

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's  
**New Arts, Commerce and Science College, Ahmednagar**  
**(Autonomous)**

(Affiliated to Savitribai Phule Pune University, Pune)



**Choice Based Credit System (CBCS)**

**Bachelor of Science (B.Sc.)**

**Syllabus of**

**T. Y. B. Sc. Microbiology**

**Implemented from**

**Academic Year 2023 - 24**

**Ahmednagar Jilha Maratha Vidya Prasarak Samaj's  
New Arts, Commerce and Science College, Ahmednagar  
(Autonomous)**

**Board of Studies in Microbiology**

Sr. No.	Name	Designation
1.	Ms. Giramkar Dipali D.	Chairman
2.	Dr. Dixit Prashant P.	Academic Council Nominee
3.	Dr. Naphade Bhushan S.	Academic Council Nominee
4.	Mr.Choure Rajendra G.	Vice Chancellor Nominee
5.	Mr. Yewatkar Saikiran	Alumni
6.	Mr. Dube Chandrakant G.	Industry Expert
7.	Dr. Patil Ulhas K.	Member (co-opt)
8.	Mr.Shaikh Sajid H.	Member (co-opt)
9.	Dr. Gahile Yogesh R.	Member (co-opt)
10.	Mr.Wani Ashish S.	Member (co-opt)
11.	Ms.Pansare Ragini P.	Member (co-opt)

**3. Programme Structure and Course Titles: (All academic years)**

Sr. No.	Class	Semester	Course Code	Course Title	Credits
1.	F.Y. B.Sc.	I	BSC-MR 101 T	Introduction to Microbiology	02
2.	F.Y. B.Sc.	I	BSC-MR 102 T	Basic Techniques in Microbiology	02
3.	F.Y. B.Sc.	I	BSC-MR 103 P	Practical Course based on Theory Paper I and II	1.5
4.	F.Y. B.Sc.	II	BSC-MR 201 T	Cell Biology of Microorganisms	02
5.	F.Y. B.Sc.	II	BSC-MR 202 T	Microbial Cultivation and Growth	02
6.	F.Y. B.Sc.	II	BSC-MR 203 P	Practical Course based on Theory Paper I and II	1.5
7.	S.Y. B.Sc.	III	BSC-MR 301 T	Medical Microbiology and Immunology	02
8.	S.Y.B.Sc.	III	BSC-MR 302 T	Bacterial Physiology and Fermentation Technology	02

9.	S.Y. B.Sc.	III	BSC-MR 303 P	Practical Course based on Theory Paper I and II	02
10.	S.Y. B.Sc.	IV	BSC-MR 401 T	Bacterial Genetics	02
11.	S.Y. B.Sc.	IV	BSC-MR 402 T	Air ,Water & Soil Microbiology	02
12.	S.Y. B.Sc.	IV	BSC-MR 403 P	Practical Course based on Theory Paper I and II	02
13.	T.Y. B.Sc.	V	BSC-MR 501 T	Medical Microbiology I	02
14.	T.Y. B.Sc.	V	BSC-MR 502 T	Immunology I	02
15.	T.Y. B.Sc.	V	BSC-MR 503 T	Enzymology	02
16.	T.Y. B.Sc.	V	BSC-MR 504 T	Genetics and Molecular Biology I	02
17.	T.Y. B.Sc.	V	BSC-MR 505 T	Fermentation Technology I	02
18.	T.Y. B.Sc.	V	BSC-MR 506 T	Applied Microbiology	02
19.	T.Y. B.Sc.	V	BSC-MR 507 P	Practical Course I- Diagnostic Microbiology and Immunology	02

20.	T.Y. B.Sc.	V	BSC-MR 508 P	Practical Course II- Biochemistry and Molecular Biology	02
21.	T.Y. B.Sc.	V	BSC-MR 509 P	Practical Course III- Fermentation Technology and Applied Microbiology	02
22.	T.Y. B.Sc.	V	BSC-MR 510 T	Nano-biotechnology	02
23.	T.Y. B.Sc.	V	BSC-MR 511 P	Practical Course based on Nano-biotechnology	02
24.	T.Y. B.Sc.	VI	BSC-MR 601 T	Medical Microbiology II	02
25.	T.Y. B.Sc.	VI	BSC-MR 602 T	Immunology II	02
26.	T.Y. B.Sc.	VI	BSC-MR 603 T	Metabolism	02
27.	T.Y. B.Sc.	VI	BSC-MR 604 T	Genetics and Molecular Biology II	02
28.	T.Y. B.Sc.	VI	BSC-MR 605 T	Fermentation Technology II	02
29.	T.Y. B.Sc.	VI	BSC-MR 606 T	Food and Dairy Microbiology	02

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30.	T.Y. B.Sc.	VI	BSC-MR 607 P	Practical Course I- Diagnostic Microbiology and Immunology	02
31.	T.Y. B.Sc.	VI	BSC-MR 608 P	Practical Course II- Biochemistry and Molecular Biology	02
32.	T.Y. B.Sc.	VI	BSC-MR 609 P	Practical Course III- Fermentation Technology and Applied Microbiology	02
33.	T.Y. B.Sc.	VI	BSC-MR 610 T	Molecular and Biochemical Techniques	02
34.	T.Y. B.Sc.	VI	BSC-MR 611 P	Project	02

**Ahmednagar Jilha Maratha Vidya Prasarak Samaj's  
New Arts, Commerce and Science College, Ahmednagar (Autonomous)**

**Syllabus of T. Y. B. Sc. Microbiology**

**Under**

**Faculty of Science and Technology**

Semester – V	Paper – I
<b>Course Code: BSC-MR 501 T</b>	<b>Title of the Course: Medical Microbiology I</b>
<b>Credits: 02</b>	<b>Total Lectures: 30 Hrs.</b>

**Course Outcomes (COs):**

- a. Students will understand anatomy and infectious diseases of human body systems.
- b. Students will learn about different bacterial pathogens w.r.t. their Classification and Biochemical characters, Antigenic structure, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis, Epidemiology, Prophylaxis and Chemotherapy.
- c. Students will understand epidemiology including case control and cohort studies, clinical trials, Epidemiology of infectious diseases etc.

**Detailed Syllabus:**

Unit No.	Topic	No. of Hours
<b>Unit 1</b>	<b>Introduction to infectious diseases of following human body systems:</b> (Brief anatomy and Physiology, Diseases, Pathogens, common symptoms) <ol style="list-style-type: none"> <li>a. Respiratory system</li> <li>b. Gastrointestinal system and liver</li> <li>c. Urogenital system</li> </ol>	<b>07</b>

	d. Central nervous system	
<b>Unit 2</b>	<b>Epidemiology:</b> <ol style="list-style-type: none"> <li>Case control and cohort studies – Study design and application</li> <li>Principle and methods – Clinical trials of drugs and vaccines (Randomized control trials Concurrent parallel and cross-over trials)</li> <li>Epidemiology of infectious diseases <ol style="list-style-type: none"> <li>Sources and Reservoirs of Infection</li> <li>Modes of Transmission of Infections</li> <li>Disease Prevention and Control Measures, Vaccine-preventable bacterial diseases and nonvaccine-preventable bacterial diseases</li> </ol> </li> </ol>	<b>08</b>
<b>Unit 3</b>	<b>Study of following groups of bacterial pathogens:</b> (With respect to- Classification and Biochemical characters, Antigenic structure, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis, Epidemiology, Prophylaxis and Chemotherapy): <ol style="list-style-type: none"> <li><i>Salmonella, Vibrio</i></li> <li><i>Streptococcus pneumoniae, Streptococcus pyogenes,</i></li> <li><i>Neisseria meningitidis and Neisseria gonorrhoeae</i></li> <li><i>Pseudomonas aeruginosa</i></li> </ol>	<b>08</b>
<b>Unit 4</b>	<b>Study of following groups of bacterial pathogens:</b> <ol style="list-style-type: none"> <li><i>Treponema, Leptospira</i></li> <li><i>Clostridium tetani</i></li> <li><i>Mycobacterium tuberculosis</i> and <i>Mycobacterium leprae</i></li> <li><i>Orientia tsutsugamushi</i> and <i>Rickettsia rickettsii</i></li> </ol>	<b>07</b>

### Suggested Readings:

- 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., Krajdén 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. 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
11. Mayers D. L., Sobel J.D., Ouellette M., Kaye K.S. and Marchaim D. (Eds.) (2017).
12. Antimicrobial Drug Resistance: Clinical and Epidemiological Aspects. Volume 2. Edition 2. Springer. ISBN 978-3-319-47266-9
13. 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

14. Sastry G. A. and Rama Rao P. (2001). Veterinary Pathology. Seventh Edition. CBS Publishers, Delhi. ISBN: 9788123907389
15. 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>

Semester – V	Paper – II
Course Code: BSC-MR 502 T	Title of the Course: Immunology I
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will understand the working of various molecular, cellular components as well as organs involved in the immune system.
- Students will acquire the knowledge about antigens, antibodies and MHC molecules.
- Students will understand the various strategies for diagnosis of diseases based on antigen and antibody reactions.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<p><b>1. Organs of immune system</b></p> <ol style="list-style-type: none"> <li>Primary lymphoid organs (Thymus and Bone Marrow): Structure and function of Thymus (positive and negative selection).</li> <li>Secondary lymphoid organs – structure and function of spleen and lymph node, lymphatic system and lymph circulation</li> </ol> <p><b>2. Components of Innate Immunity</b></p> <ol style="list-style-type: none"> <li><b>Humoral components:</b> Defensins, pattern recognition proteins (PRP) and pathogen associated molecular patterns (PAMPs), complement, kinins, and acute phase reactants. Toll Like receptors</li> <li><b>Cellular components:</b> Phagocytic cells – PMNL, macrophages (reticulo- endothelial cell system) and dendritic cells, Phagocytosis (oxygen dependent and independent systems)</li> </ol>	10

	<p>c. <b>Complement activation:</b> (Classical, Alternative and lectin pathway), Inflammation (cardinal signs, mediators, vascular and cellular changes)</p>	
<b>Unit 2</b>	<p><b>1. Antigen, Antibody and MHC Antigen</b></p> <p>a. Types of antigens: Thymus-dependent and thymus independent antigens, Synthetic antigens, Soluble and particulate antigens, Autoantigens, Isoantigens</p> <p>b. Factors affecting immunogenicity</p> <p>c. Antigenic determinants, haptens and cross-reactivity, Carrier, Adjuvants.</p> <p><b>2. Immunoglobulins</b></p> <p>a. Characteristic of domain structure of Immunoglobulin, Biological functions of antibody and antigenic nature of immunoglobulin molecules.</p> <p>b. Molecular basis of antibody diversity (kappa, lambda and heavy chain)</p> <p><b>3. Major Histocompatibility Complex</b></p> <p>a. Structure of MHC in man and mouse</p> <p>b. Structure and functions of MHC class-I and class-II molecules</p> <p>c. MHC antigen typing (microcytotoxicity and mixed lymphocyte reaction)</p>	<b>10</b>
<b>Unit 3</b>	<p><b>1. Antigen- Antibody Interactions</b></p> <p>a. Principles of interactions: Antibody affinity and avidity, ratio of antigen antibody, lattice hypothesis and two stage theory</p> <p>b. Antigen antibody reactions</p> <p>i. Precipitation reactions: in fluid and in gel (RID, Rocket Immunoelectrophoresis)</p> <p>ii. Agglutination reactions: Viral hemagglutination, bacterial agglutination, passive agglutination and agglutination-inhibition</p> <p>iii. Immunofluorescence techniques: direct and indirect, fluorescence-activated cell sorting (FACS)</p> <p>iv. Enzyme-linked immunosorbent assay (ELISA), biotin-avidin system and enzyme-linked immune absorbent spot (ELISpot) assay</p> <p>v. Radioimmunoassay RIA</p>	<b>05</b>

<b>Unit 4</b>	<p><b>1. Transplantation and Immunity</b></p> <p>a. Types of Grafts, Allograft rejection mechanisms</p> <p>b. Prevention of allograft rejection</p> <p><b>2. Hybridoma Technology and Monoclonal Antibodies</b></p> <p>a. Preparation, HAT selection and propagation of hybridomas secreting monoclonal antibodies</p> <p>b. Applications of monoclonal antibodies</p>	<b>05</b>
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### Suggested Readings:

1. Abbas A. K. and Lichtman A. H. (2004). Basic Immunology- Functions and Disorders of Immune System. 2 nd Ed. Saunders. Elsevier Inc. PA. USA.
2. Aderem A., and Underhill D. M. (1999). Mechanisms of phagocytosis in macrophages. Annu. Rev. Immunol. 17: 593-623.
3. Austin J. M. and Wood K. J. (1993). Principles of Molecular and Cellular Immunology. 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. 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
7. Ganz T. (2003). Defensins: antimicrobial peptides of innate immunity. Nat. Rev. Immunol., 3:710–720.
8. Guyton A. C. and Hall J. E. (1996) Text Book of Medical Physiology, Goel Book Agency, Bangalore.
9. Janeway C. A., Travers P. Jr., Walport M. and Shlomchik M. J. (2005). Immunobiology Interactive. Garland Science Publishing. USA.
10. Kindt T. J., Goldsby R. A. and Osborne B. A. (2007). Kuby Immunology. 6th Ed. W. H. Freeman and Co., New York

11. Kuby J. (1996) Immunology. 3rd Ed. W. H. Freeman and Co, New York
12. Pancer Z. and Cooper M. D. (2006). The Evolution of Adaptive Immunity, Ann. Rev. Immunol., 24: 497–518
13. Roitt E., Brostoff J. and Male D. (1993) Immunology. 6th Ed. Mosby and Co. London.
14. Roitt I. M. (1988). Essentials of Immunology. ELBS, London.

Semester – V	Paper – III
Course Code: BSC-MR 503 T	Title of the Course: Enzymology
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will understand methods of active site determination, role of vitamins in metabolism.
- Students will learn to perform enzyme assay, purification and quantification of enzyme activity, enzyme kinetics in terms of initial, final velocity, mathematical expression of enzyme kinetic parameters and enzyme immobilization.
- Students will acquire knowledge of metabolic regulations.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<b>Structure of enzymes:</b> <ol style="list-style-type: none"> <li>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)</li> <li>Role of vitamins in metabolism: Occurrence, Structure and Biochemical functions of the following:               <ol style="list-style-type: none"> <li>Thiamine (Vitamin B1) and Thiamine Pyrophosphate</li> <li>Vitamin D</li> </ol> </li> </ol>	04
Unit 2	<b>1. Enzyme assays:</b> <ol style="list-style-type: none"> <li>Principles of enzyme assays and calculation of enzyme unit, specific activity.</li> </ol>	

	<p>b. Enzymes assays with examples by:</p> <ol style="list-style-type: none"> <li>i. Spectrophotometric methods</li> <li>ii. Radioisotope assay</li> </ol> <p><b>2. Principles and Methods of Enzyme purification:</b></p> <ol style="list-style-type: none"> <li>a. Methods of cell fractionation</li> <li>b. Principles and methods of enzyme purification:             <ol style="list-style-type: none"> <li>i. Based on molecular size</li> <li>ii. Based on charge</li> <li>iii. Based on solubility differences</li> <li>iv. Based on specific binding property and selective adsorption</li> </ol> </li> <li>c. Construction of enzyme purification chart</li> </ol>	<b>10</b>
<b>Unit 3</b>	<p><b>1.Enzyme Kinetics:</b></p> <ol style="list-style-type: none"> <li>a. Concept and use of initial velocity</li> <li>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 <math>K_m</math>, <math>K_s</math>, <math>V_{max}</math></li> <li>c. concept and types of enzyme inhibition</li> </ol> <p><b>2. Immobilization of enzymes:</b> Concept, methods of immobilization and applications</p>	<b>08</b>
<b>Unit 4</b>	<p><b>Metabolic Regulations:</b></p> <ol style="list-style-type: none"> <li>a. Enzyme compartmentalization at cellular level</li> <li>b. Allosteric enzymes</li> <li>c. Feedback mechanisms</li> <li>d. Covalently modified regulatory enzymes (Glycogen phosphorylase)</li> <li>e. Proteolytic activation of zymogens</li> <li>f. Isozymes - concept and examples</li> <li>g. Multienzyme complex e.g. Pyruvate dehydrogenase complex(PDH)</li> </ol>	<b>08</b>



**Suggested Readings:**

1. Nelson D. L. and Cox M. M. (2021). Lehninger's Principles of Biochemistry. 8th Edition. Mac Millan Worth Pub. Co. New Delhi. ISBN:9781319228002
2. Berg J. M., Stryer L., Tymoczko J. and Gatto G. (2019). Biochemistry. 9th Edition. Palgrave Macmillan. ISBN-978-1319114657
3. 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
4. Hall D. A. and Krishna Rao K. (1994). Photosynthesis (Studies in Biology). 6th Edition. Cambridge University Press, London. ISBN-13: 978-1-133-10629-
5. Garrett R. H. and Grisham C. M. (2013). Biochemistry. 5th Edition. Brooks/Cole, Publishing Company, California. ISBN-13: 978-1-133-10629-6
6. Katoch R. (2011). Analytical Techniques in Biochemistry and Molecular Biology. Springer New York. ISBN 978-1-4419-9785-2.

Semester – V	Paper – IV
Course Code: BSC-MR 504 T	Title of the Course: Genetics and Molecular Biology I
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will understand DNA Replication and Prokaryotic and Eukaryotic Gene Expression.
- Students will learn about methods of gene transfer by transformation, conjugation and transduction.
- Students will understand the concept of gene mapping.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<b>DNA Replication</b> <b>Process of prokaryotic DNA replication</b> <ol style="list-style-type: none"> <li>Single replicon</li> <li>Bidirectional movement of replication fork</li> <li>Ori C</li> <li>Pre-priming and Priming reaction.</li> <li>DNA polymerases, DNA synthesis of leading, lagging strand Okazaki fragments.</li> <li>Termination- Ter sequence, Tus protein</li> </ol>	04
Unit 2	<b>Prokaryotic and Eukaryotic Transcription</b> <b>1. Transcription in Prokaryotes</b> <ol style="list-style-type: none"> <li>Structure of promoter</li> <li>Structure and function of RNA polymerase</li> </ol>	

	<p>c. Steps of transcription: Initiation, Elongation and termination</p> <p><b>2. Transcription in eukaryotes with respect to protein coding Gene:</b></p> <p>a. Promoter, promoter proximal elements and enhancers</p> <p>b. Transcription regulatory proteins</p> <p>c. RNA polymerases</p> <p>d. Steps in transcription: Initiation, Elongation, Termination</p> <p>e. Post transcriptional modifications: 5' capping, 3' polyadenylation and introduction to RNA splicing</p> <p><b>3. Regulation of transcription:</b> Concept and components of operon: Lac operon: Inducible operon</p>	<b>10</b>
<b>Unit 3</b>	<p><b>Translation in prokaryotes and eukaryotes</b></p> <p>a. Structure and role of m-RNA, t-RNA and Ribosomes in Translation</p> <p>b. Role of Aminoacyl t-RNA synthetase in translation</p> <p>c. Steps in translation: Initiation, elongation, translocation and termination of protein synthesis</p>	<b>05</b>
<b>Unit 4</b>	<p><b>Gene transfer and mapping techniques</b></p> <p><b>1. Gene transfer by Transformation</b></p> <p>a. Discovery of Transformation</p> <p>b. Natural transformation Systems- <i>Streptococcus pneumoniae</i> and <i>Haemophilus influenzae</i>.</p> <p>c. Factors affecting transformation</p> <p>i. Competence development</p> <p>ii. Size of DNA</p> <p>iii. Concentration of DNA</p> <p><b>2. Gene transfer by Conjugation</b></p> <p>a. Discovery of Conjugation,</p> <p>b. Properties of F plasmid, F<sup>+</sup>, F<sup>-</sup>, Hfr and F' strains</p> <p>c. Process of conjugation between F<sup>+</sup> and F<sup>-</sup>, Hfr and F, F' and F<sup>-</sup></p> <p><b>3. Gene transfer by Transduction</b></p> <p>a. Discovery of Transduction</p> <p>b. Generalized transduction mediated by P22</p> <p>c. Specialized transduction mediated by lambda phage</p>	<b>11</b>

	<p><b>4. An introduction to Gene mapping</b></p> <ul style="list-style-type: none"><li>a. Gene linkage and concept of genetic recombination</li><li>b. Recombination mapping: Map unit, recombination frequency</li><li>c. Mapping of genes by co-transformation</li><li>d. Mapping of genes by co-transduction</li><li>e. Mapping by interrupted mating experiment</li><li>f. Numerical problems based on co-transformation, co-transduction and interrupted mating</li></ul>	
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### Suggested Readings:

1. Watson J.D., Baker, T.A., Bell, S.P., Gann A., Levine M. and Losick R. (2014). Molecular Biology of the gene. 7th edition. Pearson. ISBN: 9780321762436
2. Brown T. A. (2006). Gene Cloning and DNA Analysis. Blackwell Publication. 5th Edition. ISBN: 1405111216
3. Brown T.A. (2016). Gene Cloning and DNA Analysis: An Introduction. 7thEd. Wiley Blackwell Publication, U.S.A. ISBN: 978-1-119-07254-6
4. Dubey R. C. (2014). Advanced Biotechnology. S. Chand Publishing. ISBN: 9788121942904
5. Freifelder D. (2005). Molecular Biology. 2nd Edition. Narosa Publishing House Pvt. Limited, India.
6. Gardner E. J., Simmons M. J. and Snustad D. P. (2006). Principles of Genetics. 8th edition. John Wiley and Sons Publication. ISBN-13: 9788126510436
7. Hartwell L., Goldberg M., Fischer J. and Hood L. (2018). Genetics: from genes to genomes. McGraw-Hill. ISBN13: 9781259700903
8. Lewin's GENES X (2011). Krebs J., Kilpatrick S. T., Goldstein E. S. (Editors). 10th Edition. Sudbury, Mass.: Jones and Bartlett, c2011.
9. 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

10. Primrose S. B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics, 7thEd. Blackwell Publishing: U.S.A.
11. Russel P. J. (2000). Fundamentals of Genetics. Publisher: Benjamin/Cummings. ISBN: 9780321036261
12. Russel P. J. (2010). iGenetics: A Molecular Approach. 3rd Edition. Benjamin Cummings. ISBN: 9780321569769
13. Singh B. D. (2016). Biotechnology. 5th Edition. Reprint. Kalyani Publishers, India.

Semester – V	Paper – V
Course Code: BSC-MR 505 T	Title of the Course: Fermentation Technology I
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will learn the upstream processes of fermentation such as media optimization, sterilization of media, scale up and scale down
- Students will learn the downstream processing of fermentation products, methods for detection and quantification of fermentation products and various tests for Quality assurance of fermentation products.
- Students will understand the fermentation economics, concept of IPR and validation.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<p><b>Upstream processes of fermentations</b></p> <p><b>1. Media optimization</b></p> <ol style="list-style-type: none"> <li>Objectives of media optimization</li> <li>Methods of media optimization:               <ol style="list-style-type: none"> <li>Classical approach – One factor at a time, Full factorial design</li> <li>Plackett and Burman Design (with example) (Numerical problems of PBD can be discussed using software)</li> <li>Response Surface Methodology (RSM)</li> </ol> </li> </ol> <p><b>2. Sterilization of Media:</b></p> <ol style="list-style-type: none"> <li>Methods of sterilization</li> <li>Batch sterilization and Continuous sterilization (direct and indirect methods)</li> <li>Concept and derivation of Del factor</li> </ol>	08

	d. Filter sterilization of liquid media	
<b>Unit 2</b>	<p><b>Upstream processes of fermentations</b></p> <p><b>1. Strain Improvement:</b></p> <ol style="list-style-type: none"> <li>a. Objectives of strain improvement</li> <li>b. Methods for strain improvement:             <ol style="list-style-type: none"> <li>i. Types of mutants used in strain improvement (altered cell permeability mutants, auxotrophs, analogue resistant mutants, revertants)</li> <li>ii. Selection of different types of mutants (replica plate method, filtration enrichment, penicillin enrichment method, gradient plate technique)</li> <li>iii. Application of rDNA technology (significance, technique for commercial recombinant products like insulin)</li> </ol> </li> </ol> <p><b>2. Scale-up and Scale-down:</b></p> <ol style="list-style-type: none"> <li>a. Objectives of scale-up</li> <li>b. Levels of fermentation (laboratory, pilot-plant and production level – flowsheet to explain scale up)</li> <li>c. Criteria of scale-up for critical parameters [Aeration (kLa Volumetric Mass transfer coefficient), Agitation (P/V ratio, NRe Reynolds number, Np Power number.), Sterilization and broth rheology]</li> <li>d. Scale-down</li> </ol>	<b>09</b>
<b>Unit 3</b>	<p><b>Downstream processing and Quality assurance of fermentation products</b></p> <p><b>1. Downstream processing of fermentation products: (method, principle, types, examples of fermentations, factors affecting, merits and demerits at large scale operation)</b></p> <ol style="list-style-type: none"> <li>a. Cell disruption methods</li> <li>a. Filtration</li> <li>b. Centrifugation</li> <li>c. Liquid-liquid extraction</li> <li>d. Distillation</li> <li>e. Drying</li> </ol> <p><b>2. Quality assurance of fermentation products (as per IP, USP)</b></p>	<b>04</b>

	<ul style="list-style-type: none"> <li>a. Methods of detection and Quantification of the fermentation product: physicochemical, biological and enzymatic methods</li> <li>b. Sterility testing (direct inoculation method, membrane filtration method)</li> <li>c. Bioburden test and Microbial limit test</li> <li>d. Pyrogen testing: Endotoxin detection (LAL test)</li> <li>e. Ames test and modified Ames test</li> <li>f. Toxicity testing (Acute toxicity)</li> <li>g. Shelf life determination</li> </ul>	<b>06</b>
<b>Unit 4</b>	<p><b>Fermentation economics:</b></p> <ul style="list-style-type: none"> <li>a. Contribution of various expense heads to a process (Recurring and nonrecurring expenditures) citing any suitable example.</li> <li>b. Introduction to Intellectual Property Rights – Types of IPR (patenting in fermentation industry)</li> <li>c. Concept of validation (significance of SOPs)</li> </ul>	<b>03</b>

### Suggested Readings:

1. Aiba S., Humphrey A. E. and Millis N.F. (1977). Biochemical Engineering. Academic Press, New York,
2. British Pharmacopeia. (2021). The Stationery Office Ltd (TSO), PO Box 29, Norwich, NR3 1PD. <https://www.pharmacopoeia.com/Catalogue/Products>
3. Casida L. E. J. R. (2016). Industrial Microbiology. New Age International Private Limited. ISBN- 9788122438024
4. Flickinger M. C. (2010). Encyclopedia of Bioprocess Technology. Seven Volume Set. Wiley-Interscience, New Jersey. ISBN: 978-0-471-79930-6
5. Indian Pharmacopeia. (2018- Addendum 2021):  
<https://www.indianpharmacopoeia.in/index.php>
6. 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



7. 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
8. Patel. A. H. (2016). Industrial Microbiology. Trinity Press (Publisher). ISBN-13-9789385750267
9. Peppler H. L. and Perlman D. (1979). Microbial Technology. Volume 1: Microbial Processes. Academic Press, New York. ISBN: 978-0-12-551501-6
10. Peppler H. L. and Perlman D. (1979). Microbial Technology. Volume II: Fermentation Technology (2nd Edition). Academic Press. ISBN: 9781483268279
11. Stanbury P. F., Whitaker A. and Hall S. J. (2016). Principles of Fermentation Technology. 3rd Edition. Butterworth-Heinemann. ISBN: 9780080999531

Semester – V	Paper – VI
Course Code: BSC-MR 506 T	Title of the Course: Applied Microbiology
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will understand plant growth improvement with respect to disease resistance.
- Students will understand stages of plant disease development, epidemiology, symptoms based classification and plant disease control methods.
- Students will understand the importance of microorganisms in sustainable agriculture and microorganisms in plant genetic engineering.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<b>Plant Pathology:</b> <b>1. Plant growth improvement and Stages in development of a disease</b> <ol style="list-style-type: none"> <li>Plant growth improvement with respect to disease resistance</li> <li>Stages in development of a disease: Infection, invasion, colonization, dissemination of pathogens and perennation</li> </ol> <b>2. Classification of disease based on symptoms (with one example of the following):</b> Canker, Downy mildew, Mosaic <b>3. Plant disease epidemiology:</b> Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle and forecasting of plant diseases.	09
Unit 2	<b>Methods of plant disease control</b> <ol style="list-style-type: none"> <li>Eradication</li> <li>Chemical control</li> </ol>	

	<ol style="list-style-type: none"> <li>3. Biological control (employing bacterial and fungal cultures)</li> <li>4. Integrated pest management</li> <li>5. Genetic engineering for disease resistant plants</li> </ol>	<b>06</b>
<b>Unit 3</b>	<p><b>Microorganisms in sustainable Agriculture:</b></p> <ol style="list-style-type: none"> <li>1. Soil Micro biome (plant Micro biome): Concept, Composition, functioning and methods to study plant Micro biome</li> <li>2. Conservation of soil health: Role of microorganisms in soil health</li> <li>3. Phytonutrient availability by soil microorganisms Mechanism of diazotrophy, Phosphate solubilization, Potassium mobilization,</li> <li>4. Biofilm in plant surfaces, Biofilm formation; Biofilm in Phyllosphere and rhizosphere, Examples of plant-microbe interactions in biofilms, Biotechnological applications of plant biofilms</li> </ol>	<b>09</b>
<b>Unit 4</b>	<p><b>Microorganisms in plant genetic engineering:</b></p> <ol style="list-style-type: none"> <li>1. Concept of GM crops (Transgenic crops) w.r.t. edible vaccines, insecticide resistance, herbicide resistance, improved varieties, disease resistance</li> <li>2. Tools and techniques:</li> <li>3. Microorganisms as tools in plant genetic engineering (Shuttle vectors)</li> <li>4. Technology of BT resistant crops</li> <li>5. RNAi Technology and antisense RNA technology in disease resistant plant varieties</li> </ol>	<b>06</b>

### Suggested Readings:

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. Jones D. J. (Editor). (2013). The Epidemiology of Plant Diseases. Netherlands: Springer Netherlands. ISBN: 9789401733021
5. Jones J. B., Jr. (2012). Plant Nutrition and Soil fertility. Manual 2nd Edition. CRC Press. ISBN-13:978-1-4398-1610-3 (ebook-pdf)
6. Kashyap P. L., Srivastava A. K. and Srivastava M. (2021). The Plant Microbiome in Sustainable Agriculture. United Kingdom: Wiley. ISBN: 9781119505167
7. Lakshamana V., Selvaraj G. and Bais H. P. (2021). Functional Soil Microbiome: below Ground solutions to above ground problems, <https://plantphysiol.org>.
8. Martin Alexander. (1962). Introduction to Soil Microbiology. John Wiley and Sons. Inc. New York.
9. Mehrotra R. S. (1994). Plant Pathology. Tata McGraw-Hill Limited.
10. Peter K. (2018). Genetic Engineering of Horticultural Crops. United Kingdom: Elsevier Science. ISBN: 9780128104408
11. Rangaswami G. (2005). Diseases of Crop Plants in India. 4th edition. Prentice Hall of India Private Limited., New Delhi.
12. 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.
13. Singh R. S. (1998). Plant Diseases Management. 7th edition. Oxford and IBH, New Delhi.
14. Stewart C. N. (2008). Plant Biotechnology and Genetics: Principles, techniques and applications. John Wiley and Sons. Inc. New York.
15. Thind B. (2019). Phytopathogenic Bacteria and Plant Diseases. United Kingdom: CRC Press. ISBN: 9780429512506

Semester – V	Paper – VII
Course Code: BSC-MR 507 P	Title of the Course: Practical Course I-Diagnostic Microbiology and Immunology
Credits: 02	Total Lectures: 60 Hrs.

### Course Outcomes (COs):

- Students will be able to carry out physical, chemical and microscopic examination of clinical samples and the isolation and identification of pathogens from these clinical samples.
- Students will be able to perform agglutination tests such as Widal test and RPR test.
- Students will be able to perform haematology tests such as haemoglobin estimation, ESR and PCV determination, Total RBC count, Total and differential WBC count.

### Detailed Syllabus:

Sr No.	Title of the Experiment	No. of Practicals
1.	<b>Clinical microbiology:</b> <b>Physical, Chemical and Microscopic examination of Clinical samples - Urine, stool and pus</b>	03
2.	<b>Isolation, identification of following pathogens from clinical samples:</b> <ol style="list-style-type: none"> <li><i>Klebsiella spp.</i></li> <li><i>Salmonella spp.</i></li> <li><i>Pseudomonas spp.</i></li> <li><i>Streptococcus spp.</i></li> <li><i>Shigella spp.</i></li> </ol>	

	(for identification use of keys as well as Bergey's Manual is recommended)	<b>05</b>
<b>3.</b>	<b>Agglutination tests:</b> a. Widal test (Slide test and Tube Test) and b. Rapid Plasma Reagin (RPR) test	<b>02</b>
<b>4.</b>	<b>Haematology tests:</b> 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	<b>04</b>

### Suggested Readings:

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. 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
3. 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
4. Bergey's Manual of Systematic Bacteriology. (2005). Volume Two: The Proteobacteria, Part C: The Proteobacteria. Garrity G. Brenner D. J., Krieg N. R., and Staley J. R. (Eds.). Springer. ISBN 978-0-387-24145-6
5. 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

6. Maheshwari N. (2017). Clinical Pathology Hematology and Blood Banking (For Dmlt Students). 3rd edition. Jaypee Brothers Medical Publishers. ISBN-13: 978-9386261182
7. 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
8. Mukherjee K. L. and Ghosh S. (2010). Medical Laboratory Technology, Volume II: Procedure Manual for Routine Diagnostic Tests. 2nd edition. McGraw Hill Education CBCS: 2019 Pattern T. Y. B. Sc. Microbiology(India) Private Limited. ISBN-13: 978-1259061240
9. 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

Semester – V	Paper – VIII
Course Code: BSC-MR 508 P	Title of the Course: Practical Course II - Biochemistry and Molecular Biology
Credits: 02	Total Lectures: 60 Hrs.

### Course Outcomes (COs):

- Students will be able to determine absorption spectra and molar extinction coefficient, preparation of buffer and carry out paper /Thin layer chromatography.
- Students will be able to carry out qualitative and quantitative analysis of carbohydrates and proteins.
- Students will be able to carry out isolation and estimation of genomic DNA and checking its purity, perform bacterial conjugation.

### Detailed Syllabus:

Sr No.	Title of the practical	No. of practicals
1.	Determination of absorption spectra and molar extinction coefficient of two different dyes (by colorimetry /spectrophotometry)	01
2.	<b>Qualitative analytical tests using flow charts for :</b> a. Proteins (tests for aromatic amino acids, sulfur containing amino acids, different amino acids) b. Carbohydrates (tests for monosaccharides, disaccharides, and polysaccharides)	02
3.	Preparation of buffers and calibration of pH meter	01



4.	<b>Paper Chromatography/ Thin layer Chromatography</b> a. Separation and Identification of amino acids from mixture. b. Separation and Identification of sugars from mixture	02
5.	<b>Extraction and quantitative estimation of carbohydrates /proteins from natural sample:</b> a. Estimation of total carbohydrates from natural sources by Phenol -Sulfuric acid method b. Estimation of reducing sugar from natural sources by DNSA method c. Estimation of proteins from natural sources by Folin-Lowry method	03
6.	Isolation of genomic DNA from bacteria	01
7.	<b>Determination purity of DNA and its quantification:</b> a. Estimation of DNA by UV- spectrophotometric method, 260/280 ratio b. Estimation of DNA by the diphenylamine method.	01
8.	Bacterial Conjugation	02
9.	Chromosome Staining (G-banding) Giemsa staining of chromosome from eukaryotic cell extract	01

### Suggested Readings:

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*. Volume 12. Part B: 163-166. [https://doi.org/10.1016/0076-6879\(67\)12127-7](https://doi.org/10.1016/0076-6879(67)12127-7)
4. Howe B., Umrigar A. and Tsien F. (2014). Chromosome Preparation from Cultured Cells. *J. Vis. Exp.* 83: e50203. doi:10.3791/50203
5. Jayaraman J. (2011). *Laboratory Manual in Biochemistry*. New Age International Private Limited. ISBN-13: 978-8122430493
6. Jørgensen N. O. G., Sørensen J. and Nybroe O. (2010). *Microbiology 2010: Block 3: manual of laboratory exercises*. Department of Agriculture and Ecology, University of Copenhagen.
7. Katoch R. (2011). *Analytical Techniques in Biochemistry and Molecular Biology*. Springer New York Dordrecht Heidelberg London. ISBN: 978-1-4419-9784-5.
8. Martzy R., Bica-Schröder K., Pálvölgyi, Á.M., Kolm C., Jakwerth S., Kirschner A. K. T., Sommer R., Krska R., Mach R. L., Farnleitner A. H. and Reischer G. H. (2019).
9. Plummer D. T. (2001). *Introduction to Practical Biochemistry*. Tata McGraw Hill Publishing Company. ISBN-13: 978-0070994874
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	Paper – IX
Course Code: BSC-MR 509 P	Title of the Course: Practical Course III- Fermentation Technology and Applied Microbiology
Credits: 02	Total Lectures: 60 Hrs.

### Course Outcomes (COs):

- Students will be able to perform antibiotic assay and Sterility testing, MIC, MBC of pharmaceuticals.
- Students will be able to carry out the isolation of Phosphate solubilizing bacteria, *Aspergillus niger* and *Xanthomonas spp.* from various samples.
- Students will be able to prepare bioinoculants and perform pot assay to check effect of bioinoculants on plant growth

### Detailed Syllabus:

Sr. No.	Title of the Experiment	No. of Practicals
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).	02
2.	Minimum inhibitory concentration and minimum bactericidal concentration of antibacterial compounds (MIC and MBC)	02
3.	Antibiotic assay / Growth factor assay (agar gel diffusion technique)	02

4.	Isolation and identification of <i>Xanthomonas</i> spp. from citrus canker	01
5.	Isolation of <i>Aspergillus niger</i> from black rot of onion	01
6.	Collection of plant disease specimens and study of symptoms/ Project based on digital record of plant diseases (Group Activity)	01
7.	Isolation of PGPR with phosphate solubilization potential/Vesicular-Arbuscular Mycorrhiza (VAM), Preparation of liquid bioinoculants	02
8.	Validation of commercial formulations of bioinoculants based on BIS standards, Pot studies to check effect of bioinoculants on plant growth	02

### Suggested Readings:

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](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](http://www.uspbpep.com/usp29/v29240/usp29nf24s0_c81.html).
6. 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.

7. 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>.
8. Validation of standards of biofertilizers: Manual -  
<https://law.resource.org/pub/in/bis/S06/is.6092.3.2.2004.pdf>
9. 14.Yadav A. K. and Chandra K. (2014). Mass Production and Quality Control of Microbial Inoculants. Proc Indian Natn Sci Acad. 80 (2): 483-489.

Semester – V	Paper – X
Course Code: BSC-MR 510 T	Title of the Course: Nano-biotechnology
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will understand nanoscale and nanomaterials
- Students will learn Synthesis and characterization techniques of nanoparticles.
- Students will acquire knowledge of applications of nanomaterials in Medical field and Agricultures.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<b>Introduction to Nano-biotechnology:</b> <ol style="list-style-type: none"> <li>Introduction to nanoscale, nanomaterials, nanoscience and nanotechnology</li> <li>Classification of Nanostructures - 1D, 2D and 3 D nanomaterials</li> <li>Nanoscale bioassemblies</li> <li>Liposomes, viruses, DNA, polysaccharides and proteins (Protein nanotubes, nanofibers, peptide nanoparticles).</li> <li>Biomedical applications of bioassemblies, Cell targeting, drug delivery, bioimaging and vaccine development.</li> <li>The Potential Issues Surrounding the Use of Nanomaterials in Medicine</li> </ol>	08
Unit 2	<b>Microbial mediated metallic nanoparticles synthesis:</b>	07

	<ul style="list-style-type: none"> <li>a. Gold nanoparticles (AuNPs)</li> <li>b. Silver nanoparticles (AgNPs)</li> <li>c. Au-Ag alloy nanoparticles</li> <li>d. Oxide nanoparticles</li> <li>e. Magnetic nanoparticles</li> <li>f. Non-magnetic oxide nanoparticles</li> <li>g. Sulfide nanoparticles etc.</li> </ul>	
<b>Unit 3</b>	<b>Characterization techniques for nanomaterials:</b> 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), Atomic Force Microscopy (AFM).	<b>07</b>
<b>Unit 4</b>	<p><b>Applications of nanoparticles:</b> Antibacterial agent, biosensor, animal industry, and nanotechnology in wastewater treatment.</p> <p><b>Applications of nanotechnology in medical field:</b> Drug delivery, Cancer therapy and tissue repair</p> <p><b>Nanotechnology in agriculture</b> – Fertilizer and pesticides, food, solar cells</p>	<b>08</b>

### Suggested Readings:

1. Richard Brooker and Earl Boysen (2006). Nanotechnology. Wiley Publishing Inc., India. Pp 361.
2. Duckruix, A. and R. Giege, (1992). Crystallization of Nucleic acids and Proteins. A practical approach, Oxford University Press, England.
3. Bujold K. E., Lacroix A., and Sleiman H. F. (2018). DNA Nanostructures at the Interface with Biology. Chem. 4: 495–521. Elsevier Inc.
4. Chokriwal A., Sharma M. M. and Singh A. (2014). Biological synthesis of nanoparticles using bacteria and their applications. American Journal of PharmTech Research. 4(6):38-61.

5. 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 and microbial aspects. *Nanotechnology for Environmental Engineering*. 2(1): 1-21.
6. Doll T. A. P. F., Raman S., Dey R. and Burkhard P. (2013). Nanoscale assemblies and their biomedical applications. *J R Soc Interface*.10: 20120740. <http://dx.doi.org/10.1098/rsif.2012.0740>
7. Gurunathan S., Kalishwaralal K., Vaidyanathan R., Venkataraman D., Pandian S. R. K., Muniyandi J., Hariharan N. and Soo Hyun Eom. (2009). Biosynthesis, purification and characterization of silver nanoparticles using *Escherichia coli*. *Colloids and Surfaces B*. 74(1): 328–335.
8. Fariq A., Khan T. and Yasmin, A. (2017). Microbial synthesis of nanoparticles and their potential applications in biomedicine. *J. Appl. Biomed*. 15: 241–248
9. Li X., Xu H., Chen Z. S. and Chen G. (2011). Biosynthesis of nanoparticles by microorganisms and their applications. *Journal of Nanomaterials*. 2011.
10. 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](https://doi.org/10.1007/978-3-030-21621-4_1)
11. 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>
12. Rajput N. and Bankar A. (2017). Bio-inspired gold nanoparticles synthesis and their anti-biofilm efficacy. *J. Pharm. Investig*. 47: 521–530.
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>

Semester – V	Paper – XI
Course Code: BSC-MR 511 P	Title of the Course: Practical Course based on Nano-biotechnology
Credits: 02	Total Lectures: 60 Hrs.

### Course Outcomes (COs):

- Students will be able to synthesize metallic nanoparticles by using microorganisms.
- Students will be able to characterize nanoparticles.
- Students will be able to perform antimicrobial activity of nanoparticles.

### Detailed Syllabus:

Sr. No.	Topic	No. of Practical
1	Microbial synthesis of metallic nanoparticle synthesis (any two): silver, chromium, cobalt	05
2	Green Synthesis of metal Nanoparticle using plants	01
3.	<b>Detection and Characterization of metallic nanoparticles in colloidal solutions by:</b> a. UV-Spectrophotometer b. FTIR analysis	01
4.	Checking antimicrobial activities against the microbial synthesized metallic nanoparticles (any two)	04

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5.	MIC of microbial synthesized nanoparticles	01
6.	Photocatalytic degradation of dye using microbial synthesized nanoparticles	01

### Suggested Readings:

1. Duckruix, A. and R. Giege, (1992). Crystallization of Nucleic acids and Proteins. A practical approach, Oxford University Press, England.
2. Chokriwal A., Sharma M. M. and Singh A. (2014). Biological synthesis of nanoparticles using bacteria and their applications. American Journal of PharmTech Research. 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 and microbial aspects. Nanotechnology for Environmental Engineering. 2(1): 1-21.
4. Gurunathan S., Kalishwaralal K., Vaidyanathan R., Venkataraman D., Pandian S. R. K., Muniyandi J., Hariharan N. and Soo Hyun Eom. (2009). Biosynthesis, purification and characterization of silver nanoparticles using Escherichia coli. Colloids and Surfaces B. 74(1): 328–335.
5. Li X., Xu H., Chen Z. S. and Chen G. (2011). Biosynthesis of nanoparticles by microorganisms and their applications. Journal of Nanomaterials. 2011.
6. Tiquia-Arashiro S. and Rodrigues D. (2016). Nanoparticles Synthesized by Microorganisms. In Extremophiles: Applications in Nanotechnology. 1-51. Springer, Cham.
7. 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>

Semester – VI	Paper – I
Course Code: BSC-MR 601 T	Title of the Course: Medical Microbiology II
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will understand the different modes of action of antimicrobial agents.
- Students will learn the mechanisms of drug resistance.
- Students will learn about the different Human and animal viruses, fungi and protozoal pathogens.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<b>Chemotherapy</b> <b>1. Routes of drug administration.</b> <b>2. Mode of action of antimicrobial agents on:</b> a. <b>Bacteria:</b> i. Cell wall: Beta lactams: 1st to 6th Generation- e.g. Meropenem, Imipenem, Piperacillin, Tazobactam ii. Cell membrane: Polymyxin iii. Protein synthesis: Streptomycin, Tetracycline iv. Nucleic acids: Fluroquinolones, Rifamycin v. Enzyme inhibitors: Trimethoprim, Sulfomethaxazole  b. Fungi: Griseofulvin, Amphotericin B, Anidulafungin, Vericonazole c. Viruses: Acyclovir, Oseltamivir, Remdecivir d. Protozoa: Metronidazole, Chloroquine	08
Unit 2	<b>Mechanisms of drug resistance on:</b>  a. Genetic basis:	06

	<ul style="list-style-type: none"> <li>i. Mutations in gene(s)</li> <li>ii. Acquisition of foreign DNA coding for resistance determinants through horizontal gene transfer.</li> </ul> <ul style="list-style-type: none"> <li>b. Mechanisms of drug resistance by           <ul style="list-style-type: none"> <li>i. Limiting uptake of a drug.</li> <li>ii. Modification of a drug target.</li> <li>iii. Inactivation of a drug.</li> <li>iv. Active efflux of a drug.</li> </ul> </li> </ul>	
<b>Unit 3</b>	<p><b>Human and Animal Viruses, Fungal and Protozoal Pathogens</b></p> <p>1. <b>Introduction to cultivation of viruses</b></p> <p>2. <b>Study of following groups of viral pathogens:</b></p> <ul style="list-style-type: none"> <li>a. <b>Human viruses</b> (with respect to – Virion, Characteristics, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis including serological diagnosis, Epidemiology, Prophylaxis and Chemotherapy):           <ul style="list-style-type: none"> <li>i. Respiratory Viruses: Influenza Virus, Corona Virus</li> <li>ii. Hemorrhagic Virus: Dengue</li> <li>iii. Hepatic Virus: Hepatitis A Virus</li> <li>iv. Gastrointestinal Virus: Rotavirus</li> <li>v. Cutaneous Viruses: Human papillomavirus</li> <li>vi. Neurological Viruses: Japanese Encephalitis Virus</li> </ul> </li> <li>b. <b>Animal Viruses:</b> FMD Virus and Rinderpest Virus</li> </ul>	<b>10</b>
<b>Unit 4</b>	<p>1. <b>Study of following groups of parasites</b> (with respect to – Classification, Lifecycle, Morphological characteristics, Viability characteristics, Pathogenicity, Pathogenesis, Symptoms, Laboratory diagnosis (Serological diagnosis wherever applicable), Epidemiology, Prophylaxis and Chemotherapy):</p> <ul style="list-style-type: none"> <li>a. <i>Plasmodium</i></li> <li>b. <i>Entamoeba</i></li> </ul> <p>2. <b>Study of following groups of yeast and fungal pathogens</b> (With respect to – Morphological and cultural characteristics, Classification, Pathogenicity, Pathogenesis,</p>	<b>06</b>

	Symptoms, Laboratory diagnosis, Epidemiology, Prophylaxis and Chemotherapy a. <i>Aspergillus</i> species (Pathogenic) b. <i>Cryptococcus neoformans</i> c. <i>Histoplasma capsulatum</i>	
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### Suggested Readings:

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. Finch R., Greenwood D., Whitley R. and Norrby S. R. (2010) Antibiotic and Chemotherapy. 9th Edition. Elsevier. ISBN: 9780702040641
5. Greer D. L., Kane J., Summerbell R., Sigler L., Krajdén 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
6. 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
7. Kanungo Reba. (2017). Ananthanarayan and Paniker's Textbook of Microbiology. Tenth edition. The Orient Blackswan Publisher. ISBN-13: 978-9386235251
8. 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

9. 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
10. Mayers D. L., Sobel J.D., Ouellette M., Kaye K.S. and Marchaim D. (Eds.) (2017).
11. Antimicrobial Drug Resistance: Clinical and Epidemiological Aspects. Volume 2. Edition 2. Springer. ISBN 978-3-319-47266-9
12. 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: 978-1555810.

Semester – VI	Paper – II
Course Code: BSC-MR 602 T	Title of the Course: Immunology II
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will understand the concept and working of cytokines, Humoral immune response and Cell mediated immune response.
- Students will acquire the knowledge about MHC processing pathways, Hypersensitivity reactions.
- Students will learn mechanisms behind the autoimmunity and Immunodeficiency.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<b>Cytokines:</b> <ol style="list-style-type: none"> <li>Properties of cytokines</li> <li>Biological functions of Interleukines, Tumor necrosis factors and Interferons</li> </ol>	04
Unit 2	<b>1. Adaptive / Acquired Immunity (Third line of defense):</b> <ol style="list-style-type: none"> <li>Humoral Immune Response           <ol style="list-style-type: none"> <li>Primary and secondary response kinetics, significance in vaccination programs</li> <li>Response of secondary lymphoid organs to antigen</li> <li>Antigen processing and presentation (Major Histocompatibility class I and class II processing pathways), cell-cell interactions, response to super-antigens, role of cytokines in activation and differentiation of B-cells.</li> </ol> </li> <li>Cell Mediated Immune Response</li> </ol>	08



	<ul style="list-style-type: none"> <li>i. Activation and differentiation of T<sub>k</sub> cells</li> <li>ii. Mechanism of Cytotoxic T lymphocytes (CTL) mediated cytotoxicity, Antibody-dependent cellular cytotoxicity (ADCC)</li> </ul>	
<b>Unit 3</b>	<b>1. Hypersensitivity</b> <ul style="list-style-type: none"> <li>a. General principles of different types of hypersensitivity reactions</li> <li>b. Gell and Coomb's classification of hypersensitivity – mechanism with examples for type I (Immediate), II, III and IV (delayed)</li> </ul>	<b>06</b>
	<b>1. Autoimmunity and Autoimmune diseases:</b> <ul style="list-style-type: none"> <li>a. Immunological tolerance</li> <li>b. Types of autoimmune diseases</li> <li>c. Factors contributing development of autoimmune diseases</li> <li>d. Immunopathological mechanisms</li> <li>e. Diagnosis and treatment of autoimmune disease</li> <li>f. Myasthenia gravis and Rheumatoid arthritis</li> <li>g. Therapeutic immunosuppression for autoimmunity</li> </ul>	<b>07</b>
<b>Unit 4</b>	<b>Immunodeficiency</b> <ul style="list-style-type: none"> <li>a. Complement deficiencies</li> <li>b. Introduction to congenital immunodeficiency disorders: Common Variable Immune Deficiency (CVID) and acquired immunodeficiency: Immune mechanisms in AIDS</li> </ul>	<b>05</b>

### Suggested Readings:

1. Abbas A. K. and Lichtman A. H. (2004). Basic Immunology- Functions and Disorders of Immune System. 2<sup>nd</sup> Ed. Saunders. Elsevier Inc. PA. USA.
2. Aderem A., and Underhill D. M. (1999). Mechanisms of phagocytosis in macrophages. *Annu. Rev. Immunol.* 17: 593-623.
3. Austin J. M. and Wood K. J. (1993). Principles of Molecular and Cellular Immunology. 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. 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
7. Ganz T. (2003). Defensins: antimicrobial peptides of innate immunity. *Nat. Rev. Immunol.*, 3:710–720.
8. Guyton A. C. and Hall J. E. (1996) *Text Book of Medical Physiology*, Goel Book Agency, Bangalore.
9. Janeway C. A., Travers P. Jr., Walport M. and Shlomchik M. J. (2005). *Immunobiology Interactive*. Garland Science Publishing. USA.
10. Kindt T. J., Goldsby R. A. and Osborne B. A. (2007). *Kuby Immunology*. 6th Ed. W. H. Freeman and Co., New York
11. Kuby J. (1996) *Immunology*. 3rd Ed. W. H. Freeman and Co, New York
12. Pancer Z. and Cooper M. D. (2006). The Evolution of Adaptive Immunity, *Ann. Rev. Immunol.*, 24: 497–518
13. Roitt E., Brostoff J. and Male D. (1993) *Immunology*. 6th Ed. Mosby and Co. London.
14. Roitt I. M. (1988). *Essentials of Immunology*. ELBS, London.

<b>Semester – VI</b>	<b>Paper – III</b>
<b>Course Code: BSC-MR 603 T</b>	<b>Title of the Course: Metabolism</b>
<b>Credits: 02</b>	<b>Total Lectures: 30 Hrs.</b>

### Course Outcomes (COs):

- a. Students will learn mechanisms of transport of solutes across the membrane and bioenergetics.
- b. Students will get acquainted with mechanism of biosynthesis and degradation of bio molecules.
- c. Students will learn about the photosynthesis and chemolithotrophy.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
<b>Unit 1</b>	<b>Membrane transport mechanisms:</b> <ol style="list-style-type: none"> <li>a. Passive transport - Diffusion, Osmosis, Facilitated transport</li> <li>b. Active transport - Active transport systems in bacteria</li> <li>c. Group translocation of sugars in bacteria</li> </ol> Ionophores: Mechanism and examples	<b>04</b>
<b>Unit 2</b>	<b>Bioenergetics:</b> <ol style="list-style-type: none"> <li>a. Laws of thermodynamics- first and second law.</li> <li>b. Concepts of free energy, entropy, high energy compounds: Pyrophosphate, enolic phosphates, acyl phosphates, thioester compounds, and guanidinium compounds.</li> <li>c. Mitochondrial electron transport chain: components, arrangement of different components in the inner membrane, structure and function of ATP synthetase, inhibitors and uncouplers of ETC and oxidative</li> </ol>	<b>10</b>

	phosphorylation, energetics of mitochondrial electron transport chain.	
<b>Unit 3</b>	<b>Biosynthesis and Degradation:</b> 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. $\beta$ oxidation), Proteins (urea cycle), role of extracellular enzymes.	<b>12</b>
<b>Unit 4</b>	<b>1.Bacterial Photosynthesis: Photosynthetic bacteria with reference to photosynthetic apparatus, energy generation, and CO<sub>2</sub> fixation</b> a. Cyanobacteria b. Purple bacteria  <b>2.Chemolithotrophy:</b> Concept and one example, Iron oxidizing bacteria	<b>04</b>

### Suggested Readings:

1. Garrett R. H. and Grisham C. M. (2013). Biochemistry. 5th Edition. Brooks/Cole, Publishing Company, California. ISBN-13: 978-1-133-10629-6.
2. Katoch R. (2011). Analytical Techniques in Biochemistry and Molecular Biology. Springer New York. ISBN 978-1-4419-9785-2.
3. Nelson D. L. and Cox M. M. (2021). Lehninger's Principles of Biochemistry. 8th Edition. Mac Millan Worth Pub. Co. New Delhi. ISBN:9781319228002
4. Palmer T. (2001) Enzymes: Biochemistry, Biotechnology and Clinical chemistry. Horwood Pub. Co. Chichester, England. ISBN-9781898563785
5. Segel I. H. (2010). Biochemical Calculations. 2nd Ed. Wiley India Pvt. Limited. ISBN: 9788126526437
6. Stanier R. Y., Adelberg E. A. and Ingraham J. L. (1985). General microbiology. 4th Edition. London: Macmillan

7. Wilson K. and Walker J. (Editors). (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7th edition. Cambridge University Press, New York. ISBN-13: 978-052173167

Semester – VI	Paper – IV
Course Code: BSC-MR 604 T	Title of the Course: <b>Genetics and Molecular Biology II</b>
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will understand the concept of genetic recombination and bacteriophage Genetics.
- Students will get knowledge about DNA damage and repair mechanisms.
- Student will understand the concept of Recombinant DNA Technology and tools of Recombinant DNA Technology.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
<b>Unit 1</b>	<b>Genetic Recombination</b> <ol style="list-style-type: none"> <li>Mendel's laws, Eukaryotic Cell cycle, Mitosis, Meiosis</li> <li>Holliday model for Homologous recombination, Role of Rec and Ruv proteins.</li> <li>Genetic mapping by Tetrad analysis in <i>N. crassa</i> (Numerical Calculations using PD, TT and NPD)</li> <li>Genetic Mapping by Parasexual cycle in <i>A. nidulans</i></li> </ol>	<b>09</b>
<b>Unit 2</b>	<b>Bacteriophage Genetics</b> <ol style="list-style-type: none"> <li>Lytic cycle: Virulent phages, T-series phages, Concept and formation of plaque, Lysogenic cycle: Temperate phage (lambda phage)</li> <li>Bacteriophage mutants: Plaque morphology (r type), T-series phages, Host range, Conditional lethal mutants (Ts and Am)</li> </ol>	<b>09</b>

	<ul style="list-style-type: none"> <li>c. Concept of Genetic Complementation and Cis-trans test of genetic function. (Intergenic- rII locus of T4 phage, Mechanism of Intragenic complementation.)</li> <li>d. Fine structure mapping of rII locus of T4 phage using Benzer's spot tests and deletion mapping</li> </ul>	
<b>Unit 3</b>	<p><b>DNA damage and Repair mechanisms</b></p> <ul style="list-style-type: none"> <li>a. DNA damage by hydrolysis, deamination, alkylation, oxidation, Radiation (X rays and UV rays)</li> <li>b. DNA repair by Photoreactivation</li> <li>c. DNA repair by Mismatch repair mechanism</li> <li>d. DNA repair by Excision repair mechanisms (BER/NER)</li> </ul>	<b>05</b>
<b>Unit 4</b>	<p><b>Recombinant DNA technology</b></p> <p><b>1.Recombinant DNA Technology Tools and basics of recombinant DNA technology</b></p> <ul style="list-style-type: none"> <li>a. Introduction to recombinant DNA technology</li> <li>b. Restriction enzymes</li> <li>c. Vectors: Features of an ideal vector <ul style="list-style-type: none"> <li>i. Plasmids: pBR322</li> <li>ii. Bacteriophage vectors</li> <li>iii. Cosmids</li> <li>iv. High capacity vectors: YACs, BACs</li> <li>v. Expression vectors</li> </ul> </li> <li>d. Joining of DNA molecules- DNA Ligases (<i>E. coli</i> and T4 phage), Use of Linker / Adaptor / Homopolymer tailing</li> <li>e. Methods to transfer recombinant DNA into bacterial host cells (Physical-Electroporation, Gene gun, Chemical –CaCl<sub>2</sub> mediated, liposome mediated)</li> <li>f. Methods of screening recombinants using selective markers and Blue-white screening</li> </ul> <p><b>2. Molecular techniques used in RDT</b></p> <ul style="list-style-type: none"> <li>a. Isolation of genomic DNA</li> <li>b. Principle and methodology of Agarose gel electrophoresis and its applications</li> <li>c. Concept, Methodology and applications of Southern, Northern and Western blotting</li> </ul>	<b>07</b>

**Suggested Readings:**

1. Birge E. A. (2013). Bacterial and Bacteriophage Genetics. Springer, New York. ISBN: 9781475732580
2. Watson J.D., Baker, T.A., Bell, S.P., Gann A., Levine M. and Losick R. (2014). Molecular Biology of the gene. 7th edition. Pearson. ISBN: 9780321762436
3. Brown T. A. (2006). Gene Cloning and DNA Analysis. Blackwell Publication. 5th Edition. ISBN: 1405111216
4. Clutterbuck A. J. (1996). Parasexual recombination in fungi. J. Genet. 75(3): 281-286, @ Indian Academy of Sciences
5. Goodenough U. (2016). Genetics. Publisher: Holt, Rinehart and Winston. ISBN13: 978-0030197161
6. Hartwell L., Goldberg M., Fischer J. and Hood L. (2018). Genetics: from genes to genomes. McGraw-Hill. ISBN13: 9781259700903
7. Lewin's GENES X (2011). Krebs J., Kilpatrick S. T., Goldstein E. S. (Editors). 10th Edition. Sudbury, Mass.: Jones and Bartlett, c2011.
8. 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
9. Primrose S. B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics, 7thEd. Blackwell Publishing: U.S.A.
10. Russel P. J. (2000). Fundamentals of Genetics. Publisher: Benjamin/Cummings. ISBN: 9780321036261
11. Russel P. J. (2010). iGenetics: A Molecular Approach. 3rd Edition. Benjamin Cummings. ISBN: 9780321569769
12. 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



13. Singh B. D. (2016). Biotechnology. 5th Edition. Reprint. Kalyani Publishers, India.
14. Strickberger M.W. (2012). Genetics. 3rd Edition. New Delhi: PHI Learning Gardner.
15. van Sinderen D. and McGrath S.(Editors). (2007). Bacteriophage: Genetics and Molecular Biology. Caister Academic Press

Semester – VI	Paper – V
Course Code: BSC-MR 605 T	Title of the Course: Fermentation Technology II
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will understand the solid state and submerged fermentation process.
- Students will understand the large scale production of fermentation products such as primary metabolites, secondary metabolites, enzymes etc.
- Students will understand the large scale production of fermentation products such as milk products, biomass based products, vaccines, immune sera and biotransformation of steroids.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	1. <b>Introduction to Solid State Fermentation and Submerged Fermentation:</b> Process, production strains, media, fermenter design, fermentation conditions, applications, merits and demerits 2. <b>Large scale production of</b> (process with flow sheet, nature of the product, production pathway, applications, production strains, media, fermentation process, parameters, product recovery) <b>Primary Metabolites:</b> <ol style="list-style-type: none"> <li>Vitamins (B12 and B2)</li> <li>Amino acids - Glutamic acid, Lysine</li> <li>Organic acids (Citric acid, Vinegar and Lactic acid)</li> </ol>	07
Unit 2	Large scale production of	

	<p><b>a. Alcohol and alcoholic beverages:</b></p> <ul style="list-style-type: none"> <li>i. Bioethanol</li> <li>ii. Alcoholic Beverages - Beer and Wine</li> </ul> <p><b>b. Secondary metabolites:</b></p> <ul style="list-style-type: none"> <li>i. Antibiotics-Penicillin (natural and semi synthetic)</li> <li>ii. Streptomycin]</li> </ul>	<b>08</b>
<b>Unit 3</b>	<p><b>Large scale production of</b></p> <p><b>a. Enzymes</b></p> <ul style="list-style-type: none"> <li>i. Amylase</li> <li>ii. Proteases</li> </ul> <p><b>b. Biomass based products:</b></p> <ul style="list-style-type: none"> <li>i. Yeast: Baker's and Distiller's yeast</li> <li>ii. Probiotics (Any one example)</li> <li>iii. Biocontrol agent: <i>Bacillus thuringiensis</i></li> </ul> <p><b>c. Milk products:</b></p> <ul style="list-style-type: none"> <li>i. Cheese</li> <li>ii. Yogurt</li> </ul> <p><b>d. Microbial transformation of steroids</b></p>	<b>08</b>
<b>Unit 4</b>	<p><b>Large scale production of</b></p> <p><b>a. Vaccines</b></p> <ul style="list-style-type: none"> <li>i. Polio – Inactivated Polio Vaccine, Oral Polio Vaccine</li> <li>ii. Tetanus – Tetanus toxoid (TT)</li> <li>iii. Rabies – HDCC, Chick embryo cell line, Vero cell line</li> </ul> <p><b>b. Immune sera</b></p> <ul style="list-style-type: none"> <li>i. Anti tetanus serum (ATS)</li> <li>ii. Anti rabies serum (ARS)</li> </ul>	<b>07</b>

**Suggested Readings:**

1. 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
2. Patel. A. H. (2016). Industrial Microbiology. Trinity Press (Publisher). ISBN-13-9789385750267
3. Pepler H. L. and Perlman D. (1979). Microbial Technology. Volume 1: Microbial Processes. Academic Press, New York. ISBN: 978-0-12-551501-6
4. Pepler H. L. and Perlman D. (1979). Microbial Technology. Volume II: Fermentation Technology (2nd Edition). Academic Press. ISBN: 9781483268279
5. Reed G. (Editor). (1982). Prescott and Dunn's Industrial Microbiology. Westport, CT, AVI Publishing Co Inc.
6. Stanbury P. F., Whitaker A. and Hall S. J. (2016). Principles of Fermentation Technology. 3rd Edition. Butterworth-Heinemann. ISBN: 9780080999531
7. Van Damme E. J. (1984) Biotechnology of Industrial Antibiotics. Marcel Dekker Inc. New York. ISBN-13: 978-0824770563
8. 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](https://doi.org/10.1093/clinids/6.Supplement_2.S335)
9. Wiseman A. (1983) Topics in Enzyme and Fermentation – Biotechnology. Volume 7. Ellis Horwood Limited, Publishers: Chichester. John Wiley and sons, New York.

## Reference links:

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

2. Large scale production of rabies vaccine:

<https://academic.oup.com/jimb/article-pdf/18/5/340/34773995/jimb0340.pdf>

3. Large scale production of tetanus vaccine:

<http://nopr.niscair.res.in/bitstream/123456789/26533/1/JSIR%2060%2810%29%20773-778.pdf>

4. USA Clinical Laboratory Standards Institute(CLSI) Guidelines 2021:

<https://clsi.org/standards/>

Semester – VI	Paper – VI
Course Code: BSC-MR 606 T	Title of the Course: Food and Dairy Microbiology
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs):

- Students will learn food classification based on their perishability, intrinsic and extrinsic factors affecting the growth of microbes in foods.
- Students will acquire knowledge about food spoilage, microbial food poisoning and food infection, principles and methods of food preservation.
- Students will understand the composition and types of milk, milk borne diseases, spoilage of milk and milk processing techniques as well as naturally occurring preservatives in milk.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<b>Food Microbiology</b> <ol style="list-style-type: none"> <li><b>Classification of food- Perishable, non-perishable, and stable.</b></li> <li><b>Factors affecting Microbial growth in food</b> <ol style="list-style-type: none"> <li>Intrinsic factors-pH, water activity, O-R potential, nutrient content, biological structure of food, inhibitory substances in food.</li> <li>Extrinsic factors-Temperature of storage, Relative humidity, concentration of gases.</li> </ol> </li> </ol>	06
Unit 2	<b>Food spoilage, Preservation and food in relation to disease</b> <ol style="list-style-type: none"> <li><b>Principles of food preservation</b></li> </ol>	

	<ul style="list-style-type: none"> <li>a. Importance of TDP, TDT, D, F, Z values</li> <li>b. Use of low and high temperature for food preservation.</li> <li>c. Use of chemicals and antibiotics in food preservation,</li> <li>d. Canning</li> <li>e. Dehydration</li> <li>f. Use of radiation</li> <li>g. Tetra pack technology</li> <li>h. Food grade bio preservatives</li> </ul> <p><b>2. Microbial food poisoning and food infection</b></p> <ul style="list-style-type: none"> <li>a. Food poisoning- <i>Clostridium botulinum</i>, <i>Aspergillus flavus</i></li> <li>b. Food infection- <i>Salmonella typhimurium</i>, <i>Vibrio parahaemolyticus</i></li> </ul>	<b>09</b>
<b>Unit 3</b>	<p><b>Dairy Microbiology</b></p> <ul style="list-style-type: none"> <li>1. Definition of milk, Composition and physicochemical properties of Milk of different animals. Difference between colostrum and milk.</li> <li>2. Types of milk: whole, toned, double toned, homogenized, and skimmed milk, dehydrated milk</li> <li>3. Microflora associated with milk and its importance.</li> <li>4. milk borne diseases</li> </ul>	<b>07</b>
<b>Unit 4</b>	<p><b>1.Processing Techniques and naturally occurring preservatives</b></p> <ul style="list-style-type: none"> <li>a. Bacteriological aspects of processing techniques like bactofugation, thermisation, pasteurization (in detail process is expected), sterilization and boiling.</li> <li>b. Naturally occurring preservative systems in milk like LP system, immunoglobulins, Lysozyme, Lactoferrin etc.</li> </ul> <p><b>2. Spoilage of Milk</b></p> <ul style="list-style-type: none"> <li>a. Spoilage of Milk</li> <li>b. Succession of microorganisms in milk leading to spoilage</li> <li>b. Stormy fermentation, ropiness, sweet curdling</li> <li>c. Preservation of Milk and Milk products by physical (irradiation) and Chemical agents, food grade bio preservatives (GRAS), Bacteriocins of LAB</li> </ul>	<b>08</b>

**Suggested Readings:**

1. Banwart G. J. (1989). Basic Food Microbiology. 2nd edition. Food Science and Nutrition. 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. Parihar P. and Parihar L. (2008). Dairy Microbiology. Agrobios, Jodhpur, India. ISBN 13: 9788177542738
13. Robinson R. K. (2012). Modern Dairy Technology. Volume 2. Springer. ISBN-13: 978-1468481747



14. Sharma K.S. (2021). Chemistry of Milk. AgriMoon.com. e-Krishi Shiksha. Online Courses.
15. Singh S. (2013) Dairy Technology: Volume -01: Milk and Milk Processing. New India Publishing Agency, India. ISBN-13: 978-9383305087

Semester – VI	Paper – VII
Course Code: BSC-MR 607 P	Title of the Course: Practical Course I-Diagnostic Microbiology and Immunology
Credits: 02	Total Lectures: 60 Hrs.

### Course Outcomes (COs):

- Students will be able to study permanent slides of microbial pathogens and study growth of pathogens on various growth media.
- Students will be able to perform antibiotic sensitivity testing of Gram positive and Gram negative pathogens.
- Students will be able to perform Immuno-chromatographic test, immunoprecipitation test and observe the working of a blood bank during visit.

### Detailed Syllabus:

Sr. No.	Title of the Experiment	No. of Practicals
1	<b>Study of permanent slides of following microbial pathogens:</b> <ol style="list-style-type: none"> <li><i>Entamoeba histolytica</i></li> <li><i>Giardia spp.</i></li> <li><i>Plasmodium spp.</i></li> <li><i>Mycobacterium (tuberculosis and leprae)</i></li> <li><i>Trichophyton spp.</i></li> <li><i>Epidermophyton spp.</i></li> <li><i>Microsporum spp.</i></li> </ol>	03
2.	<b>Study of growth characters of pathogens on following growth media:</b> Mannitol Salt Agar, Wilson Blair agar, Salmonella Shigella agar, Glucose azide medium, Cetrimide agar, TSI agar	02

4.	<b>Antibiotic sensitivity testing of the bacterial pathogens</b> (for Gram positive and Gram negative bacteria)	01
5.	<b>Immunoematology:</b> a. Cross-matching (Major and Minor) and b. Coomb's test (Direct and Indirect )	02
6.	<b>Immuno chromatographic test:</b> The qualitative differential detection of IgM and IgG antibodies to dengue virus in Human serum /Plasma <b>Or</b> <b>Advantage Mal Card visual immunoassay:</b> The qualitative diagnosis of <i>Plasmodium spp.</i>	01
7.	<b>Immunoprecipitation:</b> Double diffusion (Ouchterlony) technique	01
8.	<b>Demonstrations of:</b> a. ELISA (Antigen/ Antibody detection) b. Egg Inoculation Technique c. Serum Protein separation by Electrophoresis	03
9.	<b>Visit to blood bank and preparation of visit report</b>	01

### Suggested Readings:

1. Baveja C. P. and Baveja V. (2019). Text and Practical Microbiology for MLT. 3rd Edition. Arya Publishing Company. ISBN-13: 9788178558387
2. Godkar P. B. (2020). Textbook of Medical Laboratory Technology Volume 1 and 2. 3rd edition Bhalani Publishing House. ASIN: 9381496196. ISBN-13: 978- 9381496190
3. Greer D. L., Kane J., Summerbell R., Sigler L., Kraiden 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

4. Maheshwari N. (2017). Clinical Pathology Hematology and Blood Banking (For Dmlt Students). 3rd edition. Jaypee Brothers Medical Publishers. ISBN-13: 978-9386261182
5. 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
6. Mukherjee K. L. and Ghosh S. (2010). Medical Laboratory Technology, Volume II: Procedure Manual for Routine Diagnostic Tests. 2nd edition. McGraw Hill Education CBCS: 2019 Pattern T. Y. B. Sc. Microbiology(India) Private Limited. ISBN-13: 978-1259061240
7. 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
8. Talib V. H. (2019). Handbook Medical Laboratory Technology. 2nd edition. CBS Publishers and Distributors Pvt. Ltd. ISBN-13: 978-8123906775

Semester – VI	Paper –VIII
Course Code: BSC-MR 608 P	Title of the Course: Practical Course II- Biochemistry and Molecular Biology
Credits: 02	Total Lectures: 60

### Course Outcomes (COs):

- Students will be able to carry out enzyme production, purification quantification and immobilization.
- Students will be able to perform isolation and enumeration of bacteriophages as well as study mitotic cell division from onion root tips.
- Students will be able to carry out estimation of blood sugar, urea, cholesterol and serum protein.
- Students will be able to perform isolation of plasmid DNA and Agarose gel electrophoresis.

### Detailed Syllabus:

Sr. No.	Title of the experiment	No. of Practical's
1.	<b>Clinical Biochemistry - Estimations of</b> a. Blood sugar b. Blood urea c. Serum cholesterol d. Serum proteins and albumin	04
2.	<b>Enzyme production, purification, quantification and Immobilization:</b> a. Lab scale production of amylase using isolates b. Precipitation of amylase from fermentation broth (salt/solvent)	

	<p>c. determination of specific activity of crude and purified amylase</p> <p>d. Immobilization of Amylase using calcium alginate</p>	<b>04</b>
<b>3.</b>	Enrichment, Isolation and Enumeration of Bacteriophages (Principle, Methodology and Calculations of phage titer in PFU/ml)	<b>02</b>
<b>4.</b>	Isolation of Plasmid DNA and Agarose Gel Electrophoresis (Demonstration/hands on as per infrastructure availability)	<b>02</b>
<b>5.</b>	Study of Mitotic cell division from onion root tips.	<b>01</b>
<b>6.</b>	Visit to a Biotechnology/ Biochemistry institute.	<b>01</b>

### Suggested Readings:

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](http://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](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-
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 – VI	Paper – IX
Course Code: BSC-MR 609 P	Title of the Course: Practical Course III- Fermentation Technology and Applied Microbiology
Credits: 02	Total Lectures: 60 Hrs.

### Course Outcomes (COs):

- Students will be able to perform production of ethanol/citric acid as fermentation products.
- Students will learn different milk tests like phosphatase test, MBRT, Mastitis, SPC and DMC.
- Students will be able to carry out solid state fermentation and study the SOPs for the pharmaceutical industry.

### Detailed Syllabus:

Sr. No.	Title of the Experiment	No. of Practicals
1.	Lab Scale production of the fermentation products: <ol style="list-style-type: none"> <li>Ethanol (fermentation, recovery by simple distillation, estimation of end product by CAN method and fermentation efficiency)</li> </ol> <p style="text-align: center;"><b>OR</b></p> <ol style="list-style-type: none"> <li>Citric acid (fermentation, recovery by acid base precipitation and estimation of product by titrometry)</li> </ol>	02
2.	Solid state fermentation for production of any one fermentation product ( <i>Trichoderma sp.</i> / mushrooms / enzymes)	01



<b>3.</b>	Isolation and identification of Probiotic microflora from natural sources or any commercial formulation.	<b>02</b>
<b>4.</b>	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	<b>02</b>
<b>5.</b>	Detection of aflatoxin	<b>01</b>
<b>6</b>	Tests for Milk and Dairy products a. Phosphatase test b. MBRT test c. Test for mastitis d. Standard Plate Count (for milk / milk product e.g. milk powder) e. Direct Microscopic count	<b>05</b>
<b>7.</b>	Visit to any food industry or a fermentation industry	<b>01</b>

### Suggested Readings:

1. Banwart G. J. (1989). Basic Food Microbiology. 2nd edition. Food Science and Nutrition. 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. Detection of aflatoxin:  
[https://old.fssai.gov.in/Portals/0/Pdf/Draft\\_Manuals/MYCOTOXIN.pdf](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>
5. 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>

6. Meshram S. U. and Shinde G. B. (2009). Applied Biotechnology. I.K. International Publishing House Pvt. Ltd., New Delhi. Isolation of Probiotic bacteria:

<https://www.frontiersin.org/articles/10.3389/fmicb.2019.01382/full>

<https://www.hindawi.com/journals/ijmicro/2020/8865456/>.

Semester – VI	Paper – X
Course Code: BSC-MR 610 T	Title of the Course: Molecular and Biochemical Techniques
Credits: 02	Total Lectures: 30 Hrs

### Course Outcomes (COs):

- Students will be able to learn biochemical techniques like Chromatography, Spectroscopy and Electrophoresis.
- Students will understand molecular techniques such as DNA sequencing and PCR.
- Students will be able to learn techniques such as Gene Cloning, Genome mapping and Genome expression analysis.

### Detailed Syllabus:

Unit No.	Topic	No. of Hours
Unit 1	<p><b>1. Biochemical Techniques</b></p> <p><b>Chromatography-</b></p> <ol style="list-style-type: none"> <li>Ion exchange chromatography</li> <li>Affinity chromatography</li> <li>Gel filtration chromatography</li> </ol> <p><b>2. Electrophoretic techniques -</b></p> <p>Principle of electrophoresis, Continuous, zonal and capillary electrophoresis, different types of electrophoresis including paper, cellulose, acetate/nitrate and gel. Electroporation.</p> <p><b>3.Spectroscopy–</b></p> <p>Basic principle, Beer-Lambert's law, Visible and UV spectroscopy, Fluorescence spectroscopy</p>	15

<b>Unit 2</b>	<b>Molecular techniques</b> <b>1. DNA sequencing Technique</b> – Maxam Gilbert’s method, Sanger method and Next-generation sequencing (Pyrosequencing, Illumina (Solexa), SOLiD, and Ion Torrent)  <b>2. DNA amplification</b> by Polymerase chain reaction (PCR), RT-PCR and Real time PCR  <b>3. Gene Cloning:</b> Cloning vectors, molecular cloning and construction of DNA libraries. <b>4. Genome mapping:</b> RFLPs, RAPD, AFLP and FISH. <b>5. Genome expression analysis:</b> Microarray and EST	<b>15</b>
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### Suggested Readings:

1. Michael R. Green and Joseph Sambrook. Molecular Cloning: A Laboratory Manual (Fourth Edition) (2012). Cold Spring Harbor Laboratory Press.
2. Keith M. (editor); Walker John M. (editor), Wilson (author). Principles and Techniques of Practical Biochemistry (Fourth Edition). Publisher: Cambridge University Press (1994)
3. Paul R. Selvin and Taekjip Ha. Single- Molecule Techniques: A Laboratory Manual. (1st edition) (2007) Cold Spring Harbor Laboratory Press, U.S.
4. Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath. Biophysical chemistry. Himalaya publishing house
5. Devid T. Plumer. An introduction to Practical biochemistry third edition. Publisher : McGraw Hill Education (India) Private Limited.
6. Walker John M. Keith Wilson. Principles and Techniques of Biochemistry and Molecular biology (Seventh Edition) (editor);, Publisher: Cambridge University Press .
7. David J Holme, Hazel Peck. Analytical Biochemistry, 3rd Ed. (1998) Prentice Hall, Pearson Education Limited, Harlow England.
8. Rodney F. Boyer. Modern Experimental Biochemistry 3d edition., (2000)., Benjamin Cummings

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Semester – VI	Paper – XI
Course Code: BSC-MR 611 P	Title of the Course: Project
Credits: 02	Total Lectures: 60 Hrs.

### Course Outcomes (COs):

- Students will understand the concept of research.
- Students will learn to plan the research work.
- Students will be able to carry out research work in the laboratory and carry out the analysis and representation of data.

### Instructions for the Project

- A project can be carried out by a single student or by group of students where the group should not contain more than three students.
- The project report will be prepared as per the thesis format.
- Submission of the project report will be at least ten days before the date of examination.
- One copy of the report will be preserved in the department.
- If there are more than one student carrying out a single project, a single report can be submitted to the department and these students will be assessed based on single oral presentation.
- In such case, presentation should be carried out by all the students carrying out the same work; dividing the presentation equally among them.
- The allotted time for each oral presentation (one project) should be 10 to 12 minutes, followed by question and answer session of 5 to 8 minutes. The audience can participate in this session.
- Students should be made aware of the assessment parameters; on which they will be assessed.

9. The students may be assessed on the basis of Intellectual potential, research aptitude, motivation, ability to work with others, communication skills, proficiency of presentation skills, research potential of the work, dissertation report preparation, responses to the queries from the audience.