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 andTechnology) 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. MicrobiologySemester-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 3510**	Waste Management	15	35
MB 3511	Dairy Microbiology	15	35	**MB 3511**	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
Credit I	**Introduction to infectious diseases and Epidemiology**	**18**
	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-preventablebacterial 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. Salmonella, Vibrio* *b. Streptococcus pneumoniae, Streptococcus pyogenes, Neisseria meningitidis and Neisseria gonorrhoeae* *c. Pseudomonas aeruginosa* *d. Treponema, Leptospira* *e. Clostridium tetani* *f. Mycobacterium tuberculosis* and *Mycobacterium leprae* g. *Orientia tsutsugamushi* and *Rickettsia rickettsii*	 2 4 2 2 2 4 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:1st to 6th 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

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

	Epidemiology, Prophylaxis and Chemotherapy) a. *Aspergillus* species (Pathogenic) b. *Cryptococcus neoformans* c. *Histoplasma capsulatum*	 1 1 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
4. Dulbecco R., Eisen H. N. and Davis B. D. (1990). Microbiology. United States: Publisher -Lippincott. ISBN: 9780608072432
5. Finch R., Greenwood D., Whitley R. and Norrby S. R. (2010) Antibiotic and Chemotherapy. 9th Edition. Elsevier. ISBN: 9780702040641
6. Franklin T.J and Snow G. A. (1989). Biochemistry of Antimicrobial Action. Springer. First Edition. ISBN: 978-94-009-0825-3
7. Goering R., Dockrell H., Zuckerman M., Roitt I. and Chiodini P. L. (2018). Mims' Medical Microbiology and Immunology. 6th Edition. Elsevier. ISBN: 9780702071546
8. Greer D. L., Kane J., Summerbell R., Sigler L., Krajden S. and G. Land (Editors).(1999). Laboratory Handbook of Dermatophytes: a clinical guide and laboratory manual of dermatophytes and other filamentous fungi from skin, hair, and nails. Mycopathologia. 147: 113–114
9. Joklik W. K., Willett H. P., Amos D. B. and Wilfert C. M. (1995). Zinsser's Microbiology. 20th Edition. Appleton and Lange Publisher. ISBN-13: 978- 0838599839
10. Kanungo Reba. (2017). Ananthanarayan and Paniker's Textbook of Microbiology. Tenth edition. The Orient Blackswan Publisher. ISBN-13: 978-9386235251
11. Kaslow R. A., Stanberry L. R. and Le Duc J. W. (2014). Viral Infections of Humans: Epidemiology and Control. 5th edition. Springer. ISBN 978-1-4899-7448-8
12. Mayers D. L., Sobel J.D., Ouellette M., Kaye K.S. and Marchaim D. (Eds.) (2017). Antimicrobial Drug Resistance: Mechanisms of Drug Resistance. Volume 1. Edition 2. Springer. ISBN 978-3-319-46718-4
13. Mayers D. L., Sobel J.D., Ouellette M., Kaye K.S. and Marchaim D. (Eds.) (2017).

Antimicrobial Drug Resistance: Clinical and Epidemiological Aspects. Volume 2. Edition 2. Springer. ISBN 978-3-319-47266-9

14. 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
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
17. Park K. (2019). Park's Preventive and Social medicine. 25th Edition. Banarsidas Bhanot Publisher, Jabalpur. ISBN-13: 978-9382219156
18. Roth J. A., Bolin C., Brogden K. A., Chris Minion K. F. and Wannemuehler M. J.(1995). Virulence mechanisms of bacterial pathogens. Second edition. American Society for Microbiology. ISBN-13: 978-1555810856
19. Sastry G. A. and Rama Rao P. (2001). Veterinary Pathology. Seventh Edition. CBS Publishers, Delhi. ISBN: 9788123907389
20. Schuenke S. (1997). Medical Microbiology. Fourth edition. University of Texas Medical Branch of Galvesion. Samuel Baron (Editor). ASIN: B008UYPLIO
21. Tiwari S., Singh R. K., Tiwari R. and Dhole T. N. (2012). Japanese encephalitis: a review of the Indian perspective. The Brazilian Journal of Infectious Diseases. 16(6): 564-573. https://doi.org/10.1016/j.bjid.2012.10.004
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 caps*ulatum 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 b. Secondary lymphoid organs – structure and function of spleen and lymph node, mucous associated lymphoid tissue, lymphatic system and lymph circulation	2 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, andacute phase reactants. b. Cellular components: Phagocytic cells – PMNL, macrophages (reticulo-endothelial cell system) and dendritic cells 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)	1 1 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
Credit II	**Antigen- Antibody Interactions, Major Histocompatibility Complex, Transplantation and Immunity and Hybridoma Technology and Monoclonal Antibodies**	**18**
	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 secretingmonoclonal antibodies b. Applications of monoclonal antibodies	 2 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 b. Properties, Attributes and biological functions of cytokines	 1 2
	2. Adaptive / Acquired Immunity (Third line of defense): **A. Humoral Immune Response** i. Primary and secondary response kinetics, significance in vaccination programs ii. Response of secondary lymphoid organs to antigen iii. Antigen processing and presentation (Major Histocompability 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 **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) iii. Significance of Cell Mediated Immune Response (CMI) iv. Immune response against tumors and foreign transplanted cells	 2 1 5 2 3 1 1

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

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

1. Abbas A. K. and Lichtman A. H. (2004). Basic Immunology- Functions and Disordersof Immune System. 2 nd Ed. Saunders. Elsevier Inc. PA. USA.
2. Aderem A., and Underhill D. M. (1999). Mechanisms of phagocytosis inmacrophages. Annu. Rev. Immunol. 17: 593-623.
3. Austin J. M. and Wood K. J. (1993). Principles of Molecular and CellularImmunology. Oxford University Press, London
4. Barret J. D. (1983). Text Book of Immunology. 4th edition, C. V. Mosby and Co. London.
5. Bendelac A. Savage P. B. and Teyton L. (2007). The biology of NKT cells. Annu Rev Immunol. 25: 297-336.
6. BIOTOL Series. (1993). Biotechnology by open learning series. Defense Mechanisms. Butterworth and Heinemann Ltd., Oxford

7. Bohlson S. S., Fraser D. A. and Tenner A. J. (2007). Complement proteins C1q and MBL are pattern recognition molecules that signal immediate and long-term protective immune functions. Mol. Immunol. 44: 33–43.
8. Chatterji C. C. (2002). Human Physiology. Vol. 1. Special reprint edition. Medical Allied Agency, Calcutta.
9. Chatterji C. C. (2004). Human Physiology. Vol. 2. Eleventh edition. Medical Allied Agency, Calcutta.
10. De Smet K. and Contreras R. (2005). Human antimicrobial peptides: defensins, cathelicidins and histatins. Biotechnol. Lett. 27:1337–1347.
11. Fathman G., Soares L., Cha S. M. and Utz P. J. (2005). An array of possibilities for the study of autoimmunity. Nature Rev. 435(2):605-611
12. Ganz T. (2003). Defensins: antimicrobial peptides of innate immunity. Nat. Rev. Immunol., 3:710–720.
13. Guyton A. C. and Hall J. E. (1996) Text Book of Medical Physiology, Goel Book Agency, Bangalore.
14. Janeway C. A., Travers P. Jr., Walport M. and Shlomchik M. J. (2005). Immuno-biology Interactive. Garland Science Publishing. USA.
15. Kindt T. J., Goldsby R. A. and Osborne B. A. (2007). Kuby Immunology. 6th Ed. W. H. Freeman and Co., New York
16. Kuby J. (1996) Immunology. 3rd Ed. W. H. Freeman and Co, New York
17. Pancer Z. and Cooper M. D. (2006). The Evolution of Adaptive Immunity, Ann. Rev. Immunol., 24: 497–518
18. Pathak S. S. and Palan V. (1997) Immunology - Essential and Fundamental. Pareen Publications Bombay.
19. Roitt E., Brostoff J. and Male D. (1993) Immunology. 6th Ed. Mosby and Co. London.
20. Roitt I. M. (1988). Essentials of Immunology. ELBS, London.
21. Roitt M. (1984). Essentials of Immunology. P. G. Publishers Pvt. Ltd., New Delhi.
22. Stites D. P., Stobo J. D., Fudenberg H. H. and Wells J. V. (1982). Basic and Clinical Immunology. l 4th Ed. Lange Medical Publications. Maruzen Asia Pvt. Ltd., Singapore
23. Talwar G. P. (1983) Handbook of Immunology, Vikas Publishing Pvt. Ltd. NewDelhi.
24. Zanetti M. (2005). The role of cathelicidins in the innate host defense of mammals.Curr. Issues Mol. Biol. **7**:179–196.

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
Credit I	**Enzymes:**	**18**
	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) b. Role of vitamins in metabolism: Occurrence, Structure and Biochemical functions of the following: i. Thiamine (Vitamin B1) and Thiamine Pyrophosphate ii. Vitamin D	3 2
	2. Enzyme assays: a. Principles of enzyme assays and calculation of enzyme unit,specific activity b. Enzymes assays with examples by: i. Spectrophotometric methods ii. Radioisotope assay	1 2

	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
Credit II	**Enzyme Kinetics, metabolic regulation and Immobilized Enzymes:**	**18**
	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 Menton plot, 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: Concept, methods of immobilization and applications	3

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 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 synthatase, inhibitors and uncouplers of ETC and oxidative phosphorylation, energetics of mitochondrial electron transport chain	1 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) b. Degradation of macromolecules – Polysaccharides (starch), Lipids (fatty acids oxidation e.g. β oxidation), Proteins (urea cycle)	6 6
	4. Bacterial Photosynthesis: Photosynthetic bacteria with referenceto photosynthetic apparatus, energy generation, and CO_2 fixation a. Cyanobacteria, b. Purple bacteria	2 2
	5 Chemolithotrophy: Concept and one example, Iron oxidizing bacteria	2

References: MB 353 Enzymology and MB 363 Metabolism

1. Berg J. M., Stryer L., Tymoczko J. and Gatto G. (2019). Biochemistry. 9th Edition. Palgrave Macmillan. ISBN-978-1319114657.
2. Conn E. E., Stumpf P. K., Bruening G. and Doi R. H. (1987). Outlines of Biochemistry. 5th Edition. John Wiley and Sons. ISBN-13: 9780471052883
3. Hall D. A. and Krishna Rao K. (1994). Photosynthesis (Studies in Biology). 6thEdition. Cambridge University Press, London. ISBN-13: 978-1-133-10629-6
4. Garrett R. H. and Grisham C. M. (2013). Biochemistry. 5th Edition. Brooks/Cole, Publishing Company, California. ISBN-13: 978-1-133-10629-6
5. Katoch R. (2011). Analytical Techniques in Biochemistry and Molecular Biology. Springer New York. ISBN 978-1-4419-9785-2.
6. Nelson D. L. and Cox M. M. (2021). Lehninger's Principles of Biochemistry.8th Edition. Mac Millan Worth Pub. Co. New Delhi. ISBN:9781319228002
7. Palmer T. (2001) Enzymes: Biochemistry, Biotechnology and Clinical chemistry. Horwood Pub. Co. Chinchester, England. ISBN-9781898563785
8. Segel I. H. (2010). Biochemical Calculations. 2nd Ed. Wiley India Pvt. Limited. ISBN: 9788126526437
9. Stanier R. Y., Adelberg E. A. and Ingraham J. L. (1985). General microbiology. 4th Edition. London: Macmillan.
10. 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

DSEC -MB 354: Genetics

[2 Credits; 36 Lectures]

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

Course Outcomes

- To exhibit a knowledge base in Genetics and Molecular Biology
- To understand the central dogma of Molecular Biology
- To construct genetic map of bacteria and fungi
- To get introduced to concept of recombination and bacteriophage Genetics
- To understand the concept cloning in bacteria
- To demonstrate the knowledge of common and advanced laboratory practices in Molecular Biology

Credit No.	Topics	No. of lectures
	DNA Replication and Gene Expression	**18**
	1. Process of prokaryotic DNA replication a. Single replicon b. Bidirectional movement of replication fork c. Ori C d. Pre-priming and Priming reaction. e. DNA polymerases, DNA synthesis of leading, lagging strand Okazaki fragments. f. Termination- Ter sequence, Tus protein	4
Credit I	**2.Prokaryotic and Eukaryotic Transcription** **Transcription in Prokaryotes** a. Structure of promoter b. Structure and function of RNA polymerase c. Steps of transcription: Initiation, Elongation and termination	3
	Transcription in eukaryotes with respect to protein coding Gene: a. Promoter, promoter proximal elements and enhancers b. Transcription regulatory proteins c. RNA polymerases d. Steps in transcription: Initiation, Elongation, Termination e. Post transcriptional modifications: 5' capping, 3' polyadenylation and introduction to RNA splicing	4

	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
Credit II	**Gene transfer and mapping techniques**	**18**
	5. Gene transfer by Transformation a. Discovery of Transformation b. Natural transformation Systems- *Streptococcus pneumoniae* and *Haemophilus influenzae*. 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-transductionand 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 *N. crassa* (Numerical Calculationsusing PD, TT and NPD) d. Genetic Mapping by Parasexual cycle in *A. nidulans*	9
	2. Bacteriophage Genetics a. Lytic cycle: Virulent phages, T-series phages, Concept and formation ofplaque, Lysogenic cycle: Temperate phage (λphage) 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 testsand 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

	4. Recombinant DNA Technology Tools and basics of recombinant DNA technology a. Introduction to recombinant DNA technology b. Restriction enzymes: Concept, Nomenclature, properties and types withexamples (Eco R1, Sma I, Pst I). c. Vectors: Features of an ideal vector i. Plasmids: pBR322 ii. Bacteriophage vectors: Lambda iii. Cosmids iv. High capacity vectors: YACs, BACs v. Expression vectors d. Joining of DNA molecules- DNA Ligases (*E. coli*and T4 phage), Use of Linker / Adaptor / Homopolymer tailing e. Methods to transfer recombinant DNA into bacterial host cells (Physical – Electroporation, Gene gun, Chemical –$CaCl_2$ mediated, liposome mediated) f. Methods of screening recombinants using selective markers and Blue-whitescreening	10
	5. Molecular techniques used in RDT a. Isolation of genomic DNA b. Principle and methodology of Agarose gel electrophoresis and its applications c. Concept, Methodology and applications of Southern, Northern and Western blotting	3

References: MB 354 Genetics and MB 364 Molecular Biology

1. Birge E. A. (2013). Bacterial and Bacteriophage Genetics. Springer, New York. ISBN: 9781475732580
2. Brooker R. J. (2012). Genetics: Analysis and Principles. 4th edition. McGraw- Hill Publication.
3. Brown T. A. (2006). Gene Cloning and DNA Analysis. Blackwell Publication. 5th Edition. ISBN: 1405111216
4. Brown T.A. (2016). Gene Cloning and DNA Analysis: An Introduction. 7thEd. Wiley BlackwellPublication, U.S.A. ISBN: 978-1-119-07254-6
5. Clokie M. R. J. and Kropinski A. M. (editors): Bacteriophage: Methods and Protocols.

Volume 1. Isolation, Characterisation and Interactions. Series Volume 501. Humana Press, New York

6. Clutterbuck A. J. (1996). Parasexual recombination in fungi. J. Genet. 75(3): 281-286, @ IndianAcademy of Sciences
7. Dubey R. C. (2014). Advanced Biotechnology. S. Chand Publishing. ISBN: 9788121942904
8. Freifelder D. (2005). Molecular Biology. 2nd Edition. Narosa Publishing House Pvt. Limited,India.
9. Gardner E. J., Simmons M. J. and Snustad D. P. (2006). Principles of Genetics. 8th edition.John Wiley and Sons Publication. ISBN-13: 9788126510436
10. Goodenough U. (2016). Genetics. Publisher: Holt, Rinehart and Winston. ISBN-13: 978-0030197161
11. Gupta P. K. (2020). Elements of biotechnology. 4th Reprint (2nd Edition). Product Code: BC-22.Rastogi Publications. Meerut, India. ISBN: 978-81-7133-937
12. Hartwell L., Goldberg M., Fischer J. and Hood L. (2018). Genetics: from genes togenomes. McGraw-Hill. ISBN13: 9781259700903
13. Hayes W. (1968). Genetics of Bacteria and their Viruses. 2nd Edition. Oxford-Edinburgh: Blackwcll Scientific Publications.
14. 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.
15. Kemp W. (2011). Organic Spectroscopy. 3rd edition. Publisher: Red Globe Press. Macmillan
16. Klug W. S., Cummings M. R., Spencer C. A., Michael A. and Palladino M. (2019). Genetics.Pearson Publisher. ISBN 13: 978-0-134-60471-8
17. Kohli D. V. and Vyas S. P. (2009). Pharmaceutical Biochemistry. Published by CBS Publishers andDistributors CBS. ISBN 13: 9788123916903
18. Lewin's GENES X (2011). Krebs J., Kilpatrick S. T., Goldstein E. S. (Editors). 10th Edition.Sudbury, Mass.: Jones and Bartlett, c2011.
19. Lodish H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., Martin K. C., Yaffe M. and Amon A. (2021). Molecular Cell Biology, 9th Edn. Macmillan Learning. ISBN: 9781319208523
20. Pal J. K. and Ghaskadabi S. (2009). Fundamentals of Molecular Biology. Oxford UniversityPress. ISBN: 9780195697810
21. Primrose S. B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics, 7thEd. Blackwell Publishing: U.S.A.

22. Russel P. J. (2000). Fundamentals of Genetics. Publisher: Benjamin/Cummings. ISBN: 9780321036261
23. Russel P. J. (2010). iGenetics: A Molecular Approach. 3rd Edition. Benjamin Cummings. ISBN: 9780321569769
24. Sambrook J. F. and Russel D. W. (Editors). (2001). Molecular cloning, A laboratory manual (3rd Edition.). Volumes 1, 2, and 3. Cold Spring Harbor Laboratory Press. ISBN- 978-0-87969-577-4
25. Sharma. B. K. (2011). Instrumental Methods of Chemical Analysis. 27th Edition. Goel PublishingHouse, Meerut. India
26. Singh B. D. (2007). Biotechnology Expanding Horizon. Kalyani Publishers, India
27. Singh B. D. (2016). Biotechnology. 5th Edition. Reprint. Kalyani Publishers, India.
28. Stanier R. Y. (1999). General Microbiology. 5th Edition. Palgrave Macmillan
29. Strickberger M.W. (2012). Genetics. 3rd Edition. New Delhi: PHI Learning Gardner.
30. Tamarin R. H. (2002). Principles of Genetics. Publisher: McGraw-Hill Education (India) Pvt Limited. ISBN:9780070486676
31. van Sinderen D. and Mc Grath S.(Editors). (2007). Bacteriophage: Genetics andMolecular Biology. Caister Academic Press
32. Watson J.D., Baker, T.A., Bell, S.P., Gann A., Levine M. and Losick R. (2014). MolecularBiology of the gene. 7th edition. Pearson. ISBN: 9780321762436

Reference-Links:

1. Potential biohazards of recombinant DNA molecules: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC388511/?page=1
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 fermentationprocesses.
- To optimize and sterilize media used in fermentation industry for commerciallyeconomical and efficient fermentations.
- To recover the product using suitable methods and ensuring quality of the finished productby quality assurance tests.
- To acquaint fermentation economics, process patentability, process validation.
- To comprehend the large scale productions of commercially significant fermentation productsof 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 platetechnique)	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

	3. Sterilization of Media:	
	a. Methods of sterilization	1
	b. Batch sterilization and Continuous sterilization (direct and indirectmethods)	1
	c. Concept and derivation of Del factor	1
	d. Filter sterilization of liquid media	1
	4. Scale-up and Scale-down:	
	a. Objectives of scale-up	1
	b. Levels of fermentation (laboratory, pilot-plant and productionlevel – flowsheet to explain scale up)	1
	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
	d. Scale-down (example of any one commercial fermentation)	1
Credit II	**Downstream processing and Quality assurance of fermentation products**	**18**
	5. Downstream processing of fermentation products: (method, principle, types, examples of fermentations, factors affecting, merits and demerits at large scale operation)	
	a. Cell disruption methods	1
	b. Filtration	1
	c. Centrifugation	1
	d. Liquid-liquid extraction	1
	e. Distillation	1
	f. Drying	1
	6. Quality assurance of fermentation products (as per IP, USP)	
	a. Methods of detection and Quantification of the fermentation product: physicochemical, biological and enzymatic methods	2
	b. Sterility testing (direct inoculation method, membrane filtration method)	1
	c. Bioburden test	1

	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)	
	a. Primary Metabolites:	
	i. Vitamins (B12 and B2)	3
	ii. Amino acids - Glutamic acid, Lysine	3
	iii. Organic acids (Citric acid, Vinegar and Lactic acid)	4
	b. Secondary metabolites:	
	i. Bioethanol	1

	ii. Alcoholic Beverages - 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 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 i. Amylase ii. Esterases iii. Proteases	 1 1 1
	4. Microbial transformation of steroids	2
	5. Biomass based products: i. Yeast: Baker's and Distiller's yeast ii. Probiotics: *Lactobacillus sporogenes*	 2 1
	6. Milk products: 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 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 i. Anti tetanus serum (ATS) ii. Anti rabitic serum (ARS)	 1 1
	9. Modern trends in microbial production: Biosurfactant and bioemulsifier	 1

References: MB 355 Fermentation Technology- I and MB 365 Fermentation Technology- II

1. Aiba S., Humphrey A. E. and Millis N.F. (1977). Biochemical Engineering. AcademicPress, New York,
2. Arora D. K. (Editor). (2003). Fungal Biotechnology in Agriculture, Food and Environmental Applications (Mycology). CRC Press. ISBN 9780824747701.
3. Bailey J. A., Bailey J. E., Bailey J., Simpson R. J. and Ollis D. F. (1986). Biochemical Engineering Fundamentals. 2nd Edition. McGraw-Hill. Chemical Engineering Series. McGraw-Hill Publisher. ISBN: 0070032122, 9780070032125
4. BIOTOL series. (1992). Bioreactor Design and Product Yield. Butterworths- Heinemann (Publisher). ISBN-13: 978-0750615082
5. BIOTOL series. (1992). Operational Modes of Bioreactors. Butterworths-Heinemann. ISBN-13: 978-0750615082
6. British Pharmacopeia. (2021). The Stationery Office Ltd (TSO), PO Box 29, Norwich,NR3 1PD. https://www.pharmacopoeia.com/Catalogue/Products
7. Casida L. E. J. R. (2016). Industrial Microbiology. New Age International Private Limited. ISBN- 9788122438024
8. Ferreira I. N. S., Rodríguez D. M., Campos-Takaki G. M. and da Silva Andrade R. F. (2020). Biosurfactant and bioemulsifier as promissing molecules produced by *Mucor hiemalis* isolated from Caatinga soil. Electron J Biotechnol. DOI: 10.1016/j.ejbt.2020.06.006
9. Flickinger M. C. (2010). Encyclopedia of Bioprocess Technology. Seven Volume Set. Wiley-Interscience, New Jersey. ISBN: 978-0-471-79930-6
10. Indian Pharmacopeia. (2018- Addendum 2021): https://www.indianpharmacopoeia.in/index.php
11. Lydersen B. K., D' Elia N. A. and Nelson K. L. (Eds.). (1994). Bioprocess Engineering: Systems, Equipment and Facilities. Wiley. ISBN: 978-0-471-03544-2
12. Meshram S. U. and Shinde. G. B. (2009). Applied Biotechnology. I K International Publishing House. ISBN-13: 978-93-80026-56-5, ISBN: 93-80026-56-0
13. Moo-Young M. (2019). Comprehensive biotechnology. Third edition. Volume 1: Scientific Fundamentals of Biotechnology. Volume 2: Engineering Perspectives in Biotechnology. Volume 3: Industrial Biotechnology and Commodity Products. Volume 4: Agricultural and Related Biotechnologies. Volume 5: Medical Biotechnology and Healthcare. Volume 6: Environmental and Related Biotechnologies. Pergamon Press Limited, England. ISBN: 978-0-444-64047-5

14. Patel. A. H. (2016). Industrial Microbiology. Trinity Press (Publisher). ISBN-13-9789385750267
15. Peppler H. L. and Perlman D. (1979). Microbial Technology. Volume 1: Microbial Processes. Academic Press, New York. ISBN: 978-0-12-551501-6
16. Peppler H. L. and Perlman D. (1979). Microbial Technology. Volume II: Fermentation Technology (2nd Edition). Academic Press. ISBN: 9781483268279
17. Reed G. (Editor). (1982). Prescott and Dunn's Industrial Microbiology. Westport, CT, AVI Publishing Co Inc.
18. Stanbury P. F., Whitaker A. and Hall S. J. (2016). Principles of Fermentation Technology. 3rd Edition. Butterworth-Heinemann. ISBN: 9780080999531
19. Thomassen Y. E., van't Oever A. G., Vinke M, Spiekstra A., Wijffels R. H, van der Pol L. A. and Bakker W. A. M. (2013). Scale-down of the inactivated polio vaccine production process.Biotechnology and Bioengineering. 110(5):1354-1365. DOI: 10.1002/bit.24798.
20. Uzoigwe C., Burgess J.G., Ennis C.J. and Rahman P.K.S.M. (2015). Bioemulsifiers are not biosurfactants and require different screening approaches. Front. Microbiol.6:245. doi: 10.3389/fmicb.2015.00245.
21. Van Damme E. J. (1984) Biotechnology of Industrial Antibiotics. Marcel Dekker Inc. New York. ISBN-13: 978-0824770563
22. Van Wezel A. L., van Steenis G., van der Marel P. and Osterhaus A. D. M. E. (1984).Large scale production of polio vaccine - Inactivated Poliovirus Vaccine: Current Production Methods and New Developments. Reviews of Infectious Disease. 6 (2): S335–S340. https://doi.org/10.1093/clinids/6.Supplement_2.S335
23. Wiseman A. (1983) Topics in Enzyme and Fermentation – Biotechnology. Volume 7. Ellis Horwood Limited, Publishers: Chichester. John Wiley and sons,New York.

Reference links:

24. Guidelines for Tetanus Vaccine production: 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: https://academic.oup.com/jimb/article-pdf/18/5/340/34773995/jimb0340.pdf.
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/standards/

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

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

References: MB 356 Agricultural Microbiology

1. Bahadur B., Venkat rajam M., Sahijram L. and Krishnamurthy K.V. (2012). Plant Biology and Biotechnology. Vol II: Plant Genomics and Biotechnology. Springer Publications.
2. Dube. H.C. and Bilgrami. K. S. (1976). Text book of modern pathology. Vikas Publishing House. New Delhi.

3. Husain F. H. and Ahmad I. (2017). Biofilms in Plant and Soil Health. Germany: Wiley. ISBN: 9781119246374
4. Johnson D. V., Al-Khayri J. M. and Jain S. M. (2016). Advances in Plant Breeding Strategies: Breeding, Biotechnology and Molecular Tools. Germany: Springer International Publishing. ISBN: 9783319225210,
5. Jones D. J. (Editor). (2013). The Epidemiology of Plant Diseases. Netherlands: Springer Netherlands. ISBN: 9789401733021
6. Jones J. B., Jr. (2012). Plant Nutrition and Soil fertility. Manual 2nd Edition. CRC Press. ISBN-13:978-1-4398-1610-3 (ebook-pdf)
7. Kashyap P. L., Srivastava A. K. and Srivastava M. (2021). The Plant Microbiome in Sustainable Agriculture. United Kingdom: Wiley. ISBN: 9781119505167
8. Lakshamana V., Selvaraj G.and Bais H. P. (2021). Functional Soil Microbiome: below Ground solutions to above ground problems, https://plantphysiol.org.
9. Martin Alexander. (1962). Introduction to Soil Microbiology. John Wiley and Sons. Inc. New York.
10. Mehrotra R. S. (1994). Plant Pathology. Tata McGraw-Hill Limited.
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, nutrientcontent, 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- vegetablesand 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 -*Clostridium botulinum, Aspergillus flavus* b. Food infection-*Salmonella typhimurium, Vibrio parahaemolyticus*	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 Practicals x 5 lectures = 60 Lectures

Sr. No	Practical	No. of Practicals
1.	**Clinical microbiology:** **Physical, Chemical and Microscopic examination of Clinical samples -** Urine, stool and pus	2
2.	**Isolation, identification of following pathogens from clinicalsamples:** i. *Klebsiella* spp. ii. *Salmonella* spp. iii. *Pseudomonas* spp iv. *Streptococcus* spp. v. *Enterococcus* 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 Practicals x 5 lectures = 60 Lectures

Sr. No.	Practicals	No. of Practicals
1.	**Study of permanent slides of following microbial pathogens:** a. *Entamoeba histolytica* b. *Giardia* spp. c. *Plasmodium* spp. d. *Mycobacterium* (tuberculosis and leprae) e. *Trichophyton* spp. f. *Epidermophyton* spp. g. *Microsporum* spp.	**3**
2.	**Isolation and identification of following yeast and fungalpathogens:** *Cryptococcus neoformans / Histoplasma capsulatum*	**1**
3.	**Antibiotic sensitivity testing of the bacterial pathogens (for Gram negative and Gram Positive**)	**1**
4.	**Immunohematology:** Cross-matching (Major and Minor) and Coomb's test (Direct andIndirect)	**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 *Plasmodium* spps	**1**
6.	**Immunoprecipitation:** Double diffusion (Ouchterlony) technique	**1**
7.	**Demonstrations of:** a. Serum protein separation by electrophoresis	**2**

	b. ELISA (Antigen/ Antibody detection) 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., andStaley 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
7. Godkar P. B. (2020). Textbook of Medical Laboratory Technology Volume 1 and 2.3rd edition Bhalani Publishing House. ASIN: 9381496196. ISBN-13: 978- 9381496190
8. Greer D. L., Kane J., Summerbell R., Sigler L., Krajden S. and G. Land (Editors). (1999). Laboratory handbook of dermatophytes: a clinical guide and laboratory manual of dermatophytes and other filamentous fungi from skin, hair, and nails. Mycopathologia. 147: 113–114
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/histoplasmois-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 Practicals 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 Proteins (tests for aromatic amino acids, sulfur containing amino acids,different amino acids) i. 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
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

DSEC-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 Practicals 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 *Xanthomonas* spp. from citrus canker	**1**
5.	Isolation of *Aspergillus niger* 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_2015-12-22_PostCPM10_InkAmReformatted.pdf.
   http://www.asianjournalofchemistry.co.in/User/ViewFreeArticle.aspx?ArticleID=23_1_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/jsspn/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 Practicals 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 (*Trichoderma sp.* / 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 b. Physiology of marine microorganisms – metabolic diversity, marineloop, marine snow, Role of marine microorganisms in biogeochemical cycles, nutrient cycling and hydrocarbon degradation c. Sampling methods– water sampling (Niskin sampler) and sedimentsampling (Grab sampler, box corer, gravity corer), Culturing methods – VBNC, biofilm, mats from vents and estuarine sample.	3 4 4
	2. Marine microbes, role in bioremediation and bioprospecting a. Extremophilic microorganisms – econiches, different types withexamples and significance b. Archaea –biodiversity, stress response, adaptation and significance c. Marine mycology – econiche, types of marine fungi andsignificance d. Bioremediation – heavy metals, hydrocarbon pollutants – tar ball and oil spills	2 3 2 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 econiches – coastal waters, deep sea, estuarine waters, sediments	1
	3. Isolation of extremophilic bacteria – halophiles, thermophiles, acidophiles, alkalophiles, psychrophiles, osmophiles (any two of these)	1

References:

1. Alexopoulus C. J., Mims C. W. and Blackwell M. (1996). Introductory Mycology. Wiley ISBN: 978-0-471-52229-4.
2. Bathmann U. (2005). Ecological and biogeochemical response of Antarctic ecosystems to iron fertilization and implications on global carbon cycle, Ocean and Polar Research. 27(2): 231-235.
3. Bej A. K., Aislabie J. and Atlas R. M. (2009). Polar Microbiology. The ecology, biodiversity and bioremediation potential of microorganisms in extremely cold environments. Taylor and Francis. eBook. ISBN-9780429150913.
4. Belkin S. and Colwell R. R. (2005). Oceans and Health: Pathogens in the Marine Environment. Springer. ISBN 978-0-387-23709-1.
5. Boone D. R. Castenholz R. W. and Garrity G. M. (2001). Bergey's Manual of Systematic Bacteriology: The archaea and the deeply branching and phototrophic bacteria. Springer. ISBN- 978-0-387-98771-2.
6. Borse B. D., Bhat J. D., Borse K. N., Tuwar N. S. and Pawar N. S. (2012). Marine Fungi of India (Monograph). 1st edition. Broadway Publishing House. Broadway Publishing. ISBN-13: 978-9380837383.
7. Bull A. T. (2004) Microbial Diversity and Bioprospecting. ASM Press. ISBN 1-55581-267- 268.
8. Caspers H. (1980). Phytoplankton Manual. Sournia A. Editors. Monographs on Oceanographic Methodology 6. Paris: Unesco. ISBN 92-3-101572-9.
9. Clark R. B. And Clark R. L. (2001). Marine Pollution. Oxford University Press.
10. Gasol G. M. and Kirchman D. L. (2018). Microbial Ecology of the Oceans. 3rd Edition. Wiley-Blackwell. ISBN: 978-1-119-10718-7.

11. Grasshoff K., Ehrhardt M. and Kremling K. (1985) Methods of Seawater Analysis. Second, Revised and Extended Edition. Weinheim/Deerfield Beach, Florida: Verlag Chemie 1983. ISBN 3–527-2599-8 (Weinheim) 0–89573-7 (Deerfield Beach).
12. Grasshoff K., Ehrhardt M. and Kremling K. (1999). Methods of Seawater Analysis, WILEY-VCH Verlag GmbH. ISBN: 9783527295890.
13. Hopkins D.W. (2012). Polar Microbiology: Life in a Deep Freeze. Miller R. V. and Whyte L. G. Editors. Cambridge University Press. Doi: 10.1017/S095410201300059X.
14. Horikoshi K. and Grant W. D. (1998). Extremophiles – Microbial Life in Extreme Environments: 20. Wiley-Liss. ISBN-13: 978-0471026181.
15. Hunter-Cevera J., Karl D. and Buckley M. (2005). Marine Microbial Diversity: the Key to Earth's Habitability. Washington (DC): American Society for Microbiology. ISBN-0198792921, 9780198792925.
16. Meller C. B. and Wheeler P. A. (2012). Biological Oceanography. Wiley-Blackwell Publishers. ISBN: 978-1-444-33301-5.
17. Mitchell R. and Kirchman D. L. (2000). Microbial Ecology of the Oceans. Wiley-Blackwell.
18. Munn C. B. (2020). Marine Microbiology: Ecology and Applications. CRC Press. ISBN 9780367183561.
19. Prince R.C. and Atlas R.M. (2016). Bioremediation of Marine Oil Spills. In: Steffan R. (Editor). Consequences of Microbial Interactions with Hydrocarbons, Oils, and Lipids: Biodegradation and Bioremediation. Handbook of Hydrocarbon and Lipid Microbiology. Springer, Cham. https://doi.org/10.1007/978-3-319-44535-9_13-1.
20. Rainey F. A. And Oren A. (2006). Extremophile microorganisms and the methods to handle them. Methods in Microbiology. 35:1-25.
21. Satyanarayana T., Johri B. and Prakash A. (2012). Microorganisms in Environmental Management. Springer. ISBN 978-94-007-2229-3.
22. Satyanarayana T., Raghukumar C. and Shivaji S. (2005) Extremophilic microbes: diversity and perspectives. Current Science. 89(1): 78-90.
23. Seshagiri R. (2017). Fungi in Coastal and Oceanic Marine Ecosystems: Marine Fungi. Springer. ISBN 978-3-319-54304-8.
24. Stricklan J. D. H. and Parsons T. R. (1972). A Manual of Seawater Analysis. Bulletin no. 167. 2nd Edition. Ottawa: Fisheries Research Board of Canada.
25. Thomas T. R., Kavlekar, D. P., Lokabharathi, P. A. (2010) Marine drugs from sponge-microbe association: a review. Marine Drugs. 8: 1417-1468.

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 tolocal 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 propertiesof 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

	4. Microbiological aspects of quality control and qualityassurance in production of milk and milk products. i. Good Manufacturing Practices, ii. Sanitary standard operating procedures, iii. Total quality management and application of HACCP programin dairy industry. iv. Safety concern of biofilm formation on equipment surfaces and their control measures	4

Skilled Base Elective MB 3511

Dairy Microbiology Practical

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

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

References:

1. Banwart G. J. (1989). Basic Food Microbiology. 2nd edition. Food Science andNutrition. Springer. ISBN 978-1-4684-6453-5
2. Bullock D. (2019). Dairy Microbiology. ED-Tech Press. E-Book. ISBN:9781788821629
3. De Sukumar. (2001). Outlines of Dairy Technology. Oxford University Press. Delhi. ISBN-13 978-0195611946

4. Early R. (2012). Guide to Quality Management for The Food Industry. Business and Management. Springer. ISBN 978-1-4615-2127-3.
5. Frazier W. C., Westhoff D. C. and Vanitha N. M. (2017) Food Microbiology. 5th edition. McGraw Hill education, India. ISBN-10 -9781259062513
6. Gupta V. (2017). The Food Safety and Standards Act. 9th edition. Commercial Law Publishers (India) Private Limited. ISBN-13. 978-9388798532
7. James J. M., Loessner M. J. and Golden D. A. (2005). Modern Food Microbiology. 7th edition. Food Science and Nutrition. Springer. ISBN 978-0-387-23413-7.
8. Joshi V. K. (2019). Indigenous Fermented Foods of South Asia. CRC Press. ISBN 9780367377076
9. Mahindru S. N. (2010). Encyclopedia of Food Analysis. APH Publishing Corporation, India. ISBN-13: 978-8131308806
10. Marth E. H. and Steele J. (2001) Applied Dairy Microbiology. 2nd Edition. CRC Press. ISBN 9781138367609
11. Mathews G. (2018). Food and Dairy Microbiology. Scientific e-Resources, Scientific e-Resources. ISBN 1839472545, 9781839472541
12. Palmiro Poltronieri. (2017). Microbiology in Dairy Processing: Challenges and Opportunities. Wiley-Blackwell. ISBN: 978-1-119-11480-2
13. Parihar P. and Parihar L. (2008). Dairy Microbiology. Agrobios, Jodhpur, India.ISBN 13: 9788177542738
14. Parihar P. (2008) Dairy Microbiology. Agrobios, AbeBooks Seller, India. ISBN:9788177542738, 8177542737
15. Robinson R. K. (2012). Modern Dairy Technology. Volume 2. Springer. ISBN-13: 978-1468481747
16. Sharma K.S. (2021). Chemistry of Milk. AgriMoon.com. e-Krishi Shiksha. Online Courses.
17. Singh S. (2013) Dairy Technology: Volume -01: Milk and Milk Processing. New India Publishing Agency, India. ISBN-13: 978-9383305087
18. Varnam A. H. and Jane P. (2012). Milk and Milk Products: Technology, Chemistry and Microbiology. Springer. Food Science and Nutrition. ISBN 978-0-8342-1955-7

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 it 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 1.5	**A. Liquid Waste Management**	
	1. Principles of Wastewater Treatment i. The need for treatment of wastewater 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.	4
	2. Microbiology of Wastewater Role of microorganisms in wastewater treatment i. Aerobic and Anaerobic digestion models; attached / anchored andsuspended growth. ii. Removal of pathogenic microbes, indicator microbes, enumerationof different types of microbes	4
	3. Unit operations in wastewater treatment plant i. Collection system - Methods of collection, conservancy systems, water carriage system, sewerage system. ii. Screen chamber, Grit chamber, Oil and grease removal iii. Stabilization pond, Aerated lagoon iv. Activated sludge process, Trickling filter v. Rotating biological contactors, anaerobic digestion processes, fluidized bed reactor.	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

1. Chandrappa R. and Das D. B. (2012). Solid Waste Management-Principles and Practice. In Environmental Science and Engineering. Springer (Firm).
2. Dutta S., Neela Priya D., Chakradhar B. and Sasi Jyothsna T.S. (2019) Value Added By-products Recovery from Municipal Solid Waste in Waste Valorisation and Recycling. Springer, Singapore.
3. Masters G. M. (1994). Introduction to Environmental Engineering and Science. Prentice Hall of India (Private) Ltd., New Delhi.
4. Metcalf and Eddy (Eds.) 2003. Wastewater Engineering – Treatment and Reuse. 4th Edition. Tata Mac Graw Hill Publishing Co. Ltd. New Delhi.

5. Pichtel J. (2014). Waste Management Practices- Municipal, Hazardous and Industrial.2nd edition. CRC Press.
6. Prakash S. (2009). Biotechnology for Water and Wastewater Treatment. Navyug Publishers and Distributors, New Delhi.
7. Rajaram V., Siddiqui F. Z., Agrawal S. and Khan M. E. (2016). Solid and liquid waste management- Waste to wealth. PHI Learning Private Limited, New Delhi, India
8. Ramachandran T. V. (2009). Management of Municipal Solid Waste. Centre for Ecological Sciences, IISc Karnataka Research Foundation. India
9. Rangwala S. C. (2005). Water supply and sanitary engineering. Charotar Publishing House, India
10. Standard Methods for the Examination of Water and Wastewater. (2017). 23rd Edition. American Public Health Association, American Water Works Association, and Water Environment Federation
11. Tchobanoglous G. and Kreith F. (2002). Handbook of solid waste management. 2nd edition. McGraw-Hills Professional.
12. Tchobanoglous G., Burton F. L. and Stensel H. D. (2003). Wastewater Engineering, Treatment, Disposal and Reuse. 4th Ed., Metcalf and Eddy (Editors). Mc Graw Hill Companies.Inc.
13. Wesley Eckenfelder W. Jr. (2000). Industrial Water Pollution Control. 3rd Edition. McGraw Hill.

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**
		4

	4. Applications of nanoparticles: Antibacterial agent, drug delivery, biosensor, animal industry and nanotechnology inwastewater treatment.	

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 nanoparticlesin colloidal solutions by: a. UV-Spectrophotometer b. FTIR analysis	**1**
	3. Application of nanoparticles- checking antimicrobialactivities against the microbial synthesized metallic nanoparticles (any two)	**1**

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

1. Bujold K. E., Lacroix A., and Sleiman H. F. (2018). DNA Nanostructures at the Interface with Biology. Chem. 4: 495–521. Elsevier Inc.
2. Chokriwal A., Sharma M. M. and Singh A. (2014). Biological synthesis of nanoparticles using bacteria and their applications. American Journal of PharmTechResearch. 4(6):38-61.
3. Das R. K., Pachapur V. L., Lonappan L., Naghdi M., Pulicharla R., Maiti S. and Brar S. K. (2017). Biological synthesis of metallic nanoparticles: plants, animals andmicrobial aspects. Nanotechnology for Environmental Engineering. 2(1): 1-21.
4. Doll T. A. P. F., Raman S., Dey R. and Burkhard P. (2013). Nanoscale assembliesand their biomedical applications. J R Soc Interface.10: 20120740. http://dx.doi.org/10.1098/rsif.2012.0740
5. Gurunathan S., Kalishwaralal K., Vaidyanathan R., Venkataraman D., Pandian S. R. K., Muniyandi J., Hariharan N. amd Soo Hyun Eom. (2009). Biosynthesis, purification and characterization of silver nanoparticles using *Escherichia coli*. Colloids and Surfaces B. 74(1): 328–335.
6. Fariq A., Khan T. and Yasmin, A. (2017). Microbial synthesis of nanoparticles and their potential applications in biomedicine. J. Appl. Biomed. 15: 241–248
7. Li X., Xu H., Chen Z. S. and Chen G. (2011). Biosynthesis of nanoparticles by microorganisms and their applications. Journal of Nanomaterials. 2011.

8. Madkour L. H. (2019) Introduction to Nanotechnology (NT) and Nanomaterials (NMs). In: Nanoelectronic Materials. Advanced Structured Materials, vol 116. Springer, Cham. https://doi.org/10.1007/978-3-030-21621-4_1
9. Mohd Yusof H., Mohamad R., Zaidan U. H. and Rahman N. A. A. (2019). Microbial synthesis of zinc oxide nanoparticles and their potential application as an antimicrobial agent and a feed supplement in animal industry: a review. J Animal Sci Biotechnol. 10(57): https://doi.org/10.1186/s40104-019-0368-z
10. Rajput N. and Bankar A. (2017). Bio-inspired gold nanoparticles synthesis and their anti-biofilm efficacy. J. Pharm. Investig. 47: 521–530.
11. Rattan R., Shukla S., Sharma B. and_Bhat M. (2021). A mini review on lichen-based nanoparticles and their applications as antimicrobial agents. Front. Microbiol. https://doi: 10.3389/fmicb.2021.633090
12. Salame P. H., Pawade V. B. and Bhanvase B. A. (2018). Characterization tools and techniques for nanomaterials. Nanomaterials for Green Energy: 83–111. doi:10.1016/b978-0-12-813731-4.00003-5
13. Shukla M. and Shukla P. (2020) Microbial nanotechnology for bioremediation of industrial wastewater. Front. Microbiol. 590631. https://doi.org/10.3389/fmicb.2020.
14. Tiquia-Arashiro S. and Rodrigues D. (2016). Nanoparticles Synthesized by Microorganisms. In Extremophiles: Applications in Nanotechnology. 1-51. Springer,Cham.
15. Xiangqian Li, Huizhong Xu, Zhe-Sheng Chen, and Guofang Chen. (2011). Biosynthesis of nanoparticles by microorganisms and their applications nanostructures for medicine and pharmaceuticals Volume 2011 |Article ID 270974 | https://doi.org/10.1155/2011/270974
16. Yan S., He W., Sun C., Zhang X., Zhao H., Li Z., Zhou W., Tian X., Sun X., Han X. (2009). The biomimetic synthesis of zinc phosphate nanoparticles. Dyes and Pigments. 80(2): 254–258.