Government of Karnataka

Curriculum Framework for Undergraduate Programme in Colleges and Universities of Karnataka State

5th and 6th Semester Model Syllabus
for
B.Sc. in
MICROBIOLOGY

Submitted to

VICE CHAIRMAN
KARNATAKA STATE HIGHER EDUCATION COUNCIL
30, PRASANNA KUMAR BLOCK, BENGALURU CITY UNIVERSITY CAMPUS
BENGALURU, KARNATAKA – 560 009

Government of Karnataka

Model Curriculum

Program Name	**BSc in MICROBIOLOGY**	Semester	**V**
Course Title	**MOLECULAR BIOLOGY (Theory)**		
Course Code:	**MIC C9-T**	No. of Credits	**04**
Contact hours	**60 Hours(4 Hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s) :

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

CO1. Understand concepts involved in replication, transcription, translation, regulation of gene expression in bacteria and Eukaryotes.

CO2. Differentiate the process of replication, transcription, translation, regulation of gene expression in bacteria and Eukaryotes.

CO3. Understand the genetic switch in bacteriophages.

CO4. Compare and contrast housekeeping, constitutive, inducible and repressible genes

CO5. Outline regulatory mechanisms in bacteria to control cellular processes

Contents	
UNIT 1: DNA Replication and Prokaryotic transcription. **DNA Replication :** Bacterial Cell cycle. Replicon. *OriC*. Bidirectional replication. Steps in Initiation of replication. DNA polymerases, Replication fork, replisome. Mechanism of DNA polymerase III in detail. Ligase. Eukaryotic DNA polymerases. Termination of replication. Extrachromosomal replicons. Replication of DNA strand with 5' end,linear end, replication of adenovirus and ϕ29 DNAs, rolling circle in replication of phage genomes, F plasmid,. Replication of ColE1 DNA. Replication of mtDNA, D loop. Replication of telomeres **Prokaryotic transcription:** Transcription bubble, Stages of transcription, Bacterial RNA polymerase - structure and mechanism, recognition of promoters and DNA melting, abortive initiation. Elongation, Termination, antitermination. Phage T7 RNA polymerase, alternative sigma factors - transcription of heat shock genes, phage SPO1 genes, sporulation in *Bacillus*. Stringent response in *E.coli*.	**15 Hrs**

UNIT 2 Transcription **Eukaryotic Transcription**: Eukaryotic RNA polymerases - RNA polymerase I, II, III. Mechanism of RNA polymerase in detail. Promoters, Transcription factors, basal apparatus, promoter clearance, elongation. Enhancers, silencers, termination. **RNA splicing and Processing**: mRNA capping, pre-mRNA splicing, lariat, snRNPs, spliceosome, autocatalytic splicing, alternative splicing, polyadenylation, tRNA splicing and maturation, production of rRNA, Catalytic RNAs - auto splicing, ribozymes, rinonuclease P,viroids and virusoids, RNA editing	**15 Hrs**
UNIT 3 Translation Genetic code, tRNA structure, charging of tRNA, differences between initiator tRNA and elongator tRNA, ribosome structure. Accuracy of translation. Stages of translation. Role of IFs in initiation of bacterial translation, Formation of initiation complex. Initiation of eukaryotic translation - Scanning model of mRNA, IRES, Role of eIFs. Elongation of polypeptide - EF-Tu, EF-G, peptide bond formation, peptidyl transferase activity, translocation, eEFs. Termination. Regulation of translation. Post translational modifications of proteins. Protein maturation and secretion - protein splicing,molecular chaperones. Protein translocation and secretion in bacteria	**15 Hrs**
UNIT 4 Regulation of gene Expression **Control of gene expression in prokaryotes** Regulatory mechanisms in bacteria. Positive and negative transcriptional control in bacteria. Operon concept, polycistronic mRNA. *lac* operon - negative inducible, allolactose,mutants of *lac* operon structure of *lac* repressor, mechanism of binding of repressor to operator. Catabolite repression of *lac* operon.Regulation by lac repressor and CAP. *trp* operon regulation - repressor control & attenuator control. Arabinose operon - positive and negative transcriptional control by AraC. Riboswitch control of *rib* operon of *Bacillus subtilis*. Control of translation by riboswitches and small RNAs. Global regulatory mechanisms - *mal* regulon, two-component signal transduction systems.Regulation of lytic & lysogenic life cycle in bacteriophage λ. Control of lytic cycle by regulatory proteins - *cro* gene, *N* gene, lambda repressor - structure, DNA binding mechanism. Events in switch from lytic to lysogenic cycle. Maintenance of lysogeny. **Control of gene expression in eukaryotes** Regulation through modification of gene structure- DNase I hypersensitivity, histone modifications, chromatin remodeling, DNA methylation. Regulation through transcriptional activators, Co-activators and repressors, enhancers and insulators. Regulation through RNA processing and degradation. Regulation through RNA interference	**15 Hrs**

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12
Understand concepts involved in replication, transcription, translation, regulation of gene expression in bacteria and eukaryotes		√	√		√							√
Differentiate the process of replication, transcription, translation, regulation of gene expression in bacteria and eukaryotes		√	√		√							√
Understand the genetic switch in bacteriophages		√	√		√							√
Compare and contrast housekeeping, constitutive, inducible and repressible genes		√	√		√							√
Outline regulatorymechanisms in bacteria to control cellular processes		√	√		√							√

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Government of Karnataka
Model Curriculum

Course Title	**MOLECULAR BIOLOGY (Practical)**	Practical Credits	**02**
Course Code	**MIC C10-P**	Contact Hours	**4 Hours/ week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Micropipeting: Moving Very Small Volumes Very Accurately
2. Study of semi-conservative replication of DNA through micrographs / schematic representations
3. Extraction of crude DNA from bacteria and yeast by phenol/chloroform method.
4. Determination of purity and quantity of DNA
5. Determination of DNA melting point and GC content
6. Extraction and visualization of plasmids from bacterial cultures
7. Extraction and visualization of genomic DNA from bacterial cultures
8. Measurement of β-galactosidase activity in stimulated and control cells of *E.coli*
9. β-galactosidase Activity Assay in Yeast
10. DNA extraction from agarose gel
11. RNA extraction and visualization from yeast.
12. Analysis of RNA quality and integrity
13. Determining nucleotide composition of RNA
14. Restriction enzyme digestion of DNA molecule - DNA fingerprinting
15. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE)

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

References	
1	*Karp's Cell and Molecular Biology* by Gerald Karp, Janet Iwasa, Wallace Marshall. Ninth Edition. 2020
2	Lewin's Genes XII. Jocelyn E Krebs, Elliott S Goldstein, Stephen T Kilpatrick. Jones and Bartlett Learning.2017
3	James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick. Molecular Biology of the Gene, 7th edition. 2017
4	Freifelder's Essentials of MOLECULAR BIOLOGY. George M Malacinski, 4th ed. 2015
5	Freifelder D (2012). Molecular Biology, 5th edition. Narosa Publishing House, India
6	Berg JM, Tymoczko JL, Gatto GJ and Stryer L (2015) Biochemistry, 8th Edition, WH Freeman & Co., New York
7	Alberts Bruce , Johnson A , Lewis J , Raff M , Roberts K, Walter P (2014) Molecular Biology of the Cell. 5th Edition, Taylor and Francis. New York, USA.
8	Tropp BE (2012) Molecular Biology: Genes to Proteins. 4rd Edition, Jones & Bartlett, Learning, Burlington, MA
9	Allison A. Elizabeth (2012) Fundamental Molecular Biology, 2nd Edition. J Willey and Sons, Hoboken,New Jersey
10	Aranda PS, LaJoie DM, Jorcyk C L (2012). Bleach Gel: A Simple Agarose Gel for Analyzing RNA Quality. Electrophoresis. 33(2): 366–369. Doi: 10.1002/elps .201100335.
11	Bloch KD; Grossmann B (1995). Digestion of DNA with Restriction Endonucleases. https://doi.org/10.1002/0471142727.mb0301s31
12	Chomczynski P, Sacchi N (2006). "The single-step method of RNA isolation by acid guanidinium thiocyanate-phenol-chloroform extraction: twenty-something years on". Nat Protoc. 1 (2): 581–5. doi:10.1038/nprot.2006.83.
13	Elkins K M (2013). DNA Extraction Forensic DNA Biology.
14	Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, J.G. Seidman, John A. Smith, Kevin Struhl (2003). Current Protocols in Molecular Biology. John Wiley & Sons, New York, United States.
15	Johnson M (2019). RNA extraction, Synatom Research, Princeton, New Jersey, United States. DOI//dx.doi.org/10.13070/mm.en.2.201.
16	Lewis M. Agarose gel electrophoresis (basic method). Department of Pathology, University of Liverpool. http://diyhpl.us/~bryan/irc/protocol-online/protocolcache/agarogel.html
17	Randall DR. (2009). Molecular Biology Laboratory manual.
18	Sambrook JF, Russell DW (2001). Molecular Cloning: a Laboratory Manual. 3rd edition. Cold Spring Harbor, N.Y. Cold Spring Harbor Laboratory Press
19	Struhl K, Seidman J G, Moore D D, Kingston RE, Brent R, Ausubel FM, Smith JA. (2002). hort Protocols in Molecular Biology: A Compendium of Methods from Current Protocols in Molecular Biology. John Wiley & Sons Inc., New York, United States
20	Surzycki S (2000). Basic techniques in molecular biology. Springer.
21	Yılmaz M, Ozic C, Gok İ (2012). Principles of Nucleic Acid Separation by Agarose Gel Electrophoresis. Gel Electrophoresis - Principles and Basics, Dr. Magdeldin S (Ed.), ISBN: 978-953-51-0458-2, InTech. http://www.intechopen. com/books/gel-electr ophoresis-principles-Andbasics

Government of Karnataka

Model Curriculum

Program Name	**B.Sc. in MICROBIOLOGY**	Semester	**V**
Course Title	**MICROBIAL GENETICS (Theory)**		
Course Code:	**MIC C11-T**	No. of Credits	**03**
Contact hours	**45 Hours(3 Hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s) :

Course Outcomes (COs) : After the successful completion of the course, the student will be able to:

CO1 Understand the fundamental molecular principles of genetics
CO2 Understand relationship between phenotype and genotype in genetic traits;
CO3 Knowledge on the basis of genetic mapping in bacteria, linkage analysis in fungi.

Contents	
Mendel's principles of inheritance: Special features of pea plants as an ideal system to study genetics and Mendel's cross breeding experimental approach to prove genetic principles. Principles of dominance and Segregation; phenotype, genotype, traits controlled by genes, existence of alleles (dominant and recessive), segregation of alleles during the formation of gametes, aggregation of alleles during fertilization, monohybrid (single character) cross, F1 and F2 generation, heterozygous, homozygous, test cross to test genotype of F1 plants. Principle of independent assortment; Dihybrid (two characters) cross, pattern of assortment of alleles. Chromosomal basis of inheritance; chromosome number, haploid (n), diploid (2n). Chromosomal theory of Heredity; Experimental evidence linking the inheritance of genes to chromosomes, Chromosomes as arrays of genes, Chromosomal basis of Mendel's principles of segregation and independent assortment.	**15 Hrs**
Historical developments of DNA as a genetic material; Griffith experiment of Transformation,Proof that genetic information stored in DNA, Enzymatic approach to prove DNA mediates transformation by A very, MacLeod and McCarty, Hershey and Chase experiment to prove DNA carries the genetic information in T2 bacteriophage. RNA stores the genetic information in some viruses, viroids and prions. Structure of Watson Crick model of DNA, Plasmid DNA. Mechanism of DNA replication, enzymes involved in replication. Organization of genes in viruses, prokaryotes and eukaryotes, mitochondria and chloroplast.	**15 Hrs**
Genetics of Viruses Structure and life cycle of Bacteriophage T4 and Lambda, lytic and lysogenic cycle of bacteriophage. Genetics of Bacteria; Structure and life cycle of bacteria *E. coli* Mutant genes in bacteria, mutants blocked in their ability to utilize specific energy sources, mutants unable to synthesize an essential metabolite, mutants resistant to antibiotics. Mechanism of genetic exchange in bacteria, Bacterial Transformation: Types of transformation mechanisms found in prokaryotes, Natural and artificial methods of transformation. Bacterial Conjugation: U-tube experiment to prove physical contact between bacteria is essential for gene transfer, properties of the F plasmid, F^+ x F^- conjugation, sexduction F′x F^- conjugation, Hfr x F^- conjugation, Gene mapping in bacteria by conjugation. Transduction: Generalized and specialized transduction, plasmids and episomes. Genetics of Fungi: life cycle of Yeast and Neurospora, Terad analysis, unordered tetrad analysis in yeast, ordered tetrad analysis in Neurospora, two point and three point test cross, detecting linkage and mapping genes in yeast and neurospora.	**15 Hrs**

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12
Understand the fundamental molecular principles of genetics		√		√			√					
Understand relationship between phenotype and genotype in genetic traits;		√					√				√	
Knowledge on the basis of genetic mapping in bacteria, linkage analysis in fungi.		√					√					√

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Government of Karnataka

Model Curriculum

Course Title	**MOLECULAR GENETICS (Practical)**	Practical Credits	**02**
Course Code	**MIC C12-P**	Contact Hours	**4 Hours/ week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

	Practicals - List of experiments
1	Isolation of bacteria/fungal DNA
2	Isolation of Coliphages from sewage
3	Bacterial survival against UV-radiation
4	Isolation of antibiotic resistant mutant by gradient plate method
5	Isolation and characterization of petite mutant in yeast
6	Induction of mutation in yeast and bacteria by chemicals / radiation
7	Replica plating technique
8	Bacterial plasmid isolation
9	Restriction digestion of DNA
10	Ligation
11	Bacterial transformation
12	Bacterial conjugation

MICROBIAL GENETICS

Course Objectives:

The objectives of this course are to introduce students to:

- Basics of genetics and classical genetics covering prokaryotic and eukaryotic domains.
- Classical concepts of Mendelian genetics, recombination in bacteria and fungi.

Student Learning Outcomes:

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

- Describe fundamental molecular principles of genetics;
- Understand relationship between phenotype and genotype in human genetic traits;
- Evaluate the basics of genetic mapping in bacteria, linkage analysis in fungi.

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

REFERENCES :

1. Microbial Genetics by Maloy ET. Al. 1994. Jones and Bartlett Publishers.
2. Molecular Genetics of Bacteria by J. W. Dale. 1994. John Wiley and Sons.
3. Modern Microbial Genetics. 1991 by Streips and Yasbin. Niley Ltd.
4. Moleculat Biology of the Gene 4th Edition by J.D. Watson, N.H. Hoppkins, J.W. Roberts, J.A. Steitz and A.M. Weiner. 1987, The Benjamin / Cummings Publications Co. Inc. California.
5. Gene VII by Lewin Oxford University Press. 2000.
6. Bacterial and Bacteriophage Genetics. 4th Editions by Birge.
7. Microbial Genetics by Frefielder. 4th Edition.
8. Organization of Prokayotic Genome. 1999 by Robert L.Charlebois, ASM Publications.
10. Molecular Genetics of Bacteria, 1997 by Larry, Snyder and Wendy, Champness, ASM

Government of Karnataka

Model Curriculum

Program Name	**BSc in Microbiology**	Semester	**V**
Course Title	**FOOD MICROBIOLOGY (Theory)**		
Course Code:	**MIC C13-T**	No. of Credits	**03**
Contact hours	**45 Hours(3 Hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

CO1. To understand the association of microbes in food and the quality testing of food
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 types of fermented food and dairy products and its significance

CONTENTS	**45 Hrs**
Unit 1-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 *Staphylococcus, Clostridium. Salmonella, Bacillus, Brucella, Listeria.* Mycotoxin, Phycotoxins **Fermented Food :** Fermented vegetable-sauerkraut, pickles. Meat- sausage. Beverages- kombucha. Sourdough. Microbes as food- SCP, SCO. Neutrceuticals and Synbiotics	15 hrs
Unit 2-Spoilage of Food, Preservation and Food safety- **Spoilage :** Principles of food spoilage.Sources of food contamination, Types of spoilage. Spoilage of meat and poultry, Fish and sea foods. Spoilage cereals, fruits and vegetables. Spoilage of canned food. **Priservation** : Principles of food Preservation. Methods of preservation-Physical(temperature, drying, irradiation),chemical (Class I and Class II). Bio preservation.Canning.Food Packaging- Types of packaging materials, properties and benefits. **Quality testing of food**- Rapid microbiological methods, Examination of faecal streptococci **Food sanitation and control**- Good Hygiene practices, GLP, GMP(Waste treatment disposal methods), HACCP, Food control agencies and their regulation	15hrs

Unit 3-Dairy Microbiology : History. Properties of milk. Types of milk- dried,liquid, condensed. **Microorganisms in milk.** Starter culture and its types-(single, mixed) Sources of contamination of milk. Microbiological analysis of milk- Rapid platform tests(organoleptic, alcohol, COB, alcohol test, Phosphatase test, DMC, sedimentation test.). Reductase tests. SPC. Preservation of milk- Pasteurization. Dehydration, sterilization. . Packing of milk and dairy products. **Fermentation in milk**: Lactic acid, gassy fermentation, souring **Dairy products:** Cheese- Types and production (Cheddar), Tofu, Yoghurt, Acidophilus milk. Prebiotics, Probiotics.	15 hrs

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
To understand the association of microbes in food and the quality testing of food		√						√			√	√			
To understand the preservation and food safety protocols		√					√			√					
To understand the methods of spoilage of food and the diseases associated with it		√		√											
To learn the properties of milk and the types of preservation of milk.	√	√													
To learn the types of fermented food and dairy products and its significance				√	√			√							

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Government of Karnataka

Model Curriculum

Course Title	**FOOD MICROBIOLOGY (Practical)**		Practical Credits	**02**
Course Code	**MIC C14-P**		Contact Hours	**4HRS/WEEK**
Formative Assessment	**25 Marks**	Summative Assessment		**25 Marks**

Practical Content

1.Isolation of bacteria and fungi from infected fruits and vegetables
2. Isolation of bacteria and fungi from fermented food and stored/ preserved food.
3.Reductase tests-MBRT/Resazurin
4.Estimation of Titrable acidity in milk.
5.Fat estimation – Gerber's method
6.Bacterial examination by SPC, DMC
7.Estimation of lactose in milk
8. Production of yoghurt
9.Study of food borne pathogens- *Staphylococcus, Salmonella, Aspergillus, Clostridium*
10.Significant microbes in Food and Dairy *Lactobacillus, Streptococcus, Penicillium, Rhizopus*

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

References	
1	Adams, M.R and Moss, MO. 1995. Food Microbiology. The Royal Society of Chemistry, Cambridge.
2	James. M. Jay, 1992, Modern food microbiology 4ed.
3	Frazier W.C. and Westhoff C.D. 2008 Food Microbiology. Tata McGraw Hill Publishing Company Limited, New Delhi, India.
4	Doyle M. P. and Beuchat L. R. (2007). Food Microbiology- Fundamentals. Frontiers, ASM Press.
5	Garbutt J. (1997). Essentials of Food Microbiology, Armold- International Students edition, London. 8. Marriott N. G. and Gravani R. B. (2006).
6	Principles of Food Sanitation, Food Science text Series, Springer International, New York, USA.
7	ThomasJ., Matthews,Karl; Kniel, Kalmia E (2017), Food Microbiology: An Introduction, American Society for (ASM).
8	Deak T. and Beuchat L. R. (1996). Hand Book of Food Spoilage Yeasts, CRC Press, New York.

Government of Karnataka

Model Curriculum

DISCIPLINE SPECIFIC ELECTIVES (Any one paper to be chosen)

Program Name	**BSc in Microbiology**	Semester	**V**
Course Title	**A.MICROBIAL BIOENERGY AND BIOFUEL (DSE) – Theory**		
Course Code:	**MIC E1-T**	No. of Credits	**3**
Contact hours	**45 Hours(3 Hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

CO1. Learn the overview of current world energy scenario

CO2.Understand the classification of biofuels

CO3.Acquire the knowledge of microbial biofuel production technologies

CO4. Understand the recent developments in microbial biofuels.

CO5. Understand the role of biological engineers in facing societal challenges

Contents	**Hrs**
Unit-I: Introduction: Scope and importance of biofuel; Classification of biofuels- first, second, third and fourth generation; Microorganisms as a source of biofuel; from bacteria, algae and fungi.	15 Hrs
Unit-II: Production and characterization of Biofuel: Effect of pH, temperature, carbon, nitrogen, metal ions and inducers on biofuel production. Production of Biofuel- Bioethanol Biobutanol, Biodiesel, Biomethane, Biohydrogen and Biogas; Characterization of biofuel; Application of Biofuel; Advantages and challenges of Biofuel.	15 Hrs
Unit-III: Downstream processing and purification: Flocculation, Soxhlet extraction, Cell disruption, Drying, Floatation , Filtration, Sedimentation, Centrifugation, Pervaporation, Gas stripping; Purification methods by distillation, solvent extraction, supercritical fluid extraction, Lifecycle Assessment/Analysis; Biofuel policy in India	15 Hrs

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Learn the overview of current world energy scenario	√		√			√									
Understand the classification of biofuels			√												
Acquire the knowledge of microbial biofuel production technologies			√		√										
Understand the recent developments in microbial biofuels			√		√			√							
Understand the role of biological engineers in facing societal challenges			√								√				

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10 Marks
Class Test	10 Marks
Debate/Quiz/Assignment	10 Marks
Seminar	10 Marks
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References	
1	Ajar Nath Yadav, Ali Asghar Rastegari, Neelam Yadav. Rajeeva Gaur. Biofuels Production – Sustainability and Advances in Microbial Bioresources.Edt (1), Springer Nature Switzerland AG 2020. DOI:https://doi.org/10.1007/978-3-030-53933-7
2	Deepak G. Panpatte , Yogeshvari K. Jhala, Rajababu V Vyas, Harsha N Shelat. Microorganisms for Green Revolution: Volume 1: Microbes for Sustainable Crop Production (Microorganisms for Sustainability. Springer; 1st ed. 2017
3	Sunggyu Lee and Y. T. Shah. "Biofuels and Bioenergy: Processes and Technologies", CRC Press, Taylor & Francis Group, 2013
4	Michael A. Borowitzka, Navid R. Moheimani. Algae for Biofuels and Energy. Springer Dordrecht, 1st ed. 2012. https://doi.org/10.1007/978-94-007-5479-9
5	Xuefeng Lu. Biofuels: From Microbes to Molecules. Caister Academic Press, 2014. DOI: https://doi.org/10.21775/9781912530021
6	Roberto N Silva. Fungal Biotechnology for Biofuel Production (Mycology: Current and Future Developments.1st edition, Bentham Science Publishers, 2017

Government of Karnataka

Model Curriculum

Program Name	**BSc in Microbiology**	Semester	**V**
Course Title	**B. HUMAN MICROBIOTA**		
Course Code:	**MIC E1-T**	No. of Credits	**3**
Contact hours	**45 Hours(3 Hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level

Course Outcomes (COs): After the successful completion of the course, the student will be able to :

CO1 Learn the general structure, organization and functions of human body.

CO2 Understand the quantitative and qualitative distribution of microorganisms in human body.

CO3 Acquire concept of relation between human body, especially gut and associated microorganisms

CO4 Gain an insight of gut associated microorganism and human health

CO5 Strategy role of microbiologists in challenging the human resistance against emerging outbreaks of viral/bacterial infections.

UNIT-I	**Human Body**: *Homo sapiens* and races; Brief study of anatomy, physiology, Psychology and homeostasis of human body. An Overview (Structure and functions) of digestive system, circulatory system, immune system, and integumentary systems. **Microbiome**: Origin and distribution of microbes in the universe. Types of micro-organism. Grouping of beneficial and harmful micro-organism and their perspectives. Concept, origin, development, structure and functions of microbiome. Formation and persistence of microbiomes in human beings and their role in health and behavioural status.
UNIT-II	**Human microbiome**: Definition, origin, formation, development, structure and functions of human microbiome and its evolution. Factors affecting microbial diversity and functions of microbiome: -age, genetics, environment, diet, anatomy, physiology, immunity, and psychology of host(human). Dynamics microbiome changes from birth to death; pregnancy and the microbiome; personnel microbiome concepts. Geography, Ethnicity -Specific Variations in Human microbiome. “diseases of civilization” -allergies, diabetes, asthma, obesity, inflammatory bowel disease. Debate on “nature” vs. “nurture”. Biodiversity and major genera of human-microbiome, human microbiome system as a "holobiont" or "superorganism”, microbiome distributions in healthy Individuals- hands, neck, scalp, axilla, groin, toes, ear; anterior nares, oral cavity, throat, stomach, small intestine and large intestine and birth canal. **Human Diet and Microbiota**: Microbiome vs microbiota; microbiota development and functions in early life; Microbiota transmission-pregnancy, birth and postnatal. Microbiota perturbations: medical practices, hygiene and antibacterials. Nutritional modulation of the gut microbiome for metabolic health- animal models, human obesity, human type 2 diabetes, life longevity.

UNIT-III	**Microbiome and therapeutics :** Drug delivery using microbes engineered to secrete peptides, Microbes as neuromodulators, Microbes as cancer therapeutics, impacts of antibiotics on the development of resistance. Generic microbiome manipulations, designed on the basis of studies on WEIRD societies, may have unintended, and even adverse consequences in non-western populations. **Future prospective of human microbiome**: Omics technology to know insides of taxonomic and functional diversity in human microbiome. Modulation of microbiota through pre- and probiotics for good health and creating new therapeutics for verities of disease. Development of personalized medicine (precision medicine) to avid development of MDRs and effects of dysbiosis.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Learn the general structure, organization and functions of human body.		√				√						
Understand the quantitative and qualitative distribution of microorganisms in human body.								√	√			
Acquire concept of relation between human body, especially gut and associated microorganisms								√	√			
Gain an insight of gut associated microorganism and human health								√	√			
Strategy role of microbiologists in challenging the human resistance against emerging outbreaks of viral/bacterial infections								√	√		√	

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References	
1	Fundamentals of Microbiome Science – how microbes shape animal biology, Princeton University Press, New Jersey, United States. Rob DeSalle and Susan L. Perkins (2015).
2	Welcome to the microbiome. getting to know the trillions of bacteria and other microbes in, on, and around you. Yale University Press. Suggested Readings Rodney Dietert (2016).
3	The Human Superorganism: how the microbiome is revolutionizing the pursuit of a healthy life. Dutton Books. Justin Sonnenburg and Erica Sonnenburg (2014).
4	The good gut: taking control of your weight, your mood, and your long-term health. Penguin Press. Emeran Mayer (2016).
5	The Mind-Gut Connection: How the Astonishing Dialogue Taking Place in Our Bodies Impacts Health, Weight, and Mood. eBook, Harper Wave Books. Martin J. Blaser (2014).
6	Cox, L.M., et al., Altering the intestinal microbiota during a critical developmental window has lasting metabolic consequences. Cell, 2014. 158(4): p. 705-21.
7	Douglas, A., Fundamentals of Microbiome Science: How Microbes Shape Animal Biology. 2018, 41 William Street, Princeton, New Jersey 08540: Princeton University Press.
8	1.HMP, C., Structure, function and diversity of the healthy human microbiome. Nature, 2012. 486(7402):p. 207-14.
9	Diaz Heijtz, R., et al., Normal gut microbiota modulates brain development and behavior. Proc Natl Acad Sci U S A, 2011. 108(7): p. 3047-52.
10	Sonnenburg, E.D., et al., Diet-induced extinctions in the gut microbiota compound over generations. Nature, 2016. 529(7585): p. 212-5.
11	Zou, J., et al., Fiber-Mediated Nourishment of Gut Microbiota Protects against Diet-Induced Obesity by Restoring IL-22-Mediated Colonic Health. Cell Host Microbe, 2018. 23(1): p. 41-53 e4.
12	Dominguez-Bello, M.G., et al., Partial restoration of the microbiota of cesarean-born infants via vaginal microbial transfer. Nat Med, 2016. 22(3): p. 250-3.
13	Moeller, A.H., et al., Rapid changes in the gut microbiome during human evolution. Proc Natl Acad Sci U S A, 2014. 111(46): p. 16431-5
14	Ananthanarayan and Paniker's Textbook of Microbiology, 10th edition, by Dr Reba Kanungo.
15	Prescott's Microbiology, 11th EditionBy Joanne Willey and Kathleen Sandman and Dorothy Wood

Government of Karnataka

Model Curriculum

Vocational Paper (Any one Paper to be chosen)

Program Name	**BSc in MICROBIOLOGY**	Semester	**V**
Course Title	**A. MICROBIAL AND BIOCHEMICAL TECHNIQUES (Theory)**		
Course Code:	**MIC V1-T**	No. of Credits	**03**
Contact hours		Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s) :

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

CO1: Demonstrate skills in microbiological and analytical techniques.
CO2: Demonstrate professional skills at work, such as decision making, planning, and organizing, Problem solving, analytical thinking, critical thinking, and documentation.
CO3: Understand principles which underlie sterilization of culture media, glassware and plastic ware to be used for microbiological work.
CO4: Understand principles of a number of analytical instruments which the students have to use during the study and also later as microbiologists for performing various laboratory manipulations.
CO5: Handle several separation techniques which may be required to be handled later as microbiologists.
CO6: Able to identify a bacterium up to a genus level.

Contents	
Microbiological Skills **Types of culture media with examples.** Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media. Cultivation of anaerobic bacteria and accessing non-culturable bacteria. Cultivation of fungi, actinomycetes, yeasts, algae. Cultivation of anaerobes. Isolation of microorganisms and pure culture techniques. Preservation of microorganisms. Characterization of bacteria: Colony characters, biochemical tests.	**15 Hrs**
Biochemical Techniques **Microscopy:** Different types of Microscopes: Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluoresence microscopy, Confocal microscopy, Scanning and Transmission Electron Microscopy, Scanning Probe microscopy. **Centrifugation**: Principles of Centrifugation and Ultracentrifugation techniques and its applications.	**15 Hrs**

Chromatography: Principle and techniques with applications (Partition, adsorption, ion exchange, exclusion and affinity chromatography). Electrophoretic technique (agarose and polyacrylamide gel) its components, working and applications. **Spectrophotoscopy and Radiobiology**: Principle, mechanism and application of instruments used in Spectrophotometric techniques (UV and visible).Radiobiological techniques – characters of radioisotopes, autoradiography, Radioisotope dilution technique and pulse chase experiments. Basic principles & Law of absorption and radiation and its application.	**15 Hrs**

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12
Demonstrate skills in microbiological and analytical techniques		√	√		√							√
Demonstrate professional skills at work, such as decision making, planning, and organizing, Problem solving, analytical thinking, critical thinking, and documentation		√	√		√							√
Understand principles which underlie sterilization of culture media, glassware and plastic ware to be used for microbiological work		√	√		√							√
Understand principles of a number of analytical instruments which the students have to use during the study and also later as microbiologists for performing various laboratory manipulations		√	√		√							√
Handle several separation techniques which may be required to be handled later as microbiologists		√	√		√							√
Able to identify a bacterium upto a genus level		√	√		√							√

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Course Title	**A. MICROBIAL AND BIOCHEMICAL TECHNIQUES (Practical)**	Practical Credits	
Course Code	**MIC V1**	Contact Hours	**4 Hours/ week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Usage and maintenance of basic equipment of microbiology lab: Principles, calibrations, and SOPs of balances (Types), pH meter (Types), Autoclaves (Types), Laminar flows and biosafety cabinets, basic Microscopes, homogenizers, stirrers.
2. **Culture Media**: Preparation of different media: synthetic media BG-11, Nutrient agar, McConkey agar, EMB agar, blood agar, chocolate agar. Fungal growth media (PDA, Czapekdox agar)
3. **Cultivation of microorganisms:** (i) **Bacterial cultivation** (a) Streak-plate method (*E.coli, Staphylococcus aureus*) Streaking with inoculation loop. Streaking with toothpick.
(b) Pour-plate method (*E.coli*) (c) Maintenance of microorganisms (slant culture, stab culture, glycerol stocks) (ii) **Fungal cultivation** (a) Yeast (*Saccharomyces cervisiae*) Moulds (*Penicillium notatum, Aspergillus niger*)
4. Estimation of CFU count by serial dilution- spread plate method/pour plate method.
5. Study of Colony Characteristics on Nutrient agar
6. A)Biochemical characterization of bacteria

a. Sugar utilization test (minimal medium + sugar) b. Sugar fermentation test (peptone water method, Ammonium salt sugar method c. IMViC d. Enzyme detection – Amylase, Gelatinase,lipase, caseinase, Catalase, and Oxidase e. Oxidative-fermentative test, arginine hydrolysis, ornithine, lysine decarboxylase, nitrate, nitrite reduction

B) Identification of Any Two bacterial isolates at least up to genus level.

Biochemical Techniques

1. Study of fluorescent micrographs to visualize bacterial cells.
2. Ray diagrams of phase contrast microscopy and Electron microscopy.
3. Separation of mixtures by paper / thin layer chromatography.
4. Demonstration of column packing in any form of column chromatography.
5. Separation of protein mixtures by any form of chromatography.
6. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
7. Determination of absorption max for an unknown sample and calculation of extinction coefficient.
8. Separation of components of a given mixture using a laboratory scale centrifuge.

Pedagogy: Experiential learning, Problem solving, project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

References	
1	Wilson& Walker.Principles andTechniquesinPractical Biochemistr y. 5th Edition Cambridge University Press (2000).
2	MurphyD.B. Fundamentalof Light Microscopy &Electron Imaging.1st Edition.Wiley-Liss.(2001).
3	K L Ghatak. Techniques And Methods In Biology PHI Publication (2011)
4	Pranav Kumar. Fundamentals and Techniques of Biophysics and Molecular Biology (2016)
5	Aurora Blair. Laboratory Techniques & Experiments In Biology.Intelliz Press
6	D.T Plummer.An Introduction to Practical Biochemistry. McGraw Hill Publication (1987)
7	Beckner, W.M., Kleinsmith L.J and Hardin J. The world of cell. IV edition Benjamin/Cummings (2000)
8	Prescott, M.J.,Harley,J.P.andKlein,D.A.Microbiology. 5th Edition WCB Mc GrawHill,New York, (2002).
9	Black J.G.Microbiology-Principlesand Explorations.JohnWiley&SonsInc.NewYork, (2002).
10	Maheswari D K Practical Microbiology. S Chand (2010)
11	Cowan and Steel's Manual for the Identification of Medical Bacteria. G. I. Barrow (Editor), R. K. A. Feltham (Editor) 3rd Edition. 2004

Note:
If any Elective or Vocational course involves theory-cum-practical, then IA to Exam Marks will be in the ratio of 50:50. The theory part is to be evaluated as part of IA. Semester end examination is only in practical component and questions from practical part.

Government of Karnataka

Model Curriculum

Program Name	**BSc in Microbiology**	Semester	**V**
Course Title	**B. MICROBIAL FERTILIZERS AND PESTICIDES (Theory)**		
Course Code:	**MIC V 1-T**	No. of Credits :	**03**
Contact hours		Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**25**	Summative Assessment Marks	**25**

Course Pre-requisite(s): Common to the Course Programme at Entry Level

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

CO1. Knowledge about microbes and their importance

CO2. Study, characters, cultivation and importance to plants in fields

CO3. Knowledge about Biofertilizers & Biopesticides and their importance in plants & Environment

CO4. Give suggestions and knowledge to the farmers.

CO5.Advantages of Biofertilizers & Biopesticides.

Contents	
Unit-I	**15 Hrs**
Biofertilizers: General account of the microbes used as Biofertilizers for various crop plants & their advantages. **Symboitic nitrogen fixers**: Rhizobium - isolation, characters, tpes, inoculums, Production & field applications. **Non symbiotic nitrogen fixers** – free living Azospirillum, Azatobacter, Azolla, Cynobacteria isolation,character,mass Production, field applications. **Mycorrhizal Biofertilizers:** General characters, types of mycorrhizae associated plants, mass inoculation, Production of VAM, field applications mycorrhizae. **Biopesticides:** General account of microbes used as biopesticides & their advantages over synthetic pesticides. Biopesticides- types, general characters, field applications of Bacillus thuringiensis (BT), Bacillus Papillae,Viruses – NPV & CPV.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Knowledge about microbes and their importance					√										
Study, characters, cultivation and importance to plants in fields						√									
Knowledge about Biofertilizers & Biopesticides and their importance in plants & Environment									√						
Give suggestions and knowledge to the farmers.										√					
Advantages of Biofertilizers & Biopesticides.											√				

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments.

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	05 Marks
Class Test	10 Marks
Debate/Quiz/Assignment	05 Marks
Seminar	05 Marks
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

Course Title	**B. MICROBIAL FERTILIZERS AND PESTICIDES (Practical)**	Practical Credits	
Course Code	**MIC V1**	Contact Hours	**15 Hours**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

PRACTICAL CONTENT:

1. Isolation & Enumeration of Microbes by serial dilution method using soil sample.
2. Isolation & cultivation of Rhizobium bacteria from soil sample by serial dilution method.
3. Mass Cultivation & field application of Rhizobium.
3. Isolation of Azatobacteria by using Rhizosphere soil by serial dilution method.
4. Demonstaration of bacteroids from root nodules of legume plants.
5. Mass Cultivation & field application of Azatobacteria.
6. Isolation & Characterization of Cyanobacteria form different water samples.
7. Isolation & cultivation of Azosprillum from different soil samples.
8. Isolation & identification Mycorrhizae from different samples.
9. Mass Production & field applications of VAM.
10. Isolation & screening of Bacillus Thuringiensis(BT) from different samples.
11. Mass Cultivation or Production of BT crystals.
12. Type study – NPV & CPV.

Pedagogy: Experiential learning, Problem solving, Project

Tutorials, Group/individual Discussions, Seminars, Assignments, Counselling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Attendance	05 Marks
Records	05 Marks
Performance	05 Marks
Test	10 Marks
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

References

1	Kumanajam.S (2003). Biotechnology of Biofertilizers ,CHIPS,Texas.
2	Mahendra.K.Rai (2005). Handbook of Microbial biofertilizers, the Haworth Press, Inc: NewYork.
3	Reddy, S.M et al., (2002). Bioinoculants for sustainable agricultural & forestry, Scientific Publishers.
4	Subba Roa N.S (1995) Soil microorganisms and plant growth. Oxford and IBH publishing co.pvt.ltd, New Delhi.
5	Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert. Academic Publishing GmbH KG.
6	Agarwal SK (2005) Advanced Environmental Biotechnology, APH Publication.
7	Subbha Rao . Recent Advances in Biological Nitrogen Fixation. Oxford & IBH.
8	Plant Pathology, By George Agrious; Academic Press, New York.
9	Burges H.D. 1970 -1080. Microbial Control of Pests and Plant Diseases.

Note:

If any Elective or Vocational course involves theory-cum-practical, then IA to Exam Marks will be in the ratio of 50:50. The theory part is to be evaluated as part of IA. Semester end examination is only in practical component and questions from practical part.

Model curriculum for VI semester

Government of Karnataka

Model Curriculum

Program Name	**BSc in Microbiology**	Semester	**VI**
Course Title	**IMMUNOLOGY AND MEDICAL MICROBIOLOGY (Theory)**		
Course Code:	**MIC C15-T**	No. of Credits	**4**
Contact hours	**60 Hours(4 hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level
Course Outcomes (COs): After the successful completion of the course, the student will be able to: CO1: To gain a preliminary understanding about various immune mechanisms. CO2: To familiarize with Immunological techniques and serodiagnosis of infectious diseases CO3: To understand pathogenic bacterial infections, symptoms, diagnosis and treatment process. CO4: To understand pathogenic bacterial infections, symptoms, diagnosis and To understand pathogenic bacterial infections, symptoms, diagnosis and treatment process treatment process

Contents	60 Hrs
UNIT-I Normal microflora of the human body and host pathogen interaction Normal microflora of the human body: Importance of normal microflora, normal microflora of skin,throat, gastrointestinal tract, urogenital tract Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmissionof infection, Pathophysiologic effects of LPS. Sample collection, transport and diagnosis. Clinical Microbiology Medical Bacteriology The following diseases in detailwith Symptoms, mode of transmission, prophylaxis and control respiratory diseases: *Streptococcus pyogenes*, *Haemophilus influenzae*, *Mycobacterium tuberculosis* Gastrointestinal Diseases: *Escherichia coli*, *Salmonella typhi*, *Vibrio cholerae*, Others: *Staphylococcus aureus, Bacillus anthracis, Clostridium tetani*,*(10 hrs)*	**15 hrs.**
UNIT-II	**15 Hrs**
Medical Virology, parasitology and Mycology The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Corona, Influenza, swine flu, Ebola, Chikungunya, Japanese Encephalitis Protozoan diseases: Malaria, Kala-azar, Entamoeba Fungal infections- Cutaneous mycoses: Tinea, pedis (Athlete's foot) Systemic mycoses: Histoplasmosis Opportunistic mycoses: Candidiasis(10 Hrs) Antimicrobial agents: General characteristics and mode of action Antibacterial agents: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin Antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine . Antibiotic resistance, MDR, XDR, MRSA, NDM-1 5hrs	

UNIT-III	**15 Hrs**
Historical perspective of immunology; Edward Jenner, Luis Pasteur, attenuation. Immunity; Natural (active and passive) and artificial (active and passive) with example, Innate and acquired, Humoral and cell mediated. Early theories to explain the formation and specificity of antibody; Selective, instructional and clonal selection. Cells and organs of immune system: Hematopoiesis, cytokines, properties and functions of B and T Lymphocytes, Natural killer (NK) cells, Granulocytes (Neutrophils, Eosinophils and Basophils), Monocytes and macrophages, Dendritic cells and Mast cells. Primary lymphoid organs; Bone marrow and Thymus. Secondary lymphoid organs; Spleen and Lymphnodes.	
UNIT-IV **Antigen**: Immunogenicity and antigenicity, epitopes, haptens. Properties of antigen contribute to immunogenicity; Chemical nature (proteins, carbohydrates, lipids and nucleic acids), degree of foreignness, molecular weight, chemical composition and complexity, degradability. Adjuvants (alum, freunds incomplete and complete) and their importance. B and T cell epitopes. **Antibody**: Basic structure of antibody, light and heavy chain, variable and constant region,hinge region, Fab and Fc. Structure and functions of different types of antibodies (IgM, IgG, IgA, IgE, and IgD). Antibody mediated effector functions; opsonization, complement activation and antibody dependent cell mediated cytotoxicity (ADCC). Antigenic determinants on immunoglobulins: Isotype, allotype and idiotype. Monoclonal antibody production by hybridoma technology **10hrs** Principles and applications of antigen-antibody interactions: Definition of affinity and avidity. Immunoprecipitation; Radial (Mancini) and double (Ouchterlony) immunodiffusion. Agglutination reactions: Hemagglutination, Bacterial agglutination, passive agglutination, and agglutination inhibition. Enzyme linked immune-sorbent assay (ELISA): Direct, indirect, sandwich and competitive ELISA. Radioimmunoassay (RIA). Immunofluorescence. Complement system: Functions of complement components, Complement activation by classical, alternative and lectin pathway to develop membrane attack complex (MAC). Complement mediated opsonization, complement fixation test. Hypersensitive reactions: Classification, Humoral Immunity mediated hypersensitivity; Type I (IgE), Type II (IgG and IgM-ADCC), Type III (Antigen-antibody complex), and Cell mediated hypersensitivity Type IV (DTH). **5 Hrs**	**15 Hrs**

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes (POs)	**Program Outcomes (POs)**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**12**	**13**	**14**	**15**
To gain a preliminary understanding about various immune mechanisms.	√														
To familiarize with Immunological techniques and serodiagnosis of infectious diseases		√	√							√					
To understand pathogenic bacterial infections, symptoms, diagnosis and treatment process	√			√						√					
To understand pathogenic bacterial infections, symptoms, diagnosis and To understand pathogenic bacterial infections, symptoms, diagnosis and treatment process treatment process	√				√	√				√					

Pedagogy : Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10 Marks
Class Test	10 Marks
Debate/Quiz/Assignment	10 Marks
Seminar	10 Marks
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Government of Karnataka

Model Curriculum

Course Title	**IMMUNOLOGY AND MEDICAL MICROBIOLOGY (Practical)**	Practical Credits	**2**
Course Code	**MIC C16-P**	Contact Hours	**4Hours/week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1	Identify pathogenic bacteria (any three of *E. coli, Salmonella, Pseudomonas, Staphylococcu Bacillus*) on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitratereduction, urease production and catalase tests
2	Study of composition and use of important differential media for identification of pathogenicbacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
3	Study of bacterial flora of skin by swab method
4	Perform antibacterial sensitivity by Kirby-Bauer method
5	Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox,HPV warts, AIDS (candidiasis), dermatomycoses (ring worms)
6	Study of various stages of Malarial parasite in RBCs using permanent mounts.
7	Identification of human blood groups.
8	Perform Total Leukocyte Count of the given blood sample.
9	**Perform Differential Leukocyte Count of the given blood sample.**
10	Separate serum from the blood sample (demonstration).
11	Perform immunodiffusion by Ouchterlony method.
12	Perform DOT ELISA.
13	**Perform immunoelectrophoresis.**

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	Marks
Attendance	05 Marks
Records	05 Marks
Performance	05 Marks
Test	10 Marks
Total	25 Marks
Formative Assessment as per guidelines are compulsory	

REFERENCES	
1	Ananthanarayan R and Paniker C.K.J (2009) Textbook of Microbiology, 8th Edition, University Press, Publication.
2	Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3	Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4	Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology.9th edition. McGraw Hill Higher Education
5	Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms.14th edition. Pearson International Edition
6	Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th editionSaunders Publication, Philadelphia.
7	Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology.11th edition Wiley-Blackwell Scientific Publication, Oxford.
8	Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
9	Murphy K, Travers.P,Walport M. (2008).Janeway's Immunobiology.7th edition Garland Science,Publishers,New York.
10	Peakman.M.and Vergani D. (2009).Basic and Clinical Immunology,2nd edition ChurchillLivingstone Publishers, Edinberg.
11	Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

Government of Karnataka

Model Curriculum

Program Name	**BSc in Microbiology**	Semester	**VI**
Course Title	**MICROBIAL GENETIC ENGINEERING (Theory)**		
Course Code:	**MIC C17-T**	No. of Credits	**3**
Contact hours	**45 Hours(3 Hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level

CO1 : To acquire knowledge on the concepts and terminology in genetic engineering
CO2 : To learn about principles involved in manipulating genes and DNA
CO3 **:** Familiar with various cloning strategies in prokaryotes
CO4 : Learn techniques in genetic engineering
CO5 : To have awareness of IPR, the social and the ethical issues concerning cloning by genetic engineering

MICROBIAL GENETIC ENGINEERING	**45Hrs**
Unit 1: Introduction to Microbial Genetic Engineering	**15 Hrs**

Historical prospectives: Definition of genetic engineering, milestones in genetic engineering, prospects and problems of genetic engineering.

Tools in Microbial Genetic Engineering: Restriction modification systems- Types, Mode of action, nomenclature, applications of restriction enzymes in genetic engineering. DNA modifying enzymes and their applications: DNA polymerases, methylases, Terminal deoxynucleotidyl transferase, kinases and phosphatases and DNA ligases.

Unit 2: Cloning vectors, DNA transfer methods and identification of recombinants	**15 Hrs**

Cloning Vectors: Definition and Properties. Characteristics of cloning vectors. Plasmid vectors: pBR and pUC series. Bacteriophage lambda, cosmids, BACs, YACs. Use of linkers and adaptors. Expression vectors: Baculovirus based vectors, mammalian SV40-based expression vectors.

Cloning host- Cloning in *Escherichia coli*, cloning in *Saccharomyces cerevisiae*, cloning in GRAS microorganism. Gene Library: Construction of cDNA library, genomic library. DNA transfer methods: Microinjection, Biolistic, Electroporation, Calcium phosphate and Liposome mediated DNA transfer. Identification and selection of recombinants: DNA hybridisation, blue white selection, antibiotic selection, colony and plaque hybridization.

Unit 3: Techniques and applications in Microbial Genetic Engineering	**15 Hrs**

Isolation and Detection of DNA: Isolation of DNA, restriction digestion and ligation of DNA, Agarose gel electrophoresis, Blotting techniques- Southern blotting, Northern blotting, dot blot, DNA microarray analysis, Western blotting. DNA sequencing- Sanger's method. PCR techniques and applications.

Recombinant microorganisms: Application of recombinant microorganisms in basic research, industry, medicine, agriculture, environment.

Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccines. Biological, ethical and social issues of gene cloning and IPR.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
To acquire knowledge on the concepts and terminology in genetic engineering	√					√									
To learn about principles involved in manipulating genes and DNA	√		√						√						
Familiar with various cloning strategies in prokaryotes									√	√					
Learn techniques in genetic engineering						√						√			
To have awareness of IPR, the social and the ethical issues concerning cloning by genetic engineering										√					

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Government of Karnataka

Model Curriculum

Course Title	MICROBIAL GENETIC ENGINEERING (Practical)		Practical Credits	02
Course Code	MIC C18-P	Contact Hours	4 Hours/ week	
Formative Assessment	25 Marks	Summative Assessment	25 Marks	
Practical Content				

Practical: Microbial Genetic Engineering

Preparation of buffers-TE, TAE and Lysis buffer.
Isolation of plasmid DNA from *Escherichia coli.*
Estimation of DNA by DPA method.
Demonstration of estimation of DNA by spectrophotometric method.
Resolution and visualization of DNA by agarose gel electrophoresis.
Induction of mutations in bacteria by UV light.
Preparation of competent cells and demonstration of bacterial transformation.
Demonstration of bacterial transformation and calculation of transformation efficiency.
Digestion of DNA with restriction enzymes.
Demonstration of ligation of DNA fragments.
Preparation of master and replica plates.
Designing of primers for DNA amplification.
Demonstration of amplification of DNA by PCR.
Demonstration of Southern blotting.
Study of recombinant products-as per theory syllabus.

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

REFERENCES :

1	Brown TA. (2010). Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K. Clark DP and Pazdernik NJ. (2009). Biotechnology: Applying the Genetic Revolution. Elsevier Academic Press, USA
2	Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
3	Primrose SB and Twyman RM. (2008). Genomics: Applications in human biology. Blackwell Publishing, Oxford, U.K.
4	Russell PJ. (2009). i Genetics- A Molecular Approach. 3rd Ed, Benjamin Cummings
5	Sambrook J and Russell D. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press
6	Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.
7	Watson JD, Baker TA, Bell SP et al. (2008) Molecular Biology of the Gene, 6th Ed., Benjamin Cummings Wiley JM, Sherwood LM and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. McGraw Hill Higher Education.

Government of Karnataka

Model Curriculum

Program Name	**BSc in Microbiology**	Semester	**VI**
Course Title	**INDUSTRIAL MICROBIOLOGY**		
Course Code:	**MIC C19-T**	No. of Credits	**3**
Contact hours	**45 Hours(3 Hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

CO1. Learn the overview of scope and importance of industrially important microbes
CO2. Acquaint with different types of fermentation processes and equipments
CO3. Evaluate the factors influencing the enhancement of cell and product formation during fermentation
CO4. Acquire the knowledge of the production of value-added products
CO5. Acquire the knowledge of purification of value-added products

Contents	**45 Hrs**
Unit-I: Introduction to Industrial microbiology: **Scope and concepts; Criteria for selection of industrially important microbes; Preservation of industrially important microbes.** Types of fermentation process: **Submerged fermentation, Solid state fermentation (Koji), batch fermentation, continuous fermentation, kinetics of fermentation process.**	15 Hrs
Unit-II: Fermentor: **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; Sterilization of fermentor, Control of air, temperature, pH, foaming and feed; Aseptic inoculation and sampling methods; Scale up of fermentation process-Merits and demerits.** **Fermentation media:** Strategies for media formulation; Natural and synthetic media; Role of buffers, precursors, inhibitors, inducers and micronutrients.	15 Hrs
Unit-III:	15 Hrs
General production strategies of microbial products and Downstream processing: **Antibiotic, Enzymes, anti-cholesterol compound, anti-cancerous compound, hormones.** **Objectives and significance of downstream processing**: Overview of steps in extraction and purification ofproduct; Filtration and centrifugation; cell disruption- Physical, chemical and biological methods; Product extraction; product purification, recovery and product testing.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Learn the overview of scope and importance of industrially important microbes	√														
Acquaint with different types of fermentation processes and equipments												√			
Evaluate the factors influencing the enhancement of cell and product formation during fermentation								√							
Acquire the knowledge of the production of value-added products											√				
Acquire the knowledge of purification of value-added products											√				

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10 Marks
Class Test	10 Marks
Debate/Quiz/Assignment	10 Marks
Seminar	10 Marks
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Government of Karnataka

Model Curriculum

Course Title	**INDUSTRIAL MICROBIOLOGY (Practical)**	Practical Credits	**2**
Course Code	**MIC C20-P**	Contact Hours	**4 Hours/ Week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

PRACTICAL CONTENT

1. Demonstration of a basic fermentor
2. Preparation of natural medium used in a industry
3. Preparation of synthetic medium used in a industry
4. Production of amylase/protease/cellulase/pectinase/invertase by solid substrate fermentation (with Atleast 2 substrates)
5. Production of enzyme (amylase/protease/cellulase/invertase by submerged fermentation
6. Preservation of microbes with glycerol/soil.
7. Preservation of microbes by Silica gel method/lyophilization
8. Growth and revival of Mammalian cell lines
9. Air filter challenge test
10. Production and estimation of any one secondary metabolite
11. Downstream technique- Solid-liquid separation by using a centrifugation
12. Downstream technique- Demonstration of Microfiltration technique
13. Downstream technique- cell disruption by sonicator/enzyme

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Attendance	05 Marks
Records	05 Marks
Performance	05 Marks
Test	10 Marks
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

References

1. Arindam Kuilaand Vinay Sharma (2018) Principles and Applications of Fermentation Technology, Wiley.
2. Casida L E.J.R. (2016) Industrial Microbiology, 2nd edition, New Age International Publisher.
3. Crueger W&A Crueger (2017). Cruegers Biotechnology: A Text Book of Industrial Microbiology. Edited by K.R. Aneja. Panima Publishing Corporation.
4. Michael, J.W., Neil L. Morgan (2013) Industrial microbiology : an Introduction. Blackwell science
5. Nduka Okafor,Benedict Okeke (2017). Modern Industrial Microbiology and Biotechnology. 2nd Edition :CRC Press Publishers
6. Stanbury P.F., W. Whitaker & S.J. Hall (2016). Principles of Fermentation Technology. 3rd edition. Elsevier publication
7. Alexander N. Glazer, Hiroshi Nikaido (2014), Microbial Biotechnology: Fundamental of applied Microbiology, 2nd Edition, Cambridge University Press

Government of Karnataka

Model Curriculum

DISCIPLINE SPECIFIC ELECTIVES (Any one paper to be chosen)

Program Name	**BSc in Microbiology**	Semester	**VI**
Course Title	**A. EMERGING BACTERIAL AND FUNGAL DISEASES (Theory)**		
Course Code:	**MIC E2-T**	No. of Credits	**3**
Contact hours	**45 Hours(3 Hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s) : Common to the Course Programme at Entry Level

Course Outcomes (COs) : After the successful completion of the course, the student will be able to:

CO1. Obtain fundamental knowledge about emerging diseases
CO2. Methods of transmission, diagnosis and control measures of emerging bacterial infections
CO3. Methods of transmission, diagnosis and control measures of emerging fungal infections
CO4. Recent emerging disease outbreaks and strategies of control
CO5. Spread of multidrug resistant organisms and the consequences

Contents	**45 Hrs**
Unit-I:	**15 Hrs**
Introduction to infectious diseases: History of infectious diseases, introduction to the microscopic world Bacteria, Fungi, Cultivation of bacteria and fungi Infectious disease cycle- an overview the causative agent, source or reservoir of the pathogen, modes of transmission, portals of entry, infectious dose, adherence and portals of exit. Classification Infectious Diseases: Occurrence- sporadic, endemic, epidemic, pandemic. Severity or duration of disease- acute, chronic, sub-acute, latent Extent of host involvement- local infection, systemic infection, focal infection etc.	
Germ theory of disease –Koch's postulates Microbial mechanisms of pathogenicity- penetration of host defenses, damage to host cells. Emerging and re-emerging infections - Nosocomial infections.	
Unit-II	**15 Hrs**
Emerging Bacterial disease: Classification, Epidemiology, Pathogenesis, clinical conditions, laboratory diagnosis, and treatment of emerging bacterial pathogens: Enterohaemorrhagic *Escherichia coli, Vibrio cholerae, Listeria monocytogenes, Campylobacter spp, Helicobacter pylori,* Drug resistant bacteria- Methicillin-resistant *Staphylococcus aureus, Streptococcus,* Multi-drug resistant *Mycobacterium tuberculosis,* New Delhi Metallo-beta-lactamase-1 (NDM-1) *Klebsiella pneumoniae, Clostridium difficile, Neisseria gonorrhoeae.*	

Unit-III	15 Hrs
Emerging Fungal disease Classification, Epidemiology, Pathogenesis, clinical conditions, laboratory diagnosis, and treatment of emerging fungal infections: *Pneumocystis pneumonia*, invasive aspergillosis, mucormycosis co-morbid infection in COVID- 19, esophageal candidiasis in HIV, fungal keratitis, cryptococcal meningitis, Sporotrichosis and Systemic mycosis.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Obtain fundamental knowledge about emerging diseases	√		√	√							√				
Methods of transmission, diagnosis and control measures of emerging bacterial infections		√			√					√	√	√			
Methods of transmission, diagnosis and control measures of emerging fungal infections		√			√					√	√	√			
Recent emerging disease outbreaks and strategies of control			√		√	√	√								
Spread of multidrug resistant organisms and the consequences									√	√	√	√			

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10 Marks
Class Test	10 Marks
Debate/Quiz/Assignment	10 Marks
Seminar	10 Marks
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References	
1	Foundations in Microbiology, Kathleen Park Talaro, 7th edition, McGraw Hill
2	Prescott, Harley, Klein's Microbiology, Wiley, Sherwood, Woolverton, 7th edition, McGraw Hill
3	Microbiology, an Introduction, Tortora, Funke, Case, 10th edition, Pearson Education.
4	Sherris Medical Microbiology (2018), Seventh Edition.McGraw Hill Publishers
5	Mims' Medical Microbiology and Immunology, International Edition
6	Jawetz Melnick & Adelbergs Medical Microbiology
7	McCay and McCartney's Practical Medical Microbiology.14th Edition, ChurchHill Livingstone Publishers

Government of Karnataka
Model Curriculum

Program Name	**BSc in Microbiology**	Semester	**VI**
Course Title	**B. BIOSAFETY, BIOETHICS AND IPR (Theory)**		
Course Code:	**MIC E2-T**	No. of Credits	**03**
Contact hours	**45 Hours(3 Hours per week)**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level	
Course Outcomes (COs): After the successful completion of the course, the student will be able to: CO1. Understand the basic principle and practice of safety practices in microbiology laboratories CO2. Helps to identify the potentially hazardous microorganisms and health concern CO3. Basic knowledge of safety equipment's and hazardous microorganisms CO4. Develop knowledge to assess the current bioethical issues of using microorganisms CO5. Able to understand the various forms of Intellectual property rights CO6. Learn the intellectual property protection by using specific IPRs	
BIOSAFETY BIOETHICS AND IPR	**45 Hrs**
Unit-I: Introduction to biosafety	**15 Hrs**
Biosafety: Introduction, History, and significance of biosafety in microbiology, Principles of biosafety, Biosafety levels (BSL1-BSL 4), classification of hazardous microorganisms, Standard Microbiological Practices, Biosafety cabinets, and types Biosafety equipment's, Biosafety guidelines and regulations, Occupational hazards, Risk analysis, GMO: Concerns and challenges	
Unit-II Unit 2: Introduction to Bioethics	**15 Hrs**
Introduction, history and scope of bioethics, moral problems concerned with genome research, Manipulation of microorganisms and genetic diagnosis, Ethical issues of gene therapy, Social and ethical issues in GMOS, bioweapons, Ethical issues in use of animals in research and food production	

Unit-III: Introduction to IPR (Intellectual Property Rights	**15 Hrs**
Intellectual property, Introduction to intellectual property rights, different forms of IPR and importance. Patents-types of patents, Patentable and Nonpatentable Inventions. Salient features of Indian patent law. Patent filing and patent Grant process, Patent infringement- Direct and indirect Copyrights: : Introduction, copy right subject matter, copyright protection Trade mark: meanings a, types, and importance Trade secrets, Geographic indication, Industrial designs and rights.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes (POs)	**Program Outcomes (POs)**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Understand the basic principle and practice of safety practices in microbiology laboratories		√		√			√			√					
Helps to identify the potentially hazardous microorganisms and health concern		√		√						√					
Basic knowledge of safety equipment's and hazardous microorganisms		√		√						√					
Develop knowledge to assess the current bioethical issues of using microorganisms								√		√					
Able to understand the various forms of Intellectual property rights										√					
Learn the intellectual property protection by using specific IPRs										√					

Pedagogy : Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10 Marks
Class Test	10 Marks
Debate/Quiz/Assignment	10 Marks
Seminar	10 Marks
Total	**40 Marks**

References	
1	Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition. ASM 2006
2	Glazer AN and Nikaido H (2007) Microbial Biotechnology, 2nd edition, Cambridge University Press 7. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press
3	Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
4	Essentials of Intellectual Property: Law, Economics, and Strategy by Alexander I. Poltorak; Paul J. Lerner Wiley, 2011 (2nd edition)
5	Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management.Jasen Publications, Tiruchirappalli, India.Safety, Moral, Social and Ethical issues related to genetically modified foods - Smith J.E.
6	Bioethics, Ben Mephan, Oxford university press 2nd edition 2008.
7	Bioethics, Nancy. S. Jecker, Albert. R. Johnson, Robert. A. Pearlman, Johnson and Bartlett Publishers, Boston, 2nd edition 2014
8	Encyclopedic dictionary of bioethics, S.K. Ghoshi, Global vision publishing house 19A/E. GTB. Enclave Delhi. vol I&II s 2012.
9	Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan K. Sell Cambridge University Press, 2000

Government of Karnataka
Model Curriculum

Vocational Paper (Any one Paper to be chosen)

Program Name	**BSc in Microbiology**	Semester	**VI**
Course Title	**A. IMMUNOTECHNOLOGY (Theory)**		
Course Code:	**MIC V2-T**	No. of Credits	**03**
Contact hours		Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

Course Outcome: The student will be able to

CO1 : Use diagnostic kits to test different types of infectious diseases.
CO2: Usage of experimental animals for immunological studies
CO3 : Perform Single Radial Immunodiffusion.
CO4 : Purification and Analysis of antigens and antibodies.
CO5 : Diagnosis of various diseases using immunological test.

UNIT- I	**15 Hrs.**
Antigen: Ideal properties of antigen to develop good quality immune response, solubleand insoluble antigens. Humoral immunity, activation of B-lymphocytes. Cell mediated immunity, activation of TH and Tc cells, MHC, antigen presentation, mechanism of phagocytosis, primary and secondary immune response. Immunity to infectious diseases: Injury, inflammation; Immune response to control viral pathogens, bacterial pathogens, fungal diseases, parasitic diseases. Generation of antibodies; Production of polyclonal antibodies, production of monoclonal antibodies by hybridoma technology. Purification of immunoglobulins from serum samples- principle and procedure of ammonium sulfate precipitation, ion-exchange, gel filtration and affinity chromatography, electrophoresis, assessment of purity of antibodies, western blotting to detect specific protein in a protein mixture. ELISA: Enzyme systems for ELISA assay. Microscopic visualization of cells; Immunocytochemistry and immunohistochemistry. Immunofluorescence to visualize cells and molecules. Methods of designing vaccines; Live attenuated polio (Sabin) vaccine, killed polio (Salk) vaccines, Subunit (HBsAg) vaccine, Development of Toxoids from diphtheria and tetanus toxins. Immunization techniques, oral, subcutaneous, intramuscular, intravenous, intraperitonial.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12
Use diagnostic kits to test different types of infectious diseases.		√					√				√	
Usage of experimental animals for immunological studies			√							√	√	
Perform Single Radial Immunodiffusion.		√	√								√	
Purification and Analysis of antigens and antibodies.		√										√
Diagnosis of various diseases using immunological test.		√							√		√	

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

REFERENCESS:

1. Coiw, R and Sunshine, G. Immunology (A short course), 6th edition, Wiley Blackwell.
2. Forbes, B., Sahm, D.F and Weissfeld, A.S.1998. Diagnostic Microbiology, 11th edition, Mosby, Inc.Missouri.
3. Janeway, Travers, Walport and Shlomchik.2005. Immunobiology (The immune system in health and diseases), 6th editions, Garland Science Publishers, New York.
4. Kindt, T.J., Goldsby, R.A and Osborne, B.A.2007. Kuby Immunology, 6th edition,W.H. Freeman & Company, New York.
5. Male, D., Brostoff, J., Roth, D.B and Roitt, I.2006. Roitt Immunology, 7th edition, Mosby Elsevier Publishers.
6. Yadav, P.R. and Tyagi, R. 2005. Immuno-Biotechnology, Discovery Publishing House, New Delhi.
7. Essential immunology- Ivan M. Roitt.
8. Immunology – a short course Elibezamini and Sidney Leskowitz, Alan R. Lisi Inc. New York, 1988.
9. Immunology III. Joseph A. Bellanti igaku – Shein Saunders International Edn.1985
10. Immunology at a glance J.H.L.Playfeir 4th edn. Blackwell scientific publication 1987.
11. Aids to Immunology D.M. Weir Churchill, Livingtons 1986.
12. Fundamentals of Immunology, Myrvik and Weiser, 1984.
13. Fundamentals of Immunology, Bier et al, Springer 1986.
14. Textbook of Biochemistry and Human biology, Talwar G.P. Prentice Hall, 1980.
15. Basic and clinical immunology – Stites et al., 4th edn. Lange 1982.
16. The immunosystem, Mc Connell et al., Blackwell scientific 1981.

Government of Karnataka

Model Curriculum

Course Title	**A.IMMUNOTECHNOLOGY (Practical)**		Practical Credits	
Course Code	**MIC V2-P**		Contact Hours	**Hours**
Formative Assessment	**25 Marks**	Summative Assessment		**25 Marks**
PRACTICAL CONTENT				

1. Types of antigens and adjuvants
2. Preparation of antigens

a. Whole cell antigens

b. Purified proteins

3. Preparation of antigen-adjuvant mixtures
4. Methods of antigen administration to animals

a. Intramuscular

b. Intraveinal

c. Intraperitonial

d. Intradermal

5. Methods of bleeding
6. Separation of plasma from blood
7. Production of polyclonal antiserum
8. Separation of serum from blood
9. Determination of antibody titer of the serum
10. Purification of IgG from serum
11. Immunoprecipitation Radial/ double diffusion
12. ELISA

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

REFERENCESS:

1. Coiw, R and Sunshine, G. Immunology (A short course), 6th edition, Wiley Blackwell.
2. Forbes, B., Sahm, D.F and Weissfeld, A.S.1998. Diagnostic Microbiology, 11th edition, Mosby, Inc.Missouri.
3. Janeway, Travers, Walport and Shlomchik.2005. Immunobiology (The immune system in health and diseases), 6th editions, Garland Science Publishers, New York.
4. Kindt, T.J., Goldsby, R.A and Osborne, B.A.2007. Kuby Immunology, 6th edition,W.H. Freeman & Company, New York.
5. Male, D., Brostoff, J., Roth, D.B and Roitt, I.2006. Roitt Immunology, 7th edition, Mosby Elsevier, Publishers.
6. Yadav, P.R. and Tyagi, R. 2005. Immuno-Biotechnology, Discovery Publishing House, New Delhi.
7. Essential immunology- Ivan M. Roitt.
8. Immunology – a short course Elibezamini and Sidney Leskowitz, Alan R. Lisi Inc. New York, 1988.
9. Immunology III. Joseph A. Bellanti igaku – Shein Saunders International Edn.1985
10. Immunology at a glance J.H.L.Playfeir 4th edn. Blackwell scientific publication 1987.
11. Aids to Immunology D.M. Weir Churchill, Livingtons 1986.
12. Fundamentals of Immunology, Myrvik and Weiser, 1984.
13. Fundamentals of Immunology, Bier et al, Springer 1986.
14. Textbook of Biochemistry and Human biology, Talwar G.P. Prentice Hall, 1980.
15. Basic and clinical immunology – Stites et al., 4th edn. Lange 1982.
16. The immunosystem, Mc Connell et al., Blackwell scientific 1981.

Government of Karnataka
Model Curriculum

Program Name	**BSc in Microbiology**	Semester	**VI**
Course Title	**B. MICROBIAL NANOTECHNOLOGY (Theory)**		
Course Code:	**MIC V2-T**	No. of Credits	**3 (1+2)**
Contact hours	**15**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s): Common to the Course Programme at Entry Level	
Course Outcomes (COs): After the successful completion of the course, the student will be able to : CO1. Gain knowledge on the types and sources of nanoparticles CO2.Acquire knowledge on the recent developments in microbial nanotechnology CO3.Understand the basic synthesis of nanoparticles from microbes CO4. Study the significance of nanoparticles in industries CO5. Understand is advantages and disadvantages	
Contents	15 Hrs
Unit-I : Introduction, types, properties and synthesis of nanoparticles (Physical, Chemical) Green synthesis of nanoparticles by microorganisms: Advantages and disadvantages; Application of Microbial nanotechnology in Food, Clinical and Environmental Microbiology. Bionanosensor.	15 Hrs

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-15)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Gain knowledge on the types and sources of nanoparticles								√							
Acquire knowledge on the recent developments in microbial nanotechnology								√							
Understand the basic synthesis of nanoparticles from microbes											√				
Study the significance of nanoparticles in industries											√				
Understand is advantages and disadvantages											√				

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	Marks
Attendance	10 Marks
Class Test	10 Marks
Debate/Quiz/Assignment	10 Marks
Seminar	10 Marks
Total	40 Marks
Formative Assessment as per guidelines are compulsory	

Government of Karnataka
Model Curriculum

Course Title	B.**MICROBIAL NANOTECHNOLOGY** (Practical)	Practical Credits	3
Course Code	**MIC V2-T**	Contact Hours	15hours
Formative Assessment	25 Marks	Summative Assessment	25 Marks

Practical Content

1. Green synthesis of nanoparticles by bacteria
2. Green synthesis of nanoparticles by fungi/mushroom
3. Green synthesis of nanoparticles by Algae
4. Comparative analysis of nanoparticles from the above sources by muffle furnace, sonication, chemical, Sol-gel and enzymatic method
5. Characterization of synthesized nanoparticles by UV Spectrophotometer and FTIR
6. Nanoparticle size and shape determination by SEM and TEM
7. Elucidation of nanoparticle structure by XRD
8. Determination of anti-microbial activity of synthesized nanoparticles
9. Determination of antioxidant activity of synthesized nanoparticles
10. Determination of anti-inflammatory activity of synthesized nanoparticles
11. Determination of anti-cancer activity by MTT assay
12. Determination of dye reduction activity of synthesized nanoparticles
13. Purification of water by synthesized nanoparticles
14. Synthesis of Bio-nanosensor for the detection of chemical preservatives in food/food products
15. Synthesis of Bio-nanosensor for the detection of heavy metals in food/food products

Pedagogy: ……

Formative Assessment for Practical	
Assessment Occasion/ type	Marks
Attendance	05 Marks
Records	05 Marks
Performance	05 Marks
Test	10 Marks
Total	25 Marks
Formative Assessment as per guidelines are compulsory	

REFERENCES

1. Zhypargul Abdullaeva. Synthesis of Nanoparticles and Nanomaterials. Springer International Publishing AG, 2017. https://doi.org/10.1007/978-3-319-54075-7
2. **Atul Thakur, Preeti Thakur, S.M. Paul Khurana. Synthesis and applications of Nanoparticles. Springer Singapore, 1st edition. https://doi.org/10.1007/978-981-16-6819-7**
3. Mohammad Azam Ansari, Suriya Rehman. Microbial Nanotechnology: Green Synthesis and Applications. 1st edition, Springer, 2021. https://doi.org/10.1007/978-981-16-1923-6
4. **Chaudhery Mustansar Hussain. Handbook of Microbial nanotechnology. Elsevier Inc, 2022** https://doi.org/10.1016/C2020-0-00106-4
5. **Pradeep singh. Vijay kumar, Mika Sillanpaa. Environmental applications of microbial nanotechnology. Elsevier, 2023. https://doi.org/10.1016/C2021-0-01391-2**