Department of Microbiology

Discipline Specific Core Course: Microbiology

Sem	Theory/ Practical	Course Title	Teaching/ Practical Instruction hour/week	Total Hours/ Sem	Duration of Exam in hours	Assessment Marks			Credits
						Summative	Formative	Total	
V	Theory	Food and Industrial Microbiology	4	60	3	80	20	100	4
	Practical	Food and Industrial Microbiology	4	60	3	40	10	50	2
	OR								
	Theory	Microbial Biotechnology and Bioinformatics	4	60	3	80	20	100	4
	Practical	Microbial Biotechnology and Bioinformatics	4	60	3	40	10	50	2
	Elective	General Microbiology	4	60	3	80	20	100	3

B.Sc. Semester–V
Discipline Specific Course (DSC)-Microbiology
Student shall select DSC 9A & 10 A or 9B & 10 B for 06 credits only

Course Title: Food and Industrial Microbiology
Course Code: C5MCB2T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative assessment Marks	Total Marks
DSC-9A	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs):

At the end of the course students will be able to:

CO1. To understand the association of microbes in food and industrial, quality testing of food and industrial products
CO2. To understand the preservation and food safety protocols
CO3. To understand the methods of spoilage of food and the diseases associated with it
CO4. To learn the properties of milk and the types of preservation of milk.
CO5. To learn the industrial microbes, fermentation, scale up processes and its significance in industry.

Unit	Title: Food and Industrial Microbiology	60 hrs/ sem
Unit I	**Microbes and Food** **Food as a substrate for microorganisms:** Intrinsic and extrinsic parameters affecting the growth of microbes. Microorganisms in food and their sources (molds, yeast and bacteria). **Food borne infections and Intoxication:** Causative agents, foods involved, symptoms and preventive measures for Salmonella, Shigella, *Yersinia enterocolitica Staphylococcus, Clostridium. Salmonella, Bacillus cereus, Brucella, Listeria monocytogens,* Mycotoxin, Phycotoxins. **Fermented Food:** Prebiotics, Probiotics and Synbiotics and Fermented vegetable-sauerkraut, pickles. Meat- sausage. Beverages kombucha. Sourdough. Microbes as food-SCP, SCO. Nutraceuticals and Functional Foods	15 hrs
Unit II	**Spoilage of Food, Preservation and Food safety** **Spoilage of Food:** Principles of food spoilage, Sources and Types of food spoilage. Spoilage of meat and poultry, Fish and seafoods. Spoilage cereals, fruits and vegetables, Spoilage of canned food. **Food Preservation**: Principles of food Preservation. Physical (temperature, drying, irradiation), chemical (Class I and Class II). Canning, Bio preservation. Food Packaging- Types of packaging materials, properties and benefits. **Quality control in Food**-Food Sampling, preparation and handling, Surface and environmental monitoring in food industry, basic physical and chemical analysis of food, Microbiological analysis of food and food products, Rapid and molecular methods to detect food pathogens. **Food Sanitation and Safety:** Good Hygiene practices, GLP, GMP (Waste treatment disposal methods), Food Safety HACCP, FSSAI and Food safety and Standard act	15 hrs

	2006.Food control agencies and their regulation.	
Unit III	**Introduction to Industrial Microbiology:** History, scope and development of industrial microbiology. Isolation and screening (Primary and Secondary) of industrially important microorganisms, Strain improvement methods. Preservation of industrially important microbes. Basic features; design and components of a bioreactor, Specialized bioreactors and their applications: tubular bio reactors, fluidized bed reactor, packed bed reactors, membrane bioreactors, Photo-bioreactors and anaerobic bioreactors. Role of industrial microorganisms for recovery of Minerals (Bioleaching) and Petroleum (Microbial Enhanced Oil Recovery-MEOR). Role of microbes in production of biofuel by bacteria and algae (Third generation biofuel).	15 hrs
Unit IV	**Fermentation Process and Scale up process:** Types of fermentation process: Submerged fermentation, Solid state fermentation (Koji), batch fermentation, continuous fermentation, Growth kinetics of fermentation process. Inoculum preparation. Media components and formulation (Crude media components, Anti-foam agents, Precursors, Inducers, Inhibitors and Buffering agents). Sterilization of media and raw materials and maintenance of Sterility at critical points during fermentation. **Scale up of Fermentation:** Upstream and Downstream processing, Objectives and significance of downstream processing: Overview of steps in extraction and purification of products (Antibiotic, Enzyme, Hormones, Anti-cancerous compounds); Precipitation Filtration and centrifugation; cell disruption- Physical, chemical and biological methods; Product extraction; product purification, recovery drying, crystallization and product testing. Merits and demerits. Immobilization of cells and enzymes –Types, advantages and applications in fermentation industry.	15hrs

Recommended books:

References:

1. Adams, M. R., & Moss, M. O. (2016). *Food Microbiology* (4th ed.). Royal Society of Chemistry.
2. Ananthanarayanan, R., & Paniker, C. K. J. (2021). *Textbook of Microbiology* (12th ed.). Orient Longman.
3. Banwart, G. J. (2012). *Basic Food Microbiology* (3rd ed.). CBS Publishers & Distributors.
4. Hobbs, B. C. (2015). *Food Microbiology* (6th ed.). Arnold-Heinemann.
5. Casida, L. E. (2018). *Industrial Microbiology* (3rd ed.). New Age International Publishers.
6. Frazier, W. C., & Westhoff, D. C. (2018). *Food Microbiology* (5th ed.). Tata McGraw Hill.
7. Hammer, B. W., & Babal, R. (2019). *Dairy Microbiology* (4th ed.). Prentice Hall.
8. Chandra, J. (2017). *Textbook of Medical Mycology* (4th ed.). Orient Longman.
9. Jawetz, E., Melnick, J. L., & Adelberg, E. A. (2020). *Medical Microbiology* (28th ed.). McGraw Hill.
10. Jay, J. M. (2019). *Modern Food Microbiology* (8th ed.). Springer.
11. Reed, G. (2017). *Industrial Microbiology* (4th ed.). MacMillan Publications.
12. Robinson, R. K. (2018). *Dairy Microbiology* (3rd ed.). Elsevier.

13. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). *Principles of Fermentation Technology* (3rd ed.). Elsevier.
14. Stanier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, P. R. (2019). *General Microbiology* (6th ed.). Prentice Hall of India.
15. Varnam, A. H., & Evans, M. G. (2017). *Foodborne Pathogens* (3rd ed.). Springer.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	10
InternalAssessmentTest2	10
Total	**20 Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester–V
Discipline Specific Elective (DSE)
Practical: Food and Industrial Microbiology

Course Title: Food and Industrial Microbiology
Course Code: C5MCB2P1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative assessment Marks	Total Marks
DSE-10A	**Practica l**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs):

At the end of the course students will be able to:

CO1. To understand the association of microbes in food and industrial, quality testing of food and industrial products
CO2. To understand the preservation techniques, SOP and food safety protocols HACCP.
CO3. To understand the methods of spoilage of food and the diseases associated with it
CO4. To learn MBRT, SPC, DMC, fat estimation, wine fermentation and production of enzymes techniques and will be helpful for the industrial exploration of knowledge.

Practical: Food and Industrial Microbiology (4hours/Week) (Minimum 12 experiments)

1. Isolation and enumeration of Aerobic Plate count and yeast and moulds from infected fruits and vegetables, ready to eat and cooked foods and fermented foods.
2. Enumeration of *E.coli, S.aureus*, *Salmonella, Shigella* and *Bacillus cereus* form ready to eat/cooked food using selective culture medias.
3. Reductase tests-MBRT, Resazurin and Litmus milk test.
4. Estimation of Fat - Gerber's method
5. Bacterial examination of milk by SPC, DMC.
6. Production of fermented foods.
7. Detection of Mastitic milk.
8. Preparation of wine from different fruits by fermentation techniques.
9. Estimation of Alcohol by Specific gravity method.
10. Production and estimation of citric acid by *Aspergillus brasilensis.*
11. Production of enzyme (amylase/protease) by submerged fermentation).
12. Production of enzyme cellulose /invertase
13. Immobilization of cells and enzymes by solid entrapment.
14. Preservation of microbes with glycerol/soil/oil/sand.
15. Visit to Food industries, Research institutes, Sugar Distillery, Alcoholic beverages industry and report should be written and submitted along with the practical record.

PATTERN OF PRACTICAL EXAMINATION

Practical examination – B. Sc. IV Semester MICROBIOLOGY

Duration: 3 hours **Max. Marks: 40**

Q. 1	Major question	12 Marks
Q. 2	Minor question	08 Marks
Q. 3	Identify and comment	06 marks
Q. 4	Journal	05 Marks
Q. 5	Tour report	05 Marks
Q. 6	Viva – Voce	04 Marks

B.Sc. Semester–V
Discipline Specific Elective (DSE)- Microbiology

Course Title:- Microbial Biotechnology and Bioinformatics
Course Code: C5MCB2T2

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative assessment Marks	Total Marks
DSE-9B	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs):

At the end of the course students will be able to:

CO1. To understand the association of microbes in Microbial biotechnology and commercial applications, microbial industrial products and their Recovery.
CO2. To understand the concept of biofuels production and applications.
CO3. To understand the different bioremediation techniques for removal of pollutants from environment.
CO4. To learn the Bioleaching process of mineral recovery and microbes importance in leaching.
CO5. To learn the fundamentals and basics of bioinformatics and their applications in handing biological data.
CO6: To understand the biological databases and their use in protein structure predictions.

Unit	Title: Microbial Biotechnology and Bioinformatics	60 hrs/ sem
Unit I	**Introduction to Microbial Biotechnology** Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental, and food technology. Use of prokaryotic and eukaryotic microorganisms in biotechnological applications. Genetically engineered microbes for industrial application: Bacteria and yeast. **Applications of Microbial Biotechnology** Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine). Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastics Microbial biosensors.	15 hrs
Unit II	**Microbial Products and their Recovery** Microbial product purification, filtration, ion exchange & affinity chromatography techniques. Immobilization methods and their application: Whole cell immobilization. **Microbes for Bio-energy and Environment** **Biofuels:** Introduction, types, production of third generation biofuel, Bio-ethanol and bio-diesel production. Commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture. Advances in microbial production of biofuels. **Microbial Bioremediation:** Introduction, types of bioremediation and mechanism. Factors affecting the bioremediation. Degradation of heavy metals and other	15 hrs

	pollutants. Bio-removal of heavy metals from industrial /aqueous effluents. **Bioleaching:** Introduction, Bioleaching of minerals from ores, types, mechanisms, and applications.	
Unit III	**Introduction to Computer Fundamentals** RDBMS - Definition of relational database. Mode of data transfer (FTP, SFTP SCP), advantage of encrypted data transfer. **Introduction to Bioinformatics and Biological Databases**: Biological databases nucleic acid, genome, protein sequence and structure, gene expression databases, Database of metabolic pathways, Mode of data storage - File formats - FASTA, Gene bank and Uniprot, Data submission & retrieval from NCBI, EMBL, DDBJ, PDB.	15 hrs
Unit IV	**Applications of bioinformatics** Sequence Alignments, Phylogeny and Phylogenetic trees: Pairwise (Local and Global) Sequence alignment and multiple sequence alignment. Types of phylogenetic trees, Different approaches of phylogenetic tree construction - UPGMA, Neighbour joining, Maximum Parsimony, Maximum likelihood. Genome organization and analysis. **Protein Structure Predictions** Hierarchy of protein structure - primary, secondary and tertiary structures, modelling Structural Classes, Motifs, Folds and Domains. Protein structure prediction in presence and absence of structure template.	15 hrs

Recommended books:

References:

1. Glazer, A. N., & Nikaido, H. (2018). *Microbial Biotechnology* (3rd ed.). Cambridge University Press.
2. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2022). *Molecular Biotechnology* (5th ed.). ASM Press.
3. Gupta, P. K. (2017). *Elements of Biotechnology* (3rd ed.). Rastogi Publications.
4. Lesk, M. A. (2019). *Introduction to Bioinformatics* (4th ed.). Oxford University Press.
5. Pradeep, & Sinha, P. (2018). *Foundations of Computing* (5th ed.). BPB Publications.
6. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2021). *Prescott, Harley, and Klein's Microbiology* (11th ed.). McGraw Hill.
7. Primrose, S. B., & Twyman, R. M. (2016). *Principles of Genome Analysis & Genomics* (4th ed.). Wiley-Blackwell.
8. Rastogi, S. C., Mendiratta, N., & Rastogi, P. (2019). *Bioinformatics: Methods and Applications, Genomics, Proteomics and Drug Discovery* (4th ed.). Prentice Hall India.
9. Ratledge, C., & Kristiansen, B. (2017). *Basic Biotechnology* (4th ed.). Cambridge University Press.
10. Saxena, S. (2019). *A First Course in Computers* (5th ed.). Vikas Publishing House.
11. Swartz, J. R. (2021). Advances in Escherichia coli production of therapeutic proteins. *Current Opinion in Biotechnology*, 12, 195–201.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	10
InternalAssessmentTest2	10
Total	**20 Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester– V
Discipline Specific Elective (DSE)
Practical: Microbial Biotechnology and Bioinformatics

Course Title: **Microbial Biotechnology and Bioinformatics**
Course Code: C5MCB2P2

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative assessment Marks	Total Marks
DSE-10B	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs):

At the end of the course, students will be able to:

CO1. Students will understand the techniques in Microbial biotechnology and commercial applications,
microbial industrial products and their Recovery.
CO2. Students learn the concept of Bioinformatics tools for exploring biological databases.
CO3. Students will understand the process of sequence alignment and phylogenetic tree construction.
CO4. Students will be expertise in techniques for primer designing and protein structure prediction tools.

PRACTICAL: Microbial Biotechnology and Bioinformatics (4 hrs/week) (Minimum 12 experiments)

1. Study yeast cell immobilization in calcium alginate gels.
2. Study enzyme immobilization by sodium alginate method.
3. Pigment production from fungi (*Trichoderma / Aspergillus / Penicillium*).
4. Isolation of xylanase or lipase producing bacteria.
5. Study of algal Single Cell Proteins.
6. Literature database- PUBMED
7. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB.
8. Sequence retrieval using BLAST.
9. Sequence alignment & phylogenetic analysis using ClustalW & phylip.
10. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction).
11. Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Gene tool.

12. Protein structure prediction: primary structure analysis, secondary structure prediction using spired, homology modeling using Swiss model.
13. Molecular visualization using JMOL.
14. Protein structure model evaluation (PROCHECK).
15. Prediction of different features of a functional gene.

B.Sc. Semester– V
Open Elective Course (OEC)
It is for other combination students

Course Title : General Microbiology
Course Code: C5MCB5T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No .of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative assessment Marks	Total Marks
OEC-1	**Theory**	**03**	**04**	**45hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs):

At the end of the course students will be able to:

CO1: Students will get the knowledge of Microbiology, historical Background of Microbiology, where they learn about Contribution and discoveries of different scientist.

CO 2: Students will understand the concept of stains, staining techniques and working principle
and applications of equipment's.

CO 3: Understand knowledge about the general characters and types of classification of Microorganisms, Viz-Bacteria, Fungi, algae, protozoa and virus Comprehend evolutionary importance and economic significance of microorganisms

CO 4: Students learn the microscopy, culture media, microbial nutrition and sterilization techniques which are helpful for industrial applications.

Unit	Title: General Microbiology	45 hrs/ Sem
Unit I	**History of microbiology**: Theory of abiogenisis abd biogenisis. Scope and branches of Microbiology. Contributions of Anton Von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Edward Jenner Branches of microbiology. Scope and applications of microbiology in different areas. **Systems of classification**: Whittaker's five kingdom classification and Carl Woese's three domain classification. Classical and molecular characteristic used in microbial taxonomy. **General characteristics of different groups** A cellular microorganisms -Viruses, Viroids, Prions. Cellular microorganisms- Prokaryotes- Bacteria, Cyanobacteria,	15 hrs

	Archaebacteria. Eukaryotes: Algae, Fungi and Protozoa; with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.	
Unit II	**Microbiological techniques -** **Microscopy** Principle and Applications of Microscopes – Compound, Dark field, Stereomicroscope, Fluorescent microscope, Electron microscopes. **Stains and Staining techniques** – Principles of Stains and dyes. Preparation of smears and fixation. Simple staining (Positive and Negative). Differential staining **Nutrition and Culturing of Microbes** -Nutritional requirements of microorganisms: Nutritional requirement-Water, Micronutrients, Macronutrients Fastidious and Non Fastidious orgnisms Culture media: components of media natural and synthetic media chemically defined media complex media, selective, differential, enriched Conditions required for growth of the microorganisms. Preservation of pure cultures	15 hrs
Unit III	**Sterilization techniques** - Control of Microorganisms, Definitions of- Sterilization, Disinfection, Antiseptic, Germicide, Microbiostasis, Antisepsis, Sanitization. Bactericidal vs. bacteriostatic. Physical agents for control of microorganisms-Temperature, Dry heat, Moist heat, Radiations - U.V and Gamma rays, microwave. Chemical Agents for control of microorganisms: Mode of action, application - Phenol and Phenols and Halogen compounds and Heavy metals (Cu and Hg). **Factors affecting sterilization:** Time, Temp, Moisture, pH, Organic matter.	15 hrs
Unit IV	**Basic Instruments and Analytical Separation based Instruments-** Working principles and applications of Instruments: Autoclave, Hot air oven, Laminar air flow, Incubator,Hot plate,vortex mixture,.Spectrophotometer / Colorimeter Principle: Beer-Lambert law, OD at 600nm for bacterial growthParts, blank setting, applications pH Meter Principle: Glass electrode, calibration with buffers, Centrifuge Principle: Sedimentation by centrifugal force, RPM vs RCF Types: Microfuge, High-speed, Ultracentrifuge,Colony Counter & Haemocytometer Principle : use for CFU count / cell count.	15 hrs

Recommended books:

1. Brock, T. D., & Madigan, M. T. (2021). *Biology of Microorganisms* (15th ed.). Pearson.
2. Gardner, E. J., Simmons, M. J., & Snustad, D. P. (2020). *Principles of Genetics* (9th ed.). Wiley-India.
3. Gottschalk, G. (2012). *Bacterial Metabolism* (3rd ed.). Springer Verlag.
4. Klug, W. S., Cummings, M. R., Spencer, C. A., & Palladino, M. A. (2019). *Concepts of Genetics* (12th ed.). Pearson.
5. Lansing, M., Prescott, J., Ohn, P., Harley, J. P., & Klein, D. A. (2019). *Microbiology* (10th ed.). McGraw Hill.
6. Madigan, M. T., & Martinko, J. M. (2021). *Brock Biology of Microorganisms* (16th ed.). Pearson.
7. Moat, A. G., & Foster, J. W. (2019). *Microbial Physiology* (5th ed.). John Wiley & Sons.
8. Nelson, D. L., & Cox, M. M. (2021). *Lehninger Principles of Biochemistry* (8th ed.). W.H. Freeman.
9. Pierce, B. A. (2020). *Genetics: A Conceptual Approach* (7th ed.). Macmillan Higher Education.
10. Primrose, S. B., & Twyman, R. M. (2016). *Genomics: Applications in Human Biology* (4th ed.). Wiley-Blackwell.
11. Stanier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, P. R. (2019). *General Microbiology* (6th ed.). Pearson.
12. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2021). Prescott's Microbiology (11th ed.). McGraw Hill.
13. Caetano-Anollés, G. (2021). Evolutionary Genomics and Systems Biology (2nd ed.). John Wiley & Sons.
14. Bouarab, K., Brisson, N., & Daayf, F. (2010). Molecular Plant-Microbe Interaction. CABI.
15. Daniel, W. W., & Cross, C. L. (2018). Biostatistics: A Foundation for Analysis in Health Sciences (11th ed.). John Wiley & Sons.
16. Edmondson, A., & Druce, D. (2021). Advanced Biology Statistics (2nd ed.). Oxford University Press.
17. Fraser, C. M., Read, T. D., & Nelson, K. E. (2019). *Microbial Genomes* (2nd ed.). Humana Press.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
Internal Assessment Test 1	10
Internal Assessment Test 2	10

Total	20 Marks
Formative Assessment as per guidelines.	