawi.com/journals/ijmicro/2020/8865456/>.
 4. Study of SOPs:
 - <https://www.pharmaguideline.com/2012/01/sop-for-physical-monitoring-of.html>
 - <http://biomanufacturing.org/uploads/files/989767618742858542-sop-visual-inspection-process.pdf>.
 5. Detection of aflatoxin:
 - https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals/MYCOTOXIN.pdf.
 - <https://journals.sagepub.com/doi/pdf/10.1177/156482659902000411>.
 - <https://www.diva-portal.org/smash/get/diva2:799266/FULLTEXT01.pdf>.
 6. Determination of TDT, TDP, TDR, D value.
 - Frazier W. C., Westhoff D. C. and Vanitha N. M. (2013). Food Microbiology. 5th edition. McGraw Hill education, India.
 - Jay J. M. and Loessner M. J. (2005). Modern Food Microbiology. 7th edition. Springer. ISBN 978-0-387-23413-7.
 7. HACCP:
 - https://www.fsai.ie/food_businesses/haccp/principles_of_haccp.html.

SEM V

Skilled Base Elective MB 3510 Marine Microbiology

2 Credit Course: 1.5 credit theory+0.5 credit Practical

Course Outcome:

- To impart the awareness of unseen and unexplored niche of marine ecosystem of microbes.
- To acquire advances in the knowledge of marine microbes and marine ecology.
- To learn the field research on marine processes and laboratory research on microorganisms.
- To comprehend the role of marine microbes in bioremediation and bioprospecting.
- To avail career opportunities in marine education, industry and research.

Theory Total Lectures: 21

Credit	Theory	No. of lectures
Credit 1.5	1. Marine ecology and sampling	
	a. Marine Habitats – estuaries, mangroves, coral reefs, salt marshes, coastal ecosystems, deep sea, hydrothermal vents, Polar habitat – Arctic, Antarctica, Southern Ocean	3
	b. Physiology of marine microorganisms – metabolic diversity, marine loop, marine snow, Role of marine microorganisms in biogeochemical cycles, nutrient cycling and hydrocarbon degradation	4
	c. Sampling methods– water sampling (Niskin sampler) and sediment sampling (Grab sampler, box corer, gravity corer), Culturing methods – VBNC, biofilm, mats from vents and estuarine sample.	4
	2. Marine microbes, role in bioremediation and bioprospecting	
	a. Extremophilic microorganisms – econiches, different types with examples and significance	2
	b. Archaea –biodiversity, stress response, adaptation and significance	3
c. Marine mycology – econiche, types of marine fungi and significance	2	
d. Bioremediation – heavy metals, hydrocarbon pollutants – tar ball and oil spills	3	

Skilled Based Elective MB 3510:**Marine Microbiology Practical****Total Lectures: 15 Practical 03 x 05 lectures=15 lectures**

Credit	Practical	No. of Practicals
Credit 0.5	1. Physico-chemical analysis of sea water	1
	2. Isolation of marine bacteria/ fungi from different niches – coastal waters, deep sea, estuarine waters, sediments	1
	3. Isolation of extremophilic bacteria – halophiles, thermophiles, acidophiles, alkalophiles, psychrophiles, osmophiles (any two of these)	1

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Semester V

Skilled Base Elective MB 3511 Dairy Microbiology

2 Credit Course: Total lectures: 36: Theory-21 L; Practical-15L

Course Outcome:

- To understand prospects of dairying at commercial marketing.
- To acquire skills of processing of milk and dairy products.
- To assess quality control in dairy industry.
- To comprehend production of dairy products of commercial significance with emphasis to local and global market demand.

Skilled Base Elective MB 3511 Dairy Microbiology Theory Total Lectures: 21

Credit No.	Theory	No of Lectures
Credit 1.5	1. Definition, types, microflora and pathogens: i. Definition of milk, Composition and physicochemical properties of Milk of different animals. Difference between colostrum and milk. ii. Types of milk: whole, toned, double toned, homogenized, and skimmed milk, dehydrated milk iii. Microflora associated with milk and its importance. iv. Sources of contamination of raw milk and relative importance in influencing quality of milk during production, collection, transportation, and storage, milk borne diseases.	8
	2. Processing Techniques and naturally occurring preservatives i. Bacteriological aspects of processing techniques like bactofugation, thermisation, pasteurization (in detail process is expected), sterilization and boiling. ii. Naturally occurring preservative systems in milk like LP system, immunoglobulins, Lysozyme, Lactoferrin etc.	4
	3. Spoilage of Milk i. Spoilage of Milk ii. Succession of microorganisms in milk leading to spoilage iii. Stormy fermentation, ropiness, sweet curdling iv. Color and flavor defects v. Preservation of Milk and Milk products by physical (irradiation) and Chemical agents, food grade bio preservatives (GRAS), Bacteriocins of LAB	5

	<p>4. Microbiological aspects of quality control and quality assurance in production of milk and milk products.</p> <p>i. Good Manufacturing Practices,</p> <p>ii. Sanitary standard operating procedures,</p> <p>iii. Total quality management and application of HACCP program in dairy industry.</p> <p>iv. Safety concern of biofilm formation on equipment surfaces and their control measures</p>	4
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Skilled Base Elective MB 3511

Dairy Microbiology Practical

Total Lectures: 15 Total Practical 05 x 05 lectures = 15 Lectures

Credit	Practicals	Number of Practical
Credit 0.5	<p>1. Microbiological analysis of milk:</p> <p>Enumeration of bacteria. (Standard Plate Count (SPC) and Direct Microscopic Count) – raw milk and pasteurized milk</p>	1
	<p>2. Microbiological quality control tests for milk:</p> <p>i. Dye reduction tests (MBRT/Resazurin)</p> <p>ii. Mastitis test</p> <p>iii. Somatic cell count</p> <p>iv. Phosphatase test</p>	1
	<p>3. Microbiological quality of indigenous dairy products:</p> <p>i. Khoa</p> <p>ii. Kulfi</p> <p>iii. Shrikhand</p> <p>iv. Paneer</p> <p>v. Curd/ Buttermilk</p>	1

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Semester VI
Semester VI Skilled Base Elective MB 3610 Waste Management

2 Credit Course: Total lectures: 36: Theory-21 L; Practical-15L

Course Outcome:

- To understand waste management and its practicable applicability.
- To assess the magnitude and influence of hazardous content of waste, pollution of waters and waste water treatment technologies.
- To learn the design and working of treatment plants and methods used for liquid and solid waste treatment.
- To impart the understanding of kinetics of biological systems used in waste treatment.
- To learn the standards of waste management and competent authorities involved at National and international level.

Skilled Base Elective MB 3610 Waste Management Theory Total Lectures 21

Credit	Theory	No. of Lectures
Credit	A. Liquid Waste Management	
1.5	<p>1. Principles of Wastewater Treatment</p> <p>i. The need for treatment of wastewater</p> <p>ii. General characteristics of liquid waste - pH, Color Turbidity, Odor, Electrical conductivity, COD, BOD, Total Solids, Total Dissolved Solids, Total Suspended Solids, Total Volatile Solids, Chlorides, Sulphates, Oil and Grease.</p>	4
	<p>2. Microbiology of Wastewater</p> <p>Role of microorganisms in wastewater treatment</p> <p>i. Aerobic and Anaerobic digestion models; attached / anchored and suspended growth.</p> <p>ii. Removal of pathogenic microbes, indicator microbes, enumeration of different types of microbes</p>	4
	<p>3. Unit operations in wastewater treatment plant</p> <p>i. Collection system - Methods of collection, conservancy systems, water carriage system, sewerage system.</p> <p>ii. Screen chamber, Grit chamber, Oil and grease removal</p> <p>iii. Stabilization pond, Aerated lagoon</p> <p>iv. Activated sludge process, Trickling filter</p> <p>v. Rotating biological contactors, anaerobic digestion processes, fluidized bed reactor.</p>	4

	Topic	No. of lectures
	B. Solid Waste Management and hazardous waste	
	4. Characterization of solid wastes: Dairy and e-waste	2
	5. Biomedical waste: Definition, Types, Processing	2
	6. Solid biodegradable waste processing: Composting, Vermicomposting, Biogas production	2
	7. Post-processing by-products of municipal solid waste treatment: leachate refused-derived fuel (RDF)	3

Skilled Base Elective MB 3610 Waste Management Practicals Total Lectures 15

Total Practicals 05 x 05 lectures= 15 lectures

Credit	Practicals	No. of Practicals
Credit 0.5	1. Determination of Solids in wastewater: Total Solids, Suspended Solids, Dissolved Solids, Volatile Solids, Fixed Solids, Settleable Solids	1
	2. Determination of Dissolved Oxygen, BOD and COD of waste water (before and after treatment) (MPCB Standards)	1
	3. Preparation of Project report based on a case study (Hotel/ Industry-Dairy, Food processing) Study of the source, generation rates and characteristics of hazardous wastes and their regulation, handling, treatment, and disposal. Special emphasis is placed on process design of waste handling, treatment and disposal systems.	1

References: Skilled Base Elective MB 3610 Waste Management

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Semester VI

Skilled Base Elective MB 3611 Nano-biotechnology

2 Credit Course: 1.5 credit theory+0.5 credit Practical

Theory-21 L; Practical-15L

Course Outcome

- To understand design, development and application of Nanomaterials and their application in Nanodevices.
- To learn fundamentals of nanotechnology as to Synthesis and characterization techniques of nanoparticles.
- To acquire knowledge of applications of nanomaterials in different disciplines of humanlife.
- To compare the merits of using nanotechnology with existing technologies.

Skilled Base Elective MB 3611 Nano-biotechnology Theory [total lectures 21]

Sr. No.	Topic	No. of Lectures
Credit 1.5	1. Introduction to Nano-biotechnology: a. Introduction to nanoscale, nanomaterials, nanoscience and nanotechnology b. Nanoscale bioassemblies c. Liposomes, viruses, DNA, polysaccharides and proteins (Protein nanotubes, nanofibers, peptide nanoparticles). d. Biomedical applications of bioassemblies e. Cell targeting, drug delivery, bioimaging and vaccine development.	6
	2. Microbial mediated metallic nanoparticles synthesis: a. Gold nanoparticles (AuNPs) b. Silver nanoparticles (AgNPs) c. Au-Ag alloy nanoparticles d. Oxide nanoparticles e. Magnetic nanoparticles f. Non-magnetic oxide nanoparticles g. Sulfide nanoparticles etc.	5
	3. Characterization techniques for nanomaterials: UV-visual spectroscopy, Fourier transform infrared (FTIR), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) and dynamic light scattering (DLS).	6
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	4. Applications of nanoparticles: Antibacterial agent, drug delivery, biosensor, animal industry and nanotechnology in wastewater treatment.	
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Skilled Base Elective: MB 3611 Nano-biotechnology. Practicals [total lectures 15]

Credit	Practical	No. of Practicals
Credit 0.5	1. Microbial synthesis of metallic nanoparticle synthesis (any two): silver, chromium, cobalt)	1
	2. Detection and Characterization of metallic nanoparticles in colloidal solutions by: a. UV-Spectrophotometer b. FTIR analysis	1
	3. Application of nanoparticles- checking antimicrobial activities against the microbial synthesized metallic nanoparticles (any two)	1

References: Skilled Base Elective: MB 3611 Nano-biotechnology.

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