NATIONAL CURRICULUM AND CREDIT FRAMEWORK (NCCF)

Syllabus
for

MICROBIOLOGY

(w.e.f. Academic Session 2023-24)

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Preamble:

Microbiology is the study of microorganisms or microbes such as bacteria, viruses, fungi, algae, cyanobacteria, protozoa, and prions. They are extremely important, as their diverse activities range from causing deadly diseases in humans, animals, and plants to producing highly useful products such as antibiotics, enzymes, alcohol, and fermented foods, and recycling dead and decaying organic matter in nature. Thus, microbiology plays an important role in health, agriculture, the environment, and industry. Several discoveries over the last two to three decades that significantly impact these areas have put Microbiology at the centre of teaching, research, and development worldwide.

The Choice-Based Credit System (CBCS) and Learning Outcome-Based Curriculum Framework (LOCF) curriculum for Microbiology at the undergraduate level has now been developed into a new system, the National Curriculum and Credit Framework (NCCF), under the recommendations and guidance of the University Grants Commission (UGC). The NCCF approach first envisioned the programme learning outcomes of the B.Sc. (Honours) program in Microbiology as well as the learning outcomes of the courses being taught under this programme, keeping in view the graduate attributes of the subject. The curriculum was then developed in tune with the learning outcomes. It is envisaged that students trained under this curriculum will possess the required attributes of knowledge, skills, temperament, and ethics related to Microbiology. In addition to the curriculum content, the teaching-learning processes have also been designed to achieve these attributes. A variety of learning assessment tasks have been included in the curriculum. Besides assessing the knowledge/skills acquired by the students, these tasks would also help to supplement the teaching-learning processes.

The NCCF, aligned with the National Education Policy (NEP) 2020, represents a major shift from the previous CBCS and LOCF by transitioning from a rigid 3-year structure to a flexible 4-year undergraduate program featuring multiple entry/exit options and multidisciplinary learning.

There are 21 Major Courses (MJC) that encompass all the important aspects of the discipline of Microbiology and are compulsory. The Minor Courses (MNC) are designed to provide students from other disciplines with a comprehensive understanding of Microbiology. Microbiology students will have the option to select courses from other disciplines, in addition to Microbiology, depending on their interests and passions. The Major and Minor Courses are all 5 credits (3 credits of theory and 2 credits of laboratory work). Skill Enhancement Courses (SEC), 3 credits each, would give students the option to develop skills in areas directly relevant to employability in diagnostics, health, food, and pharmaceutical industries, agriculture, and environment-related job opportunities in Microbiology. The focus of the Ability Enhancement Courses (AEC), which are each 4 credits, is to develop communication skills. Value Added Courses (VAC) are 4-credit courses designed to develop well-rounded learners with 21st-century skills. Focusing on holistic development, they span four key areas: understanding India, environmental science, digital/technological solutions, and health & wellness/yoga. These courses aim to improve employability and impart practical skills alongside traditional education. Multidisciplinary Course (MDC), 3 credits each, allows students to choose subjects across disciplines, providing a holistic education by integrating the arts, sciences, and professional fields, with the aim of developing critical thinking, flexibility, and analytical skills. Students will also perform a Summer Internship (SI) of 2 credits to gain practical industry experience, focusing on hands-on training, skill development, or research projects.

Four-year undergraduate students may opt for Honours or Honours with Research in the 8th semester, following the University guidelines.

Course Details

Semester	Course Code	Course Name	Credits (Th + Pr)	Marks	Page No.
I	BSCMCBMJ101	Bacteriology	3+2	100	4
	Minor	*Choose from the pool*	3+2	100	
	MD	*Choose from the pool*	3+0	50	
	AE	*Choose from the pool*	4+0	50	
	BSCMCBSE101	Microbial World and Principles of Microbiology	0+3	50	6
		Semester Total =	**20**	**350**	
II	BSCMCBMJ201	Biochemistry	3+2	100	8
	Minor	*Choose from the pool*	3+2	100	
	MD	*Choose from the pool*	3	50	
	VA201	Environment Studies	4+0	50	
	BSCMCBSE201	Microbial Techniques and Instrumentation	0+3	50	10
	SI201	*Summer Internship (If opt for exit after the 2nd semester)*			
		Semester Total =	**20**	**350**	
III	BSCMCBMJ301	Cell Biology	3+2	100	12
	BSCMCBMJ302	Molecular Biology	3+2	100	13
	Minor	*Choose from the pool*	3+2	100	
	MD	*Choose from the pool*	3+0	50	
	AE	*Choose from the pool*	4+0	50	
		Semester Total =	**22**	**400**	
IV	BSCMCBMJ401	Microbial Diagnostics and Public Health	3+2	100	16
	BSCMCBMJ402	Industrial Microbiology	3+2	100	17
	Minor	*Choose from the pool*	3+2	100	
	BSCMCBSE401	Microbial Physiology and Metabolism	0+3	50	18
	VA	*Choose from the pool*	4	50	
	SI401	*Summer Internship (If opt for exit after the 4th semester)*			
		Semester Total =	**22**	**400**	
V	BSCMCBMJ501	Environmental Microbiology and Microbial Ecology	3+2	100	21
	BSCMCBMJ502	Microbial Genetics	3+2	100	22
	BSCMCBMJ503	Virology	3+2	100	24
	Minor	*Choose from the pool*	3+2	100	
		Semester Total =	**20**	**400**	
VI	BSCMCBMJ601	Medical and Veterinary Microbiology	3+2	100	27
	BSCMCBMJ602	Immunology	3+2	100	28
	BSCMCBMJ603	Food and Dairy Microbiology	3+2	100	30
	BSCMCBMJ604	Heredity and Evolution	3+2	100	31
	SI601	Summer Internship	0+2	50	33
		Semester Total =	**22**	**450**	
VII	BSCMCBMJ701	Microbial Products in Agriculture	3+2	100	36
	BSCMCBMJ702	Biostatistics and Bioinformatics	3+2	100	37
	BSCMCBMJ703	Genetic Engineering and Applications	3+2	100	39
	BSCMCBMJ704	Advance Microbiology	3+2	100	40
	Minor	*Choose from the pool*	3+2	100	
		Semester Total =	**25**	**500**	
VIII (Honours)	BSCMCBMJ801	Microbial Biotechnology	3+2	100	44
	BSCMCBMJ802	Pharmaceutical Microbiology	2+2	100	45
	BSCMCBMJ803	Research Methodology and Ethics	2+2	100	47
	BSCMCBMJ804	Project Work on Microbiology of Societal Importance	2+2	100	48
	Minor	*Choose from the pool*	3+2	100	
		Semester Total =	**22**	**500**	
VIII (Honours with Research)	BSCMCBMJ801	Microbial Biotechnology	3+2	100	51
	BSCMCBRP801	Research Methodology	2+2	100	51
	BSCMCBRP802	Dissertation	0+8	200	51
	Minor	*Choose from the pool*	3+2	100	
		Semester Total =	**22**	**500**	
		Course Total =	**96**	**1300**	

NOTES ON MARKS DISTRIBUTION:

1. 30% marks in Theory & 60% marks in Practical are allotted for Internal Assessments [e.g., in Theory of 50 marks, **15 marks** will be allotted for Continuous Assessment (CA) & **35 marks** for End Semester Examination (ESE), and in Practical of 50 marks, **30 marks** will be allotted for CA & **20 marks** for ESE].

Detailed Syllabus

Semester - 1

Course Name: Bacteriology Course Code: BSCMCBMJ101					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-1**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

and

Course Name: Bacteriology Course Code: BSCMCBMN101					
Course Type: **Minor (Theoretical & Practical)**	Course Details: **MNC-1**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

After the completion of the course, the students will:

- Describe characteristics of bacterial cells, cell organelles, cell wall composition, and various appendages like capsules, flagella, or pili.
- Differentiate between many common bacteria by their salient characteristics and classify them accordingly.
- Describe the nutritional requirements of bacteria for growth; develop knowledge and understanding that several other microbes grow in extreme environments besides common bacteria.
- Perform basic laboratory experiments to study microorganisms; methods to preserve bacteria in the laboratory; calculate the generation time of growing bacteria.

Course Content:

Theory

Unit – 1: History of microbiology and introduction to the microbial world. Theory of spontaneous generation, Germ theory of disease, golden era of microbiology. Contributions of Antony von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Martinus W. Beijerinck, Sergei N. Winogradsky, Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Unit – 2: Cell size, shape and arrangement, capsule, flagella, fimbriae, and pili. Cell wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, archaebacterial cell wall, lipopolysaccharide (LPS), spheroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall. Cell membrane: Structure, function, and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid. Endospore: Structure, formation, stages of sporulation.

Unit – 3: Nutritional requirements in bacteria and nutritional categories. Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, enriched, and enrichment media. Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, and radiation. Chemical methods of microbial control: disinfectants, types, and mode of action. in vitro cultivation of microorganisms; Sterilization techniques (physical & chemical sterilization). Conditions for microbial growth. Pure culture isolation: Streaking, serial dilution, and plating methods; cultivation, maintenance, and preservation of pure cultures.

Unit – 4: Aim and principles of classification, systematics, and taxonomy, the concept of species, taxa, strain; conventional, molecular, and recent approaches to evolutionary chronometers, rRNA oligonucleotide sequencing, and its importance. Differences between eubacteria and archaea. General characteristics, phylogenetic overview of bacteria and archaea. Introduction to Proteobacteria, Firmicutes, *Nanoarchaeota (Nanoarchaeum)*, *Thermoproteota (Sulfolobus)*, and *Euryarchaeota (Methanobacterium, Halococcus)*.

Practical

1) Staining: Gram-negative and Gram-positive bacteria: characteristics and examples. Study of typical eubacteria (*Bacillus, Clostridium, Staphylococcus, Streptococcus, Escherichia*); simple staining, negative staining, acid-fast staining, Capsule staining, Endospore staining; Motility by hanging drop method.
2) Preparation of different media: synthetic media, complex media - Nutrient agar, McConkey agar, EMB agar. Preparation of culture media (liquid & solid) for bacterial cultivation.
3) Handling and care of laboratory equipment - autoclave, hot air oven, incubator, and laminar airflow; Sterilization of media using autoclave and assessment of sterility.
4) Sterilization of glassware using a hot air oven. Sterilization of heat-sensitive material by membrane filtration.
5) Isolation & Estimation of pure cultures of bacteria by streaking method, CFU count by spread plate method/pour plate method.
6) Preservation of bacterial cultures by various techniques. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air.

Reference Books:

1. Prescott MJ, Harley JP, Klein DA. Microbiology. 5th Ed., WCB McGraw-Hill, New York, (2002).
2. Tortora GJ, Funke BR, Case CL. Microbiology: An Introduction. Pearson Education, Singapore, (2004).
3. Alcomo IE. Fundamentals of Microbiology. VI Ed., Jones and Bartlett Publishers. Sudbury. Massachusetts, (2001).
4. Black JG. Microbiology - Principles and Explorations. John Wiley & Sons Inc. New York, (2002).
5. Besty T, Koegh J. Microbiology Demystified. McGraw-Hill (2005).
6. Ray A, Mukherjee R. Basic Lab Manual of Microbiology, Biochemistry and Molecular Biology. Taurean Publications, India.

Course Name: Microbial World and Principles of Microbiology Course Code: BSCMCBSE101					
Course Type: **SE (Practical)**	Course Details: **SEC -1**			L-T-P: **0 - 1 - 4**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30		**20**	

Instructions: **Continuous assessment (CA) of this course should include a written test with questions from the principle portions.**

Course Learning Outcomes:

After the completion of the course, the students will be able to:

- Develop a good knowledge of the development of the discipline of Microbiology and the contributions made by prominent scientists in this field.
- Develop a very good understanding of the characteristics of different types of microorganisms, methods to organize/classify these, and basic tools to study these in the laboratory.
- Able to explain the beneficial and harmful activities of the microorganisms.
- Able to perform basic experiments to grow and study microorganisms in the laboratory.
- Identify commonly available fungi and algae and their characteristics. Discuss how fungi and algae are used as biofertilizers in agriculture and as biopesticides.

Course Content:

Unit – 1: ***Principle:*** Binomial nomenclature, Whittaker's five kingdoms, and Carl Woese's three-domain classification systems and their utility. General characteristics of cellular microorganisms, wall-less forms - MLO (mycoplasma and spheroplasts) with emphasis on distribution and occurrence - chlamydia and rickettsia, Fundamentals of viral structure and its importance.

Practical: Identification of unknown bacterial isolates based on morpho-physio-biochemical characters using Bergey's manual.

Unit – 2: ***Principle:*** General concept of phytoplankton and zooplankton. General characteristics, structure, mode of reproduction, and economic importance of actinomycetes. General characteristics, occurrence, structure, reproduction, and importance of protozoa.

Practical: (1) Simple staining of protozoa. (2) Hay culture to study *Paramoecium*. Identification of *Amoeba, Entamoeba*, and *Plasmodium*.

Unit – 3: ***Principle:*** Characteristics, classification, and cellular and thallus organization of fungi. General features, structure, nutrition, reproduction of different fungal phyla - Chytridiomycota, Zygomycota, Ascomycota, Basidiomycota, and Deuteromycota. Role of fungi in biotechnology. Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoprotein); Secondary metabolites (Pharmaceutical preparations, red-penciling); Agriculture (Biofertilizers, eg, VAM); Mycotoxins; Biological control (Mycoinsecticides). Mushrooms and their cultivation.

Practical: (1) Isolation and cultivation of fungi from natural sources. (2) Simple staining of fungi. (3) Lab-scale preparation of spawn and cultivation of mushrooms. (4) Study of the vegetative and reproductive structures of the following genera through temporary or permanent slides - *Mucor, Saccharomyces, Rhizopus, Penicillium, Aspergillus.*

Unit – 4: ***Principle:*** General characteristics of algae. Occurrence, thallus organization, algae cell ultrastructure - pigments, flagella, eye-spot, food reserves; vegetative, asexual, and sexual

reproduction. Classification of algae by Robert Edward Lee (2008) and economic importance. Mass cultivation of algae as a source of protein.

Practical: (1) Enumeration of Yeast by using a haemocytometer. (2) Study of the vegetative and reproductive structures of the following genera through temporary or permanent slides - *Spirogyra, Chlamydomonas, Volvox*.

Reference Books:

1. Prescott MJ, Harley JP, Klein DA. Microbiology. 5th Ed., WCB McGraw-Hill, New York, (2002).
2. Tortora GJ, Funke BR, Case CL. Microbiology: An Introduction. Pearson Education, Singapore, (2004).
3. Alcomo IE. Fundamentals of Microbiology. VI Ed., Jones and Bartlett Publishers. Sudbury. Massachusetts, (2001).
4. Black JG. Microbiology - Principles and Explorations. John Wiley & Sons Inc. New York, (2002).
5. Besty T, Koegh J. Microbiology Demystified. McGraw-Hill (2005).
6. Ganguly KK. Science and Technology, History and Evolution. Chapter - History of Microbiology, July 2020, pp. 221 -237, Publisher: Kumud Publications, ISBN:978-81-945060-3-4.
7. Ray A, Mukherjee R. Basic Lab Manual of Microbiology, Biochemistry and Molecular Biology. Taurean Publications, India.

Semester – 2

Course Name: Biochemistry Course Code: BSCMCBMJ201					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-2**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

and

Course Name: Biochemistry Course Code: BSCMCBMN201					
Course Type: **Minor (Theoretical & Practical)**	Course Details: **MNC-2**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the end of this course, the students will -

- Develop a perfect understanding of various biomolecules that are required for the development and functioning of a bacterial cell.
- Understand how carbohydrates make the structural and functional components, such as energy generation and storage of food molecules for the bacterial cells
- Conversant about the multifarious functions of proteins; can calculate enzyme activity and other quantitative and qualitative parameters of enzyme kinetics; also knows lipids and nucleic acids.
- Able to make buffers, study enzyme kinetics, and calculate Vmax, Km, Kcat values.

Course Content:

Theory

Unit – 1: Concept of bio-molecules - Building blocks of life, Macromolecules. Basic concept of the structure of water molecules and forces within molecules. Concept of pH and buffers, and numerical problems to explain the concepts.

Concept of bioenergetics - first and second laws of thermodynamics. Definitions of Gibbs free energy, enthalpy, and entropy and mathematical relationship among them, Standard free energy change and equilibrium constant. Coupled reactions and additive nature of standard free energy change, Energy rich compounds, ATP.

Unit – 2: Carbohydrate: Basic idea on carbon atom structure. Stereo isomerism of monosaccharides, epimers, mutarotation, and anomers of glucose. Families of monosaccharides – aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Furanose and pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose, sugar derivatives, and glucosamine. Disaccharides; concept of reducing and non-reducing sugars, occurrence and Haworth projections of maltose, lactose, sucrose, polysaccharides, storage polysaccharides, starch, and glycogen. Structural polysaccharides, cellulose, peptidoglycan, and chitin.

Unit – 3: Protein: Amino acids as the building blocks of proteins. Titration curve of amino acid and its Significance, Classification, biochemical structure, and notation of standard protein amino acids Ninhydrin reaction. General formula of amino acid and concept of zwitterion. Natural modifications of amino acids in proteins hydrolysine, cystine, and hydroxyproline, non-protein amino acids: Gramicidin, beta-alanine, D-alanine, and D-glutamic acid. Primary, secondary, tertiary, and quaternary structures. Enzymes: General concept of enzyme, Apoenzyme, and cofactors, prosthetic group - TPP, coenzyme - NAD, metal cofactors, Classification of enzymes (IUBMB), Mechanism of action of enzymes: active site, transition state complex, and activation energy. Lock and key hypothesis, and Induced-Fit hypothesis. Significance of hyperbolic, double reciprocal plots of enzyme activity, Km, and allosteric mechanism. Definitions of terms – enzyme unit, specific activity and turnover number, Effect of pH and temperature on enzyme activity. Enzyme inhibition: competitive- sulfa drugs; non-competitive - heavy metal salts and Uncompetitive. Feedback inhibition. Cooperativity.

Unit – 4: Lipids: Definition and major classes of storage and structural lipids. Storage-lipids. Structure and functions of fatty acids. Essential fatty acids. Triacylglycerols: structure, functions, and properties. Saponification, Iodine number. Structural lipids. Phosphoglycerides: Building blocks, general structure, functions, and properties. Structure of phosphatidylethanolamine and phosphatidylcholine. Sphingolipids: building blocks, the structure of sphingosine, ceramide. Special mention of sphingomyelins, cerebrosides, and gangliosides. Lipid functions: cell signals, cofactors, prostaglandins, Introduction to lipid micelles, monolayers, bilayers, liposome.

Unit – 5: Nucleic acids and vitamins: Base composition: Purine, pyrimidine bases, nucleoside, nucleotide - structure, properties. Types, structure, and function of DNA & RNA. Model of DNA structure. Superhelicity in DNA, linking number, topological properties. Vitamin: Classification and characteristics with suitable examples, sources, and importance.

Practical

1) Preparation of buffer - Phosphate buffer, Tris buffer.
2) Qualitative/Quantitative tests for carbohydrates, reducing sugars (DNS), and non-reducing sugars (Anthrone).
3) Qualitative/quantitative tests for amino acid (Ninhydrin), and protein (Lowry).
4) Qualitative tests for lipids - Sudan.
5) Study of enzyme kinetics – calculation of Vmax, Km, Kcat values.
6) Study the effect of temperature and pH on enzyme activity.
7) Estimation of vitamin - Ascorbic acid.

Reference Books:

1. Tortora GJ, Funke BR, Case CL. Microbiology: An Introduction. Pearson Education (2004).
2. Stanbury, Biochemistry
3. Voet & Voet. Fundamentals of Biochemistry. Wiley
4. Cox MM, Nelson DL. Lehninger's principles of biochemistry. WH Freeman
5. Stryer. Biochemistry WH Freeman
6. Jain JL, Jain S, Jain N. Fundamentals of Biochemistry. S. Chand (2016).

Course Name: Microbial Techniques and Instrumentation Course Code: BSCMCBSE201					
Course Type: **SE (Practical)**	Course Details: **SEC -2**			L-T-P: **0 - 1 - 4**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30		**20**	

Instructions: **Continuous assessment (CA) of this course should include a written test with questions from the principle portions.**

Course Learning Outcomes:

By the end of this course, the students will -

- Understand principles that underlie the sterilization of culture media, glassware, and plasticware to be used for microbiological work.
- Understand principles of several analytical instruments that the students have to use during the study and also later as microbiologists for performing various laboratory manipulations.
- Learned handling and use of microscopes for the study of microorganisms, which are among the basic skills expected from a practicing microbiologist. They are also introduced to a variety of modifications to microscopes for specialized viewing.
- Understand several separation techniques that may be required to be handled by microbiologists.

Course Content:

Theory

Unit – 1: ***Principle:*** Microscopy- Principle, mechanism, and application of photo-optical instruments (different types of microscopes), Phase contrast microscope, Bright field microscope, Dark field microscope, Fluorescence microscopy, Confocal microscopy, Scanning and transmission electron microscopy, Expansion microscopy, Micrometry.

Practical: (1) Ray diagrams of phase contrast microscopy and electron microscopy. (2) Measurement of a microscopic object using an ocular micrometer and a stage micrometer.

Unit – 2: ***Principle:*** Purification and separation techniques: Principle and techniques with applications (partition, adsorption, ion exchange, size exclusion, 2-D, HPLC, GLC, and affinity chromatography). Electrophoretic technique (agarose and polyacrylamide gel), its components, working, and applications. Principles of centrifugation and ultracentrifugation techniques and their applications. The basic idea of salting out and dialysis.

Practical: (1) Separation of mixtures by paper/ thin layer chromatography - Amino acid, Sugar; Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE); (2) Separation of components of a given mixture using a laboratory scale centrifuge; (3) Understanding density gradient centrifugation with the help of pictures.

Unit – 3: ***Principle:*** Biophysical principles: Osmosis, osmotic pressure, Donnan equilibrium, diffusion potential, diffusion coefficient, endocytosis & exocytosis, the gradient of chemical potential as driving force in transport, membrane potential & ionophores.

Practical: Demonstration of the protoplast formation using lysozyme.

Unit – 4: ***Principle:*** Principle, mechanism, and application of instruments used in spectrophotometric techniques (UV visible, IR, Fluorescence, NMR, ESR). The basic concept of CD and ORD. Radioactivity: Laws of radioactivity, half-life & average life, types of radiation (α, β, γ radiations),

application of radioactive isotopes in biology. Radioisotope dilution technique and autoradiography.

Practical: Spectrophotometric determination of DNA/RNA concentration and its purity checking without and chromogenic reaction.

Reference Books:

1. Wilson & Walker. Principles and Techniques in Practical Biochemistry. 5th Ed., Cambridge University Press (2000).
2. Murphy DB. Fundamentals of Light Microscopy & Electron Imaging. 1st Ed., Wiley-Liss. (2001).
3. Ghatak KL. Techniques and Methods: In Biology. PHI Publication (2011).
4. Kumar P. Fundamentals and Techniques of Biophysics and Molecular Biology (2016).
5. Blair A. Laboratory Techniques & Experiments: In Biology. Intelliz Press
6. Plummer DT. An Introduction to Practical Biochemistry. McGraw-Hill Publication (1987).
7. Beckner WM, Kleinsmith LJ, Hardin J. The world of cells. 4th Ed., Benjamin Cummings (2000).
8. Upadhyay, Upadhyay, Nath. Biophysical Chemistry. Himalaya Publishing House.

Semester - 3

Course Name: Cell Biology Course Code: BSCMCBMJ301					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-3**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, students will be capable of –

- Describing the structure and function of different components of a cell.
- Differentiating the cellular and molecular processes between prokaryotes and eukaryotes.

Course Content:

Theory

Unit – 1: Concepts of cell - Comparison of Prokaryotic & Eukaryotic cells. Eukaryotic cell organelles - structure and function. Eukaryotic cells - cell wall & plasma membrane; Eukaryotic cell wall, extracellular matrix, and cell-matrix interactions, cell-cell interactions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata (only structural aspects).

Unit – 2: Cytoskeleton: Structure and organization of actin filaments, microtubules. Nuclear envelope, nuclear pore complex, and nuclear lamina. Chromatin structure – Molecular organization, Nucleolus.

Unit – 3: Eukaryotic cell cycle and its regulation, Mitosis and Meiosis. Development of cancer, programmed cell death. The basic idea of stem cells and pluripotency.

Unit – 4: Basic idea and function of signalling molecules and their receptors. Pathways of intracellular receptors – Cyclic AMP pathway, cyclic GMP and MAP kinase, JAK-STAT, Integrin pathway.

Unit – 5: Protein sorting and transport - targeting and insertion of proteins in the ER, protein folding and processing, role of chaperones in protein folding, export of proteins and lipids. Protein glycosylation, sorting, and export from Golgi apparatus and Lysosomes. Outline idea of protein turnover.

Practical

1) Microscopic study of a eukaryotic cell.
2) Study of polyploidy through permanent slides.
3) Study of mitotic index in onion/garlic root tips.
4) Electron microscopic study of cellular ultrastructure. (video/photomicrographs)
5) Identification and study of cancer cells. (video/photomicrographs)
6) Demonstration of the presence of mitochondria in striated muscle cells.
7) Study of epithelial cells.

Reference Books:

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular Biology of the Cell, 4th Ed., Garland Publishing Inc. (2002).
2. Darnell, Lodish, Baltimore. Molecular Cell Biology, Scientific American Publishing Inc. (2000).

Course Name: Molecular Biology **Course Code: BSCMCBMJ302**					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-4**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, students will be capable of –

- Describing the importance and mechanism of the central dogma of life
- Differentiating the cellular and molecular processes between prokaryotes and eukaryotes.

Course Content:

Theory

Unit – 1: Structures of Genetic Material: Types of genetic material, denaturation, and renaturation, cot curves. DNA topology - linking number, topoisomerases; Organization of DNA in Prokaryotes, Eukaryotes, Viruses, mitochondria, and chloroplasts.

Unit – 2: Replication of DNA (Prokaryotes and Eukaryotes): Bidirectional and unidirectional replication, semi-conservative, semi-discontinuous replication. Mechanism of DNA replication: Enzymes and other accessory proteins involved in DNA replication – DNA polymerases, DNA ligase, primase, telomerase (for replication of linear ends). Various models of DNA replication including rolling circle, D-loop (mitochondrial), and Θ (theta) mode of replication.

Unit – 3: Transcription in Prokaryotes and Eukaryotes: Transcription: Definition, the difference from replication, promoter - concept, and strength of promoter RNA polymerase and the transcription unit. Transcription in Eukaryotes: RNA polymerases, general transcription factors. Post-transcriptional processing: Split genes, concept of introns and exons, RNA splicing, spliceosome machinery, the concept of alternative splicing, Polyadenylation and capping, Processing of rRNA, Mode of action of transcription inhibitors, RNA interference: siRNA, miRNA, and its significance.

Unit – 4: Translation (Prokaryotes and Eukaryotes): Translational machinery, Ribosome: ultrastructure and assembly, charging of tRNA, aminoacyl-tRNA synthetases, Mechanisms of initiation, elongation, and termination of polypeptides in both prokaryotes and eukaryotes, Fidelity of translation. Mode of action of translation inhibitors.

Unit – 5: Regulation of Gene Expression in Prokaryotes and Eukaryotes: Principles of transcriptional regulation. Regulation in *lac* and *trp* operons, Sporulation in *Bacillus*. Epigenetic changes in chromatin structure - DNA methylation and Histone acetylation mechanisms.

Practical

1) Study of different types of DNA and RNA using video/pictorial micrographs and model / schematic representations.
2) Study of semi-conservative replication of DNA through micrographs /schematic representations.
3) Isolation of genomic DNA from *E. coli* and checking of its purity (A260/280).
4) Estimation of salmon sperm/calf thymus DNA using UV spectrophotometer (A260 measurement).
5) Estimation of DNA and RNA using diphenylamine and orcinol reagent, and UV spectrophotometer (A260 measurement).
6) Separation and visualization of DNA by Agarose Gel Electrophoresis.
7) Extraction, Separation, and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).

Reference Books:

1. Benjamin Lewin, Gene VII, Oxford University Press, (2000).
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, Molecular Biology of the Cell, 4th Ed., Garland Publishing Inc. (2002).
3. Darnell, Lodish and Baltimore, Molecular Cell Biology, Scientific American Publishing Inc. (2000).
4. Watson JD, Baker. TA, Bell SP, Gann A, Levine M, Losick R. Molecular Biology of Gene, 5th Ed., The Benjamin/Cummings Pub. Co. Inc. (2003).
5. Brown TA. Gene Cloning and DNA Analysis. 2nd Ed., A S Mpress. (2004).
6. Sandy Primrose. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers. (2006).
7. Glick BR. Pasternak JJ. Molecular Biotechnology, 2nd Ed.ASM Press. (2003).

<table>
<tr><td colspan="6">Course Name: Fundamentals of Molecular Biology
Course Code: BSCMCBMN301</td></tr>
<tr><td colspan="2">Course Type:
Minor (Theoretical & Practical)</td><td colspan="2">Course Details: MNC-3</td><td colspan="2">L-T-P: 3 - 0 - 4</td></tr>
<tr><td rowspan="3" colspan="2">Credit: 5</td><td rowspan="3">Full Marks:
100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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<tr><td>30</td><td>15</td><td>20</td><td>35</td></tr>
</table>

Course Learning Outcomes:

By the conclusion of this course, students will be capable of –

- Describing the importance and mechanism of the central dogma of life
- Differentiating the cellular and molecular processes between prokaryotes and eukaryotes.

Course Content:

Theory

Unit – 1: Structures of Genetic Material: Types of genetic material, different models of DNA structure, salient features of the double helix, types of DNA, denaturation, and renaturation, cot curves.

Unit – 2: Replication of DNA (Prokaryotes and Eukaryotes): Bidirectional and unidirectional replication, semi-conservative, semi-discontinuous replication. Mechanism of DNA replication: Enzymes and proteins involved in DNA replication.

Unit – 3: Transcription in Prokaryotes and Eukaryotes: Transcription: Definition, the difference from replication, promoter - concept, and strength of promoter, RNA polymerase and the transcription unit. Transcription in Eukaryotes: RNA polymerases, general transcription factors.

Unit – 4: Translation (Prokaryotes and Eukaryotes): Translational machinery, charging of tRNA, aminoacyl-tRNA synthetases. Mechanisms of initiation, elongation, and termination of polypeptides in both prokaryotes and eukaryotes.

Unit – 5: Regulation of Gene Expression in Prokaryotes and Eukaryotes: Principles of transcriptional regulation. Regulation in *lac* and *trp* operons. Epigenetic changes in chromatin structure - DNA methylation and Histone acetylation mechanisms.

Practical

1) Isolation of genomic DNA from *E. coli*.
2) Estimation of salmon sperm/calf thymus DNA using a colorimeter (diphenylamine reagent) or UV spectrophotometer (A260 measurement).
3) Separation and visualization of DNA by Agarose Gel Electrophoresis.
4) Separation and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).

Reference Books:

1. Benjamin Lewin, Gene VII, Oxford University Press, (2000).
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, Molecular Biology of the Cell, 4th Ed., Garland Publishing Inc. (2002).
3. Darnell, Lodish, Baltimore. Molecular Cell Biology, Scientific American Publishing Inc. (2000).
4. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. Molecular Biology of Gene, 5th Ed., The Benjamin/Cummings Pub. Co. Inc. (2003).
5. Brown TA. Gene Cloning and DNA Analysis. 2nd Ed., ASM Press. (2004).
6. Sandy Primrose. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers. (2006).
7. Glick BR, Pasternak JJ. Molecular Biotechnology, 2nd Ed. ASM Press. (2003).

Semester - 4

Course Name: Microbial Diagnostics and Public Health Course Code: BSCMCBMJ401					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-5**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students will -

- Developed a good understanding of the practical aspects of the collection of different clinical samples, their transport, culture, and examination by staining, and molecular and immunological diagnostic methods for the diagnosis of microbial diseases.
- Developed an excellent understanding of the practical aspects of antibiotic sensitivity testing, water and food testing skills using kits available in the market.

Course Content:

Theory

Unit – 1: Importance of diagnosis of diseases: Bacterial, Viral, Fungal, and Protozoan diseases of various human body systems, Disease-associated clinical samples for diagnosis.

Unit – 2: Collection of clinical samples: How to collect clinical samples (oral cavity, throat, skin, Blood, CSF, urine, and feces) and precautions required. Method of transport of clinical samples to laboratory and storage.

Unit – 3: Direct microscopic examination and culture. Examination of the sample by staining - Gram stain, Ziehl-Neelsen staining for tuberculosis, Giemsa-stained thin blood film for malaria. Preparation and use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar. Distinct colony properties of various bacterial pathogens.

Unit – 4: Serological and molecular methods: Serological methods - Agglutination, ELISA, immunofluorescence; Nucleic acid-based methods - PCR, Nucleic acid probes. Kits for rapid detection of pathogens: Typhoid, Dengue, HIV, and Swine flu.

Unit – 5: Testing for antibiotic sensitivity in bacteria: Importance, determination of resistance/ sensitivity of bacteria using disc diffusion method, determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method.

Practical

1) Isolation of bacteria in pure culture and antibiotic sensitivity.
2) Identification of common bacteria (*E. coli, Staphylococcus aureus*, and *Streptococcus* sps.) by studying their morphology, cultural characteristics, biochemical reactions, and other tests.
3) Maintenance and preservation of stock culture.

Reference Books:

1. Ananthanarayan R, Paniker CKJ. Textbook of Microbiology. 7 Press Publication. (2005).
2. Prescott's Microbiology, Authors Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton, Publisher McGraw-Hill (2011).

Course Name: Industrial Microbiology **Course Code: BSCMCBMJ402**					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-6**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students will -

- Be capable of describing a large number of substrates that are used for industrial fermentation processes.
- Developed an understanding of different types of reactors or fermenters, which are used for laboratory, pilot, and industrial scale fermentations and their process parameters.
- Acquired a detailed knowledge of several products that are produced by industrial fermentation processes.

Course Content:

Theory

Unit – 1: Sources of industrially important microbes and methods for their isolation, preservation, and maintenance of industrial strains, strain improvement, crude, and synthetic media; molasses, corn-steep liquor, sulfite waste liquor, whey, yeast extract, and protein hydrolysates.

Unit – 2: Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (e.g., Baker's yeast), and continuous fermentations. Components of a typical bioreactor, Types of bioreactors - laboratory, pilot-scale and production fermenters, constantly stirred tank and air-lift fermenters. Measurement and control of fermentation parameters-pH, temperature, dissolved oxygen, foaming, and aeration.

Unit – 3: Downstream processing; Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization, and spray drying. Microbial cells as food. SCP - mushroom cultivation.

Unit – 4: Microbial production of industrial products (microorganisms involved, media, fermentation conditions, downstream processing, and uses) - citric acid, ethanol, penicillin, glutamic acid, Vitamin B_{12}. Enzymes (amylase), wine, and beer.

Unit – 5: Methods of immobilization, advantages, and applications of immobilization, large-scale applications of immobilized enzymes (glucose isomerase). Role of microbes in medicine and textile industry.

Practical

1) Demonstrate different parts of the fermenter.
2) Microbial fermentations for the production and estimation (qualitative and quantitative) of:
   (a) Enzymes: Amylase
   (b) Amino acid: Glutamic acid
   (c) Alcohol: Ethanol
3) Enzyme or cell immobilization in sodium alginate or a suitable bead. Followed by activity comparison of free enzyme and enzyme seeded in the beads.
4) Visit any industry or production center related to microbiology and prepare a report on the entire visit. *(Mandatory for all students of all colleges unless there is any severe health issue)*. College-industry certification.

Reference Books:

1. Reed G. Prescott and Dunn's Industrial Microbiology. CBS Publishers. (1999).
2. Demain AL. Industrial Microbiology and Biotechnology. 2nd Ed., (2001).
3. Waites MJ, Morgan NL, Rockey JS, Higton G. Industrial Microbiology: An Introduction. Blackwell Science Publishers (2002).
4. Casida LE. Industrial Microbiology, J. Wiley, (1968).
5. Pelczar MJ, Chan ECS, Krieg NR. Microbiology, McGraw-Hill.
6. Willey, Sherwood, Woolverton. Prescott, Harley and Klein's Microbiology. McGraw-Hill Publ.
7. Tortora, Funke, Case. Microbiology. Pearson Benjamin Cummings.

<table>
<tr><td colspan="5">Course Name: Microbial Physiology and Metabolism
Course Code: BSCMCBSE401</td></tr>
<tr><td>Course Type:
SE (Practical)</td><td colspan="2">Course Details: SEC - 3</td><td colspan="2">L-T-P: 0 - 1 - 4</td></tr>
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50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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</table>

***Instructions*: Continuous assessment (CA) of this course should include a written test with questions from the principle portions.**

Course Learning Outcomes:

By the conclusion of this course, the students will be capable of-

- Describing the growth characteristics of the microorganisms capable of growing under the unusual environmental conditions of temperature, oxygen, solute, and water activity.
- Describing the growth characteristics of the microorganisms that require different nutrients for growth and the associated mechanisms of energy generation for their survival, like autotrophs, heterotrophs, chemolithoautotrophs, etc.
- Differentiating concepts of aerobic and anaerobic respiration and how these are manifested in the form of different metabolic pathways in microorganisms.

Course Content:

Unit – 1: ***Principle:*** Definitions of growth, measurement of microbial growth, Phases of growth, Batch culture, Continuous culture, generation time and specific growth rate, synchronous growth, and diauxic growth curve. Microbial growth in response to the environment - Temperature (psychrophiles, mesophiles, thermophiles, extremophiles, thermoduric, psychrotrophs), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative anaerobe), barophilic.

Practical: (1) Study and plot the growth curve of *E. coli* by turbidometric. (2) Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data

Unit – 2: ***Principle:*** Microbial growth in response to nutrition and energy – Autotroph/ phototroph, heterotrophy, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, Photolithoautotroph, Photoorganoheterotroph. Passive and facilitated diffusion. Primary and secondary active transport, concept of uniport, symport and antiport, Group translocation, Iron uptake.

Practical: (1) Effect of temperature on growth of *E. coli*, (2) Effect of pH on growth of *E. coli*, (3) Effect of salt on the growth of *E. coli*.

Unit – 3: ***Principle:*** Concept of aerobic metabolism, anaerobic metabolism, and fermentation - Sugar degradation pathways, i.e., EMP, ED, Pentose phosphate pathway, TCA cycle. Electron transport chain: components of the respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers, and inhibitors. Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways). Account of beta-oxidation of even and odd numbers, saturated and unsaturated fatty acids.

Practical: Demonstration of alcoholic fermentation.

Unit – 4*:* ***Principle:*** Introduction to aerobic and anaerobic chemolithotrophy with an example of each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction). Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic vs. oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria, and Cyanobacteria.

Practical: Demonstration of the thermal death time and thermal death point of *E. coli*.

Unit – 5: ***Principle:*** Anaerobic respiration with special reference to dissimilatory nitrate. Reduction (denitrification; nitrate/nitrite and nitrate/ammonia respiration; fermentative nitrate reduction). Concept & mechanism of biological nitrogen fixation, Ammonia assimilation. Assimilatory nitrate reduction, dissimilatory nitrate reduction, and denitrification. Concept and reaction of transamination, deamination, transmethylation and decarboxylation. Urea cycle in connection with amino acid catabolism.

Practical: Effect of deprivation of carbon and nitrogen sources on growth of *E. coli*.

Reference Books:

1. Voet & Voet. Fundamentals of Biochemistry Wiley
2. Cox MM, Nelson DL. Lehninger's principles of biochemistry. WH Freeman
3. Stryer. Biochemistry. WH Freeman
4. Jain JL, Jain S, Jain N. Fundamentals of Biochemistry. (2016) S. Chand
5. Madigan, Martinko, Bender, Buckley, Stahl. Brock Biology of Microorganisms. Pearson
6. Prescott MJ, Harley JP, Klein DA. Microbiology. 5th Ed., WCB McGraw-Hill, New York.

Course Name: Public Health and Microbial Diagnostics Course Code: BSCMCBMN401					
Course Type: **Minor (Theoretical & Practical)**	Course Details: **MNC-4**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students will -

- Developed a good understanding of the practical aspects of the collection of different clinical samples, their transport, culture, and examination by staining, as well as molecular and immunological diagnostic methods for the diagnosis of microbial diseases.
- Developed an excellent understanding of the practical aspects of antibiotic sensitivity testing, water and food testing skills using kits available in the market.

Course Content:

Theory

Unit – 1: Importance of diagnosis of diseases: Bacterial, Viral, Fungal, and Protozoan diseases of various human body systems, Disease-associated clinical samples for diagnosis.

Unit – 2: Collection of clinical samples: How to collect clinical samples (oral cavity, throat, skin, Blood, CSF, urine, and faeces) and precautions required. Method of transport of clinical samples to laboratory and storage.

Unit – 3: Direct microscopic examination and culture. Examination of the sample by staining - Gram stain, Ziehl-Neelsen staining for tuberculosis, Giemsa-stained thin blood film for malaria. Preparation and use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar, Distinct colony properties of various bacterial pathogens.

Unit – 4: Serological and molecular methods: Serological methods - Agglutination, ELISA, immunofluorescence, Nucleic acid-based methods - PCR, Nucleic acid probes. Kits for rapid detection of pathogens: Typhoid, Dengue, HIV, and Swine flu.

Unit – 5: Testing for antibiotic sensitivity in bacteria: Importance, determination of resistance/ sensitivity of bacteria using disc diffusion method, Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method.

Practical

1) Isolation of bacteria in pure culture and Antibiotic sensitivity.
2) Identification of common bacteria (*E. coli, Staphylococcus aureus,* and *Streptococcus* sps.) by studying their morphology, cultural characteristics, Biochemical reactions, and other tests.
3) Maintenance and preservation of stock culture.

Reference Books:

1. Ananthanarayan R, Paniker CKJ. Textbook of Microbiology. 7 Press Publication. (2005).
2. Prescott MJ, Harley JP, Klein DA. Microbiology. 5th Ed., WCB McGraw-Hill, New York.

Semester - 5

Course Name: Environmental Microbiology and Microbial Ecology Course Code: BSCMCBMJ501					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-7**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the completion of this course, the students will -

- Developed a reasonably good knowledge and understanding of different types of environments and habitats where microorganisms grow, including the microbiomes of the human gut and animal gut.
- Be able to identify the important role microorganisms play in maintaining a healthy environment by degradation of solid/liquid wastes; how these activities of microorganisms are used in sewage treatment plants, the production of activated sludge, and the functioning of septic tanks.
- Understood the significance of BOD/ COD and various tests involving the use of enumerating faecal *E. coli* for assessing the quality of water.
- Developed the practical skills for conducting experiments to assess the BOD/COD of waste waters and their interpretation; practically assess the portability of drinking water by the use of standard microbiological tests.

Course Content:

Theory

Unit – 1: Terrestrial Environment: Soil profile and soil microflora. Aquatic Environment: Microflora of freshwater and marine habitats. Atmosphere: Aeromicroflora and dispersal of microbes. Air purification. Animal Environment: Microbes in/on the human body (microbiomics), & animal (ruminant) body.

Unit – 2: Solid Waste Management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill). Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank), and tertiary sewage treatment.

Unit – 3: Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter, and biosurfactants. Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (I) standard qualitative procedure: presumptive test/ MPN test, confirmed and completed tests for faecal coliforms, (II) Membrane filter technique.

Unit – 4: History, significance, and developments in the field of microbial ecology. Contributions of Beijerinck, Winogradsky, and Waksman. Structure and function of ecosystems. Microbial succession in the decomposition of plant organic matter. Biological Interaction: (I) Microbe–Microbe Interactions - Mutualism, Synergism, Commensalism, Competition, Amensalism, Parasitism, Predation. Biocontrol agents, (II) Microbe–Plant Interactions: Rhizospheric, Phyllospheric, Caulospheric, Endophytic.

Unit – 5: Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin, and chitin. Nitrogen cycle: Nitrogen fixation, ammonification, anammox, nitrification, denitrification, and nitrate reduction. Phosphorus cycle: Phosphate immobilization and solubilization. Sulfur cycle: Microbes involved in the sulfur cycle.

Practical

1) Analysis of soil pH, moisture content, and water holding capacity.
2) Isolation of microbes (bacteria & fungi) from soil with different moisture content.
3) Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4) Assessment of microbiological quality of water- Rapid kit-based coliform detection, MPN, IMViC.
5) Demonstration of BOD of the wastewater sample- Titration method
6) Isolation of amylase-producing bacteria from soil.
7) Isolation of Rhizobium from root nodules.

Reference Books:

1. Medigan MT, Martinko JM, Parker J. Brock Biology of Microorganisms. Pearson Education Inc., New York.
2. Pelczar MJ, Chan ECS, Krieg NR. Microbiology. McGraw-Hill.
3. Willey JM, Sherwood LM, Woolverton CJ. Prescott, Harley, and Klein's Microbiology, McGraw-Hill Publication.
4. Tortora GJ, Funke BR, Case CL. Microbiology. Pearson Benjamin Cummings.
5. Black JG. Microbiology Principles and Explorations. John Wiley & Sons, Inc.

<table>
<tr><th colspan="6">Course Name: Microbial Genetics
Course Code: BSCMCBMJ502</th></tr>
<tr><td colspan="2">Course Type:
Major (Theoretical & Practical)</td><td colspan="2">Course Details: MJC-8</td><td colspan="2">L-T-P: 3 - 0 - 4</td></tr>
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100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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<tr><td colspan="2"></td><td>30</td><td>15</td><td>20</td><td>35</td></tr>
</table>

Course Learning Outcomes:

By the conclusion of this course, the students will -

- Understood genome organization of model organisms, namely *E. coli* and *Saccharomyces*, and the molecular mechanisms that underlie mutations.
- Developed a fairly good knowledge about the three well-known mechanisms by which genetic material is transferred among microorganisms, namely transformation, transduction, and conjugation.
- Be able to describe different types of extra-chromosomal elements or plasmids, and the nature of the transposable elements in prokaryotic and eukaryotic cells.
- Gain hands-on skills in the isolation of plasmid DNA from bacterial cells and its visualization by performing agarose gel electrophoresis.

Course Content:

Theory

Unit – 1: Genome organization: *E. coli, Saccharomyces*. Mutations and mutagenesis: Definition and types of mutations; Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations. Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes. DNA damage & repair.

Unit – 2: Microbial Genetics: Transformation - discovery, Griffith's experiment, mechanism of transformation; Factors affecting transformation process, Competence and development of competence in *S. pneumoniae*. Transduction – discovery, Lederberg and Tatum's experiment, mechanism and types of transductions - generalized transduction, specialized transduction, sexduction, and abortive transduction.

Unit – 3: Bacterial Conjugation - discovery, experimental evidence, F-factor, F+ & Hfr, mechanism of conjugation, Cross between Hfr, F+, F- & F′ Conjugant and its application. Mapping based on bacterial genetics.

Unit – 4: Types of plasmids – F plasmid, R plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast-2µ plasmid; Plasmid replication and partitioning, host range, plasmid-incompatibility, plasmid amplification, regulation of copy number, curing of plasmids.

Unit – 5: Prokaryotic transposable elements – Insertion sequences, composite and non-composite transposons, Replicative and non-replicative transposition, Mu transposon. Eukaryotic transposable elements - Maize (Ac/Ds). Uses of transposons and transposition.

Practical

1) Study the effect of UV mutagen on bacterial cells and study the survival curve of bacteria after exposure to ultraviolet (UV) light.
2) Preparation of master and replica plates.
3) Isolation of genomic DNA from *E. coli* and visualization through agarose gel electrophoresis.
4) Demonstration of bacterial conjugation.
5) Demonstration of bacterial transformation and transduction.

Reference Books:

1. Lewin B. Gene VII. Oxford University Press (2000).
2. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. Molecular Biology of the Cell, 4th Ed., Garland Publishing Inc. (2002).
3. Darnell JE, Lodish H, Baltimore D. Molecular Cell Biology, Scientific American Publ. Inc. (2000).
4. Watson. JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. Molecular Biology of Gene, 5th Ed., The Benjamin Cummings Pub. Co. Inc. (2003).
5. Brown TA, Gene Cloning and DNA Analysis. 2nd Ed., ASM Press. (2004).
6. Primrose S. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers. (2006).
7. Glick BR, Pasternak JJ. Molecular Biotechnology, 2nd Ed. ASM Press. (2003).
8. Streips UN, Yasbin RE. Modern Microbial Genetics. 2nd Ed., Wiley-Liss, Inc. (2002).
9. Gardner EJ, Simmons MJ, Snupstad DP. Principles of Genetics, 8th Ed., John Wiley & Sons. (2006).
10. Freifelder D. Essentials of Molecular Biology. Jones and Bartlett Publishers, 1998.

Course Name: Virology Course Code: BSCMCBMJ503					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-9**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students will -

- Understood what viruses are and the chemical nature of viruses, different types of viruses infecting animals, plants, and bacteria (bacteriophages)
- Understand the biology of bacteriophages.
- Gained knowledge of a variety of plant viruses and animal viruses.
- Gained the ability to describe the role of viruses in the causation of cancer

Course Content:

Theory

Unit – 1: Virology: Discovery of viruses, nature and definition of viruses, general properties, Theories of viral origin, Structure of viruses. Modes of viral infection: Persistent, non-persistent; viral transmission: vertical and horizontal. Concept of viroids, virusoids, satellite viruses, and Prions. Viral taxonomy- Classification and nomenclature of different groups of viruses - ICTV & Baltimore system of classification.

Unit – 2: Isolation, purification, and cultivation of bacterial viruses. Study of the one-step growth curve of bacterial viruses. Types of bacteriophages, lytic and lysogenic phages (lambda phage), concept of early and late proteins, regulation of transcription in lambda phage, and T4.

Unit – 3: Replication, assembly, maturation, and release of viruses. Salient features of viral nucleic acid: Unusual bases (TMV, T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double-stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV) Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies (ϕX174, Retroviridae, M13).

Unit – 4: Introduction to oncogenic viruses. Types of oncogenic DNA and RNA viruses. Concepts of oncogenes, proto-oncogenes, and viral origin onco-proteins.

Unit – 5: Antiviral compounds and their mode of action; Interferons and their mode of action; viral vaccines. Viral outbreaks- MARS and SARS-CoV-2

Practical

1) Study of the structure of important animal viruses (Rhabdo, Influenza, Paramyxo) using electron micrographs.
2) Study the structure of important plant viruses (Gemini, tobacco mosaic, and alpha-alpha mosaic viruses) using electron micrographs.

3) Study of the structure of important bacterial viruses (M13, T4) using electron micrographs.
4) Isolation and enumeration of bacteriophages (PFU) from water/sewage samples using the double agar layer technique.

Reference Books:

1. Pelczar M, Chan ECS, Krieg NR. Microbiology. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. Stainier RV, Ingraham JL, Wheelis ML, Painter PR. The Microbial World. Printice-Hall of India (Pvt.) Ltd., New Delhi
3. Strauss E, Strauss J. Viruses and Human Disease, 2nd Ed., Academic Press
4. Burrell C, Howard C, Murphy F. Fenner and White's Medical Virology, 5th Ed., Academic Press

Course Name: Introduction to Virology **Course Code: BSCMCBMN501**					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MNC-5**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students will -
- Understood what viruses are and the chemical nature of viruses, different types of viruses infecting animals, plants, and bacteria (bacteriophages)
- Understand the biology of bacteriophages.
- Gained knowledge of a variety of plant viruses and animal viruses.
- Gained the ability to describe the role of viruses in the causation of cancer.

Course Content:

Theory

Unit – 1: Virology: Discovery of viruses, nature and definition of viruses, general properties; Theories of viral origin; Structure of viruses. Preliminary idea of modes of viral infection. Concept of viroids, virusoids, satellite viruses, and Prions. Viral taxonomy- Classification of viruses - ICTV.

Unit – 2: Isolation, purification, and cultivation of bacterial viruses. Study of the one-step growth curve of bacterial viruses. Types of bacteriophages, lytic and lysogenic phages (lambda phage), concept of early and late proteins, T4.

Unit – 3: Replication, assembly, maturation, and release of viruses. Salient features of viral nucleic acid. Replication strategies (ϕX174, Retroviridae).

Unit – 4: Introduction to oncogenic viruses. Concepts of oncogenes and proto-oncogenes.

Unit – 5: Antiviral compounds and their mode of action; Interferon and its mode of action; viral vaccines. Viral outbreaks- MARS and SARS-CoV-2.

Practical

1) Study of the structure of important animal viruses (Rhabdo, Influenza, Paramyxo) using electron micrographs.
2) Study the structure of important plant viruses (Gemini, tobacco mosaic, and alpha-alpha mosaic viruses) using electron micrographs.
3) Study of the structure of important bacterial viruses (M13, T4) using electron micrographs.
4) Isolation and enumeration of bacteriophages (PFU) from water/sewage samples using the double agar layer technique.

Reference Books:

1. Pelczar M, Chan ECS, Krieg NR. Microbiology. Tata McGrew Hill Publishing Co. Ltd., New Delhi.
2. Stainier RV, Ingraham JL, Wheelis ML, Painter PR. The Microbial World. Printice-Hall of India (Pvt.) Ltd., New Delhi
3. Strauss E, Strauss J. Viruses and Human Disease 2nd Ed., Academic Press
4. Burrell C, Howard C, Murphy F. Fenner and White's Medical Virology, 5th Ed., Academic Press

Semester - 6

Course Name: Medical and Veterinary Microbiology Course Code: BSCMCBMJ601					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-10**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students will clearly -

- Understood the basic and general concepts of causation of disease by the pathogenic microorganisms and the various parameters of assessment of their severity, including the broad categorization of the methods of diagnosis.
- Develop a thorough understanding of common bacterial, viral, fungal, and parasitic diseases of human beings, including some important diseases of animals.

Course Content:

Theory

Unit – 1: Importance of 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. Transmission of infection, Pathophysiologic effects of LPS. Collection, transport, and culturing of clinical samples.

Unit – 2: List of diseases of various organ systems and their causative agents. Symptoms, mode of transmission, prophylaxis, and control of the diseases: Botulism, Tetanus, Hepatitis, Dengue, AIDS, Tuberculosis (MDR, XDR).

Unit – 3: Study of the following animal diseases concerning etiology, symptoms, mode of transmission, prophylaxis, and control: Bird flu, Rabies.

Unit – 4: Antimicrobial agents: source, general characteristics, and mode of action; Basic idea of antimicrobial agents (physical, chemical, and chemotherapeutic). Chemotherapeutic agents: criteria and basic idea.

Unit – 5: Classification of antibiotics based on the mode of action (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. General idea of drug resistance (MDR, MRSA).

Practical

1) Bacterial identification (any three of *E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus*) using laboratory strains on the basis of cultural, morphological, and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests.
2) Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS.
3) Study of bacterial flora of skin Swab method).
4) Perform an antibiotic susceptibility profile by Kirby-Bauer method.

5) Determination of minimal inhibitory concentration (MIC) of an antibiotic.
6) Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ring worms).
7) Study of various stages of the malarial parasite in RBCs using permanent mounts.

Reference Books:

1. Ananthanarayan R, Paniker CKJ (2009). Textbook of Microbiology. 8th Ed., University Press Publication
2. Brooks GF, Carroll K, Butel JS, Morse SA, Mietzner TA (2013). Jawetz, Melnick and Adelberg's Medical Microbiology. 26th Ed., McGraw-Hill Publication
3. Goering R, Dockrell H, Zuckerman M, Wakelin D (2007). Mims' Medical Microbiology. 4th Ed., Elsevier
4. Willey JM, Sherwood LM, Woolverton CJ (2013). Prescott, Harley and Klein's Microbiology. 9th Ed., McGraw-Hill Higher Education
5. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2014). Brock Biology of Microorganisms. 14th Ed., Pearson, International Ed.,

Course Name: Immunology **Course Code: BSCMCBMJ602**					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-11**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students will clearly -

- Conceptualized the protective role of the immune system of the host and developed an understanding of the basic components as well as the mechanisms underlying the immune system and its response to pathogenic microorganisms.
- Able to conduct experiments for growing common bacteria in different microbiological media, antibiotic sensitivity determination, and antigen-antibody reaction (precipitation test in agarose)

Course Content:

Theory

Unit – 1: Introduction: Concept of innate and adaptive immunity; Contributions of the following scientists to the development of the field of immunology - Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Susumu Tonegawa.

Immune Cells and Organs: Structure, functions, and properties of immune cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT

Unit – 2: Generation of Immune Response: Primary and secondary immune response; Generation of Humoral immune response (plasma and memory cells).

Antigens: Characteristics of an antigen (Foreignness, molecular size, and heterogeneity); Epitopes (T & B cell epitopes), T-dependent and T-independent antigens; Haptens, Adjuvants.

Antibodies: Structure, types, functions and properties of antibodies; Antigenic determinants on antibodies (isotypic, allotypic, idiotypic); VDJ rearrangements; Monoclonal and chimeric antibodies.

Unit – 3: Major Histocompatibility Complex: Organization of MHC locus (Mice & Humans); Structure and functions of MHC I & II molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways).

Complement System: Components of the complement system; Activation pathways (classical, alternative, and lectin pathways); Biological consequences of complement activation.

Generation of cell-mediated immune response (Self MHC restriction, T cell activation, Co-stimulatory signals); Killing mechanisms by CTL and NK cells, Introduction to tolerance. Concept of vaccination.

Unit – 4: Immunological Disorders and Tumour Immunity: Types of autoimmunity and hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice), Types of tumours, tumour antigens, causes and therapy for cancers.

Unit – 5: Immunological Techniques: Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, Radio-Allergo Sorbent Test (RAST), Western blotting, Immunofluorescence, Flow cytometry, CART Cells and their application.

Practical

1) Identification of human blood groups - Blood agglutination and grouping
2) Enumeration of the total leukocyte count of the given blood sample.
3) Study of immunodiffusion by the Ouchterlony double immunodiffusion method.
4) DOT ELISA.
5) Rocket immunoelectrophoresis.

Reference Books:

1. Roitt I. Essential Immunology. 10th Ed. Blackwell Science.
2. Kuby. Immunology. 4th Ed., WH Freeman & Company.
3. Willey JM, Sherwood LM, Woolverton CJ (2013). Prescott, Harley and Klein's Microbiology. 9th Ed., McGraw-Hill Higher Education.

Course Name: Food and Dairy Microbiology Course Code: BSCMCBMJ603					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-12**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students will clearly -

- Develop an understanding of the multifarious roles of microorganisms in the soil, in association with plants, and thus in the field of agriculture.
- Able to describe the role of microorganisms in the production of food, its spoilage, and their role in homemade fermented foods.
- Able to identify the role of microorganisms in the causation of diseases and how to protect against food-borne pathogens.
- Develop experimental skills for testing the milk and different foods for the presence of microorganisms

Course Content:

Theory

Unit – 1: Microbes and their importance in the maintenance of soil fertility. Vermicompost. Concept of Rhizosphere, Phyllosphere, Rhizoplane.

Unit – 2: Intrinsic and extrinsic factors that affect the growth and survival of microbes in foods, natural flora, and sources of contamination of foods in general. Spoilage of vegetables, fruits, eggs, butter, bread, and canned foods. Principles of food preservation: temperature, canning, drying, irradiation, microwave processing, and aseptic packaging. Chemical methods of food preservation: salt, sugar, organic acids, SO_2, benzoates, nitrite.

Unit – 3: Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, and cheese; Other fermented foods: sauerkraut, soy sauce, and tempeh; Probiotics: health benefits, types of microorganisms used, probiotic foods available in the market; Prebiotics & Symbiotics. Utilization and disposal of dairy by-product – whey.

Unit – 4: Food-borne diseases (causative agents, foods involved, symptoms, and preventive measures) - Food intoxications: *Clostridium botulinum,* and mycotoxins; Food infections: *Vibrio cholerae*, *Escherichia coli*, Salmonellosis, and *Campylobacter jejuni*.

Unit – 5: Food sanitation and control; HACCP, Indices of food sanitary quality, and sanitizers. Cultural and rapid detection methods of food-borne pathogens using predictive microbiology: SMAC, Rainbow agar, CHROM agar, LAMP; Biosensors in food- ECL, FRET, Aptamer. Genetically modified foods, Nutraceuticals. Applications of microbial enzymes in the dairy industry (Protease, Lipases, Lactase).

Practical

1) MBRT of milk samples.

2) Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3) Isolation of any food-borne bacteria from food products and reporting of colony morphology and staining properties.
4) Isolation of spoilage microorganisms from spoiled vegetables (from carrot)/ fruits and reporting of colony morphology and staining properties.
5) Preparation of Fermented Rice/Dahi/Beat Kanzi.

Reference Books:

1. Salle AJ. Fundamental Principles of Bacteriology (7th Ed.). McGraw-Hill. New York and London.
2. Subba Rao NS. Soil Microbiology. Oxford and IBH Publishing Company (2009).
3. Prescott MJ, Harley JP, Klein DA. Microbiology. 5th Ed., WCB McGraw-Hill, New York (2002).
4. Pelczar MJ, Chan ECS, Krieg NR. Microbiology, McGraw-Hill.
5. Medigan MT, Martinko JM, Parker J. Brock Biology of Microorganisms. Pearson Education Inc., New York.

Course Name: Heredity and Evolution **Course Code: BSCMCBMJ604**					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-13**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students have -
- Developed a perception of evolution by taking examples from well-studied model organisms of bacteria, fungi, and other organisms.
- Good understanding of concepts of Mendelian genetics and structural organizations of chromosomes.
- Developed practical skills to do karyotyping and pedigree analysis

Course Content:

Theory

Unit – 1: Historical developments; Model organisms in genetic analyses and experimentation: *Escherichia coli, Saccharomyces cerevisiae, Arabidopsis thaliana, Drosophila melanogaster, Danio rerio*. Mendel's Laws: dominance, segregation, independent assortment, deviation from Mendelian inheritance, Chromosome theory of inheritance: allele, multiple alleles, pseudo allele, complementation tests.

Unit – 2: Extensions of Mendelian genetics: allelic interactions, the concept of dominance, recessiveness, incomplete dominance and co-dominance, multiple alleles, epistasis. Linkage and recombination of genes, cytological basis of crossing over, crossing over at four-strand stage, molecular mechanisms of crossing over, mapping.

Unit – 3: Interaction of genes (Factor hypothesis) – complementary gene, inhibitory gene, duplicate gene, and lethal gene. Rules of extranuclear inheritance, Organelle heredity- Chloroplast mutations in *Chlamydomonas*, mitochondrial mutations in *Saccharomyces*, Maternal effects– Shell coiling in *Limnaea peregra*. Infectious heredity - Kappa particles in *Paramecium*. DNA repair mechanisms: mismatch and excision.

Unit – 4: Structural organization of chromosomes - centromeres, telomeres and repetitive DNA, Packaging DNA molecules into chromosomes, Concept of euchromatin and heterochromatin, Normal and abnormal karyotypes of human chromosomes, Chromosome banding; Giant chromosomes: polytene and lampbrush chromosome;, Variations in chromosome structure: deletion, duplication, inversion and translocation; Variation in chromosomal number and structural abnormalities - Klinefelter syndrome, Turner syndrome, Down syndrome.

Unit – 5: Homologous and non-homologous recombination, Transpositional and site-specific recombination. Basics of Pedigree analysis, Polygenic inheritance.

Practical

1) Assessing the Mendelian principle using the Chi-square test.
2) Demonstration of Barr Body.
3) Demonstration of Karyotyping.
4) Study of polytene chromosomes from *Drosophila*/Chironomid larvae.

Reference Books:

1. Gardner EJ, Simmons MJ, Snustad DP. Principles of Genetics. 8th Ed. Wiley-India
2. Snustad DP, Simmons MJ (2011). Principles of Genetics. 6th Ed. John Wiley and Sons Inc.
3. Weaver RF, Hedrick PW. Genetics. 3rd Ed. McGraw-Hill Education
4. Klug WS, Cummings MR, Spencer CA, Palladino M (2012). Concepts of Genetics. 10th Ed. Benjamin Cummings
5. Griffith AJF, Wessler SR, Lewontin RC, Carroll SB. (2007). Introduction to Genetic Analysis. 9th Ed. W.H. Freeman and Co., New York
6. Russell PJ. iGenetics - A Molecular Approach. Benjamin Cummings.

Course Name: Summer Internship Course Code: SI601					
Course Type: **Summer Internship (Practical)**	Course Details: **SIMC-1**			L-T-P: **0 - 0 - 4**	
Credit: **2**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30		**20**	

University Guidelines/Modalities on Summer Internship:

1. About the Internship:

The internship is an integral component of the academic programme and is designed to provide students with exposure to real-world work environments, research settings, and community engagement opportunities. Students are required to complete the internship during the designated period and submit all required documents for evaluation within the stipulated timeline.

The internship programs for employability are to be conceptualized and interactive for building research capabilities/aptitude/skills for

1. Development of the project and its execution
2. Decision-making
3. Confidence development
4. Working/coordinating in a team
5. Creative and critical thinking and problem-solving
6. Ethical values
7. Professional development
8. Understanding the government/local bodies' world of work
9. Reference of resource persons in the field
10. Development of an online/ simulation-based module for a virtual research internship
11. Understanding the nuances of building a deep-technology start-up
12. Entrepreneurship
13. Study of the enterprises, farmers, artisans, etc.

2. Scope of Internship:

Students will undergo an internship at Home Institutions (from departments excepting the parent departments), University, Academic and research Institutions, local industry, business organizations, health and allied areas, local governments (such as panchayats, municipalities), Parliament or elected representatives, media organizations, artists, crafts persons, and a wide variety of organizations.

Internship may be as field-work training/training in the laboratory under the supervision of a **Supervisor** from the parent department (own college) and a **Mentor** from the host department/Institution/Organization.

Activities to be performed under internship should follow the syllabus of the discipline concerned. (**link:** https://www.knu.ac.in/syllabus)

3. Nodal Officer and Research & Development (R&D) Cell:

The R&D Cell of each affiliated institution shall oversee the implementation of the Internship Programme through a designated Nodal Officer appointed by the Principal/TIC of the concerned Institution.

Affiliated colleges are to develop an online internship registration system on their college websites to facilitate the process for students.

4. Duration of Internship:

- **60 Working Hours** (preferably offline)
- Equivalent to **2 Credits**
- From the completion of the 4th semester (ESE) exam till the commencement of the 6th semester Examinations (ESE) – subject to prior approval of the Principal/TIC of the college / Head or Coordinator in case of University Department.

5. Report Submission Requirements:

Each student must submit:

a) Internship Report (3000–5000 words)
b) **Internship Completion Certificate** issued by the Supervisor and Mentor certifying the performance and attendance of the intern.
c) **Self-Assessment and Feedback Form**
d) **COPY OF DECLARATION FORM** regarding IPR issue
e) **COPY OF DECLARATION FORM FROM STUDENT**
f) Any additional documents, if required by the college/university.

6. Evaluation Process:

- **Continuous Assessment (CA): 30 Marks**
  - To be assessed by the **Supervisor** in consultation with the Mentor
  - Based on attendance, performance, and report quality
- **End Semester Evaluation (ESE): 20 Marks**
  - To be conducted at the home institution
  - Through seminar presentation and/or viva-voce
  - To be assessed by **AT LEAST two Internal Examiners** from the Home institution (concerned Colleges), comprising the supervisor and another teacher nominated by the R& D Cell of the concerned college

All evaluation processes, including mark submission for SI601, must be completed by 10th July -2026 (For the session -2025-26 only)

7. Compliance:

All UG students are directed to strictly adhere to these guidelines. Non-completion of the internship will result in withholding of results/degree award as per university regulations.

Discipline-specific Activities and Guidelines for Microbiology:

ACTIVITIES OFFERED BY MICROBIOLOGY: *Students will learn at least one of the following:*

1) Bacterial culture maintenance and its techniques.
2) Natural sample microbiological quality testing and its techniques.
3) Biochemical testing for bacterial culture identification and its techniques.
4) Survey microbial load in different industrial/ ecological/ medicinal/ socio-economic fields.

5) Bioinformatic analysis of macromolecules.
6) Rearing and maintenance of model and/or laboratory organisms.
7) Bioassay techniques.
8) Handling of equipment (UV-Vis spectrophotometer/ PCR/ fluorescence microscope/ centrifuge machine/ microtome/ laminar airflow/ western blotting, etc.)
9) Project development, manuscript writing, and learning ethics in research.
10) Experimental design and conduct of *in-vivo*/ *in-vitro* experiments/ short research projects, preparation of laboratory reagents, data analysis, and interpretation.

EVALUATION:

- On completion of the summer internship program, students will submit a report (as per the guidelines and specified format) with relevant photographs as part of the report.
- The report must include all the duly signed certificates and forms as specified by the University.
- The following marks distribution is to be followed for evaluation:
  For CA: Attendance - 15; Evaluation report of supervisor and mentor - 15
  For ESE: Seminar presentation and the quality of the intern's report - 10; *viva-voce* - 10

GUIDELINES FOR THE PREPARATION OF THE PROJECT REPORT:

1) Frontpage
   - (Title of the project)
   - Submitted for partial completion of (degree name) in Microbiology

   - Submitted by: (name of the student)
   - Registration no.: _____ of _____
   - Roll no.:
   - 6th Semester Examination, (year)
   - Course Name: Summer Internship
   - Course Code: BSCMCBSI601

   - Logo of the institution
   - Under the supervision of Dr./Mr./Mrs./Ms. _____
   - Name and full address of the Institution

2) Certificate from supervisor and mentor (attendance should be mentioned)
3) Signed declarations/forms from the student
4) Acknowledgments
5) Abstract (250 words)
6) Introduction (within 1000 words) (includes hypothesis, literature review, objectives, etc.)
7) Materials and Methods
8) Results (including figures, tables, and pictures)
9) Discussion
10) Conclusion
11) References

Note: Except for the front page, the body of the text should be typed in Times New Roman, font size 12, and line spacing 1.5. Headings and subheadings should be in font size 14, Bold, and italics (if required).

Semester - 7

Course Name: Microbial Products in Agriculture Course Code: BSCMCBMJ701					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-14**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students-

- Have developed a very good understanding of the practical aspects of the production of bio-fertilizers.
- Have developed a very good understanding of practical aspects of the production of bio-pesticides/ bio-insecticides.

Course Content:

Theory

Unit – 1: Bio-fertilizers: General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers. Symbiotic N_2 fixers: *Rhizobium* - Isolation, characteristics, types, inoculum production and field application, legume/ pulses plants. *Frankia* - Isolation, characteristics. *Azolla* - Isolation, characterization, mass multiplication, Role in rice cultivation, crop response, field application.

Unit – 2: Cyanobacteria as Bio-fertilizers: Isolation, characterization, mass multiplication, Role in rice cultivation, crop response, field application. Non-symbiotic nitrogen fixers. Free-living *Azospirillum*, *Azotobacter* - isolation, characteristics, mass inoculums, production, and field application.

Unit – 3: Phosphate Solubilizes: Phosphate solubilizing microbes - Isolation, characterization, mass inoculum production, field application. PGPR – Isolation and characterization; mass production and application.

Unit – 4: Mycorrhizal Bio-fertilizers: Importance of mycorrhizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

Unit – 5: Bioinsecticides: General account of microbes used as bioinsecticides and their advantages over synthetic pesticides; *Bacillus thuringiensis* - production, field applications; Viruses – cultivation and field applications.

Practical

1) Study the microflora of different types of soils.
2) Isolation of *Rhizobium* from leguminous plant roots.
3) Isolation of Azotobacteras from soil.
4) Design and functioning of a biogas plant.
5) Isolation of cellulose-degrading organisms.

Reference Books:

1. Eldor AP. Soil Microbiology, Ecology and Biochemistry. 6th Edition: Academic Press (2007).
2. Eugene LM. Environmental Microbiology: From Genomes to Biogeochemistry. 1st Edition, Wiley-Blackwell Publishing (2008).
3. Agrios GN. Plant pathology. Harcourt Asia Pvt. Ltd. (2000).
4. Buchanan BB, Gruissem W, Jones RL. Biochemistry and Molecular Biology of Plants. I.K. International Pvt. Ltd. (2000).
5. Mehrotra RS, Agrawal A. Plant Pathology. Tata McGraw-Hill, 6th reprint (2006).
6. Bilgrami KS, Dube HC. A textbook of modern pathology. 6th Edition, Vani Educational Books, a division of Vikas (1984).
7. Suri S. Biofertilizer and Biopesticide. Aph Publishing Corporation (2011).

Course Name: Biostatistics and Bioinformatics Course Code: BSCMCBMJ702					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-15**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students clearly-

- Understand the basic physical parameters of cells or biological processes and the basic methods used to study these.
- Have developed basic knowledge of mathematics as applied to the biological phenomenon.
- Have developed basic concepts of statistics and their importance.

Course Content:

Theory

Unit – 1: Statistical methods: Applications and scope of statistics, Principles of statistical analysis of biological data. Sampling parameters. Differences between sample and population, Sampling errors, Censoring, and differences between parametric and non-parametric statistics. Measures of central tendency, Mean, Median, and Mode; Measures of dispersion, standard deviation, and variance; Skewness, Kurtosis.

Unit – 2: Probability; Discrete and continuous random variables, Concept of normal distribution and curve fitting; Correlation and regression. Emphasis on examples from biological systems. Concept of sample size, testing of hypothesis, level of significance, and degree of freedom; Large sample test based on normal distribution; Small sample test based on t-test, Z test and F test; Confidence interval; Distribution-free test; Chi-square test; ANOVA.

Unit – 3: Local and global sequence alignment, pairwise and multiple sequence alignment. Scoring an alignment, scoring matrices, PAM & BLOSUM series of matrices. Types of phylogenetic trees. Different approaches of phylogenetic tree construction - UPGMA, Neighbor joining, Maximum Parsimony, Maximum likelihood.

Unit – 4: RDBMS - Definition of a relational database; Biological databases - nucleic acid, genome, protein sequence and structure, gene expression databases, database of metabolic pathways. Mode of data storage – File formats - FASTA, Genbank and Uniprot, Data submission & retrieval from NCBI, EMBL, DDBJ, Uniprot, PDB.

Unit – 5: Diversity of Genomes: Viral, prokaryotic & eukaryotic genomes; Genome, transcriptome, proteome; 2-D gel electrophoresis, MALDI TOF spectroscopy; Major features of completed genomes of *E. coli*, *S. cerevisiae*, and *Arabidopsis*.

Practical

1) Mean, Median, Mode from grouped and ungrouped datasets.
2) Standard deviation and Coefficient of variation.
3) Correlation.
4) Regression.
5) Normal distribution and finding the area under the curve using normal probability.
6) Testing of hypotheses: z-test, t-test, and Chi-Square-test.
7) Introduction to bioinformatics databases: NCBI/PDB/DDBJ, Uniprot, PDB.
8) Sequence retrieval using BLAST.
9) Sequence alignment & phylogenetic analysis using clustal W & phylip.
10) Picking out a given gene from genomes using Genscan (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer/equivalent), Primer designing.
11) Protein structure prediction: primary structure analysis, secondary structure prediction using psi-pred, and homology modeling using the Swiss model. Molecular visualization using Jmol, Protein structure model evaluation (PROCHECK).

Reference Books:

1. Wilson &Walker. Principles and Techniques in Practical Biochemistry. Cambridge University Press.
2. Chap TL, Lynn EE. Introductory Biostatistics 2nd Edition. Wiley.
3. Banerjee PK. Introduction to Biostatistics. S Chand Publication.
4. Das NG. Statistical Methods (Vol 1 and 2). Tata McGraw-Hill Education India.
5. Mount D. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press, New York. (2004).
6. Baxevanis AD, Francis Ouellette BF. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Wiley India Pvt. Ltd. (2009).
7. Attwood TK, Parry-Smith DJ. Introduction to Bioinformatics. Pearson Education. (1999).
8. Claverie JM, Notredame C. Bioinformatics for Dummies. Publisher: Dummies (2007).
9. Lesk AM. Introduction to bioinformatics. Oxford University Press (2004).
10. Krane DE, Raymer ML. Fundamental Concepts of Bioinformatics (2002).

Course Name: Genetic Engineering and Applications Course Code: BSCMCBMJ703					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-16**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students-

- Has acquired a good knowledge of the tools and methods for genetic engineering.
- Has acquired a good understanding of how these tools and methods are employed in the laboratory for the manipulation of DNA so as to make it relevant for biotechnological uses.
- Students can perform isolation of DNA, amplification of any gene by PCR, and its analysis by gel electrophoresis.

Course Content:

Theory

Unit – 1: Introduction to genetic engineering: Milestones in genetic engineering and biotechnology. Restriction modification systems: Mode of action, applications of Type II restriction enzymes in genetic engineering. DNA-modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase, kinases and phosphatases, and DNA ligases.

Unit – 2: Cloning: Use of linkers and adaptors: Transformation of DNA: Chemical method, Electroporation. Methods of DNA, RNA, and Protein analysis: Agarose gel electrophoresis, Southern- and Northern-blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE, and Western blotting.

Unit – 3: Cloning Vectors: Definition and Properties Plasmid vectors: pBR and pUC series Bacteriophage lambda and M13-based vectors Cosmids, BACs, YACs Expression vectors: *E. coli* lac and T7 promoter-based vectors, yeast YIp, YEp, and YCp vectors, Baculovirus-based vectors, mammalian SV40-based expression vectors.

Unit – 4: DNA Amplification and DNA sequencing: PCR: Basics of PCR, RT-PCR, Real-Time PCR; Genomic and cDNA libraries: Preparation and uses; Genome sequencing of Sanger.

Unit – 5: Application of Genetic Engineering and Biotechnology: Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, Agrobacterium-mediated delivery. Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, flavosavo tomato, Gene therapy, recombinant vaccine, protein engineering.

Practical

1) Isolation of Plasmid DNA from *E. coli*.
2) Plasmid Cloning of DNA fragments in bacteria.
3) Interpretation of sequencing gel electropherograms (DIAGRAMATIC).
4) Designing primers for DNA Amplification (SOFTWARE BASED).

5) Demonstration of Southern blotting (SCHEMATIC).

Reference books:

1. Lewin B. Gene VII. Oxford University Press, (2000).
2. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. Molecular Biology of the Cell, 4th Edition. Garland Publishing Inc. (2002).
3. Darnell JE, Lodish HF, Baltimore D. Molecular Cell Biology. Scientific American Pub Inc (2000).
4. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. Molecular Biology of the Gene, 5th Edition. The Benjamin/Cummings Pub. Co. Inc. (2003).
5. Frifielder D, Maloy SR. Molecular Biology and Microbial Genetics. 2nd Edition, Jones and Bartlett Publishers. (1994).
6. Brown TA. Gene Cloning and DNA Analysis. 2nd Edition, ASM Press. (2004).
7. Primrose S. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers (2006).
8. Glick BR, Pasternak JJ. Molecular Biotechnology, 2nd Ed. ASM press (2003).
9. Streips UN, Yasbin RE. Modern Microbial Genetics. 2nd Edition. Wiley-Liss Inc. (2002).
10. Nicholl DST. An Introduction to Genetic Engineering. Cambridge Univ. Pr. (2023).

Course Name: Advance Microbiology **Course Code: BSCMCBMJ704**					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-17**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students will -

- Explain salient characteristics of genomes of representative microorganisms.
- Understood the concept and importance of metagenomics.
- Develop an initial understanding of recent developments in host-microbe interactions, synthetic biology, viable but non-culturable forms of microorganisms, etc.
- Able to extract DNA from bacteria/soil and perform PCR for 16s Ribosomal genes using universal primers and interpret the results.

Course Content:

Theory

Unit – 1: Evolution of Microbial Genomes: Salient features of sequenced microbial genomes, core genome pool, flexible genome pool, and concept of pan-genome. Evolution of bacterial virulence - Genomic islands, Pathogenicity islands (PAI) and their characteristics.

Unit – 2: Metagenomics: Brief history and development of metagenomics, understanding bacterial diversity using a metagenomics approach. Basic knowledge of viral metagenome, metatranscriptomics, metaproteomics, and metabolomics.

Unit – 3: Molecular Basis of Host-Microbe Interaction: Basic concept on Epiphytic fitness in plant pathogens, Hypersensitive response (HR) to plant pathogens, Type three secretion systems (TTSS) of plant and animal pathogens, Biofilms: types of microorganisms, molecular aspects and significance in the environment, health care, virulence, and antimicrobial resistance.

Unit – 4: Systems and Synthetic Biology: Networking in biological systems, Quorum sensing in bacteria, Basics of synthesis of poliovirus in the laboratory, Future implications of synthetic biology with respect to bacteria and viruses.

Unit – 5: Microbiomes and their importance, VBNC (viable but not culturable bacteria). Genetically modified organisms and their uses. Modern methods for rapid identification of microbes (PCR, mass spectrometry, fluorescence-based techniques). CRISPR-Cas system.

Practical

1) Extraction of metagenomic DNA from water and its estimation.
2) Virtual demonstration of PCR amplification of metagenomic DNA using universal 16s ribosomal gene primers.
3) Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis.
4) Amplification of DNA by PCR (SCHEMATIC).

Reference Books:

1. Lewin B. Gene VII. Oxford University Press.
2. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. Molecular Biology of the Cell, 4th Edition. Garland Publishing Inc. (2002).
3. Darnell JE, Lodish HF, Baltimore D. Molecular Cell Biology. Scientific American Pub Inc (2000).
4. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. Molecular Biology of the Gene, 5th Edition. The Benjamin/Cummings Pub. Co. Inc. (2003).
5. Frifielder D, Maloy SR. Molecular Biology and Microbial Genetics. 2nd Edition, Jones and Bartlett Publishers. (1994).
6. Brown TA. Gene Cloning and DNA Analysis. 2nd Edition, ASM Press. (2004).
7. Primrose S. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers (2006).
8. Glick BR, Pasternak JJ. Molecular Biotechnology, 2nd Ed. ASM press (2003).
9. Streips UN, Yasbin RE. Modern Microbial Genetics. 2nd Edition. Wiley-Liss Inc. (2002).
10. Russel PJ. Essential Genetics. Blackwell Science Inc.

Course Name: Genetic Engineering and Applications Course Code: BSCMCBMN701					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MNC-6**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students-

- Has acquired a good knowledge of the tools and methods for genetic engineering.
- Has acquired a good understanding of how these tools and methods are employed in the laboratory for the manipulation of DNA to make it relevant for biotechnological uses.
- Students can perform isolation of DNA, amplification of any gene by PCR, and its analysis by gel electrophoresis.

Course Content:

Theory

Unit – 1: Introduction to genetic engineering: Milestones in genetic engineering and biotechnology. Restriction modification systems: Mode of action, applications of Type II restriction enzymes in genetic engineering. DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase, kinases and phosphatases, and DNA ligases.

Unit – 2: Cloning: Use of linkers and adaptors: Transformation of DNA: Chemical method, Electroporation. Methods of DNA, RNA, and Protein analysis: Agarose gel electrophoresis, Southern - and Northern-blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE, and Western blotting.

Unit – 3: Cloning Vectors: Definition and Properties Plasmid vectors: pBR and pUC series Bacteriophage lambda and M13 based vectors Cosmids, BACs, YACs Expression vectors: E. coli lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors, Baculovirus based vectors, mammalian SV40-based expression vectors.

Unit – 4: DNA Amplification and DNA sequencing: PCR: Basics of PCR, RT-PCR, Real-Time PCR Genomic and cDNA libraries: Preparation and uses. Genome sequencing by Sanger.

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Unit – 5: Application of Genetic Engineering and Biotechnology: Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, Agrobacterium-mediated delivery. Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, flavosavo tomato, Gene therapy, recombinant vaccine, protein engineering.

Practical

1) Isolation of Plasmid DNA from *E. coli*.
2) Interpretation of sequencing gel electropherograms (DIAGRAMATIC).
3) Amplification of DNA by PCR (SCHEMATIC).
4) Demonstration of Southern blotting (SCHEMATIC).

Reference books:

1. Lewin B. Gene VII. Oxford University Press.
2. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. Molecular Biology of the Cell, 4th Edition. Garland Publishing Inc. (2002).
3. Darnell JE, Lodish HF, Baltimore D. Molecular Cell Biology. Scientific American Pub Inc (2000).
4. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. Molecular Biology of the Gene, 5th Edition. The Benjamin/Cummings Pub. Co. Inc. (2003).
5. Frifielder D, Maloy SR. Molecular Biology and Microbial Genetics. 2nd Edition, Jones and Bartlett Publishers. (1994).
6. Brown TA. Gene Cloning and DNA Analysis. 2nd Edition, ASM Press. (2004).
7. Primrose S. Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers (2006).
8. Glick BR, Pasternak JJ. Molecular Biotechnology, 2nd Ed. ASM press (2003).
9. Streips UN, Yasbin RE. Modern Microbial Genetics. 2nd Edition. Wiley-Liss Inc. (2002).
10. Russel PJ. Essential Genetics. Blackwell Science Inc.
11. Nicholl DST. An Introduction to Genetic Engineering. Cambridge Univ. Pr. (2023).

Students to opt for Either Honours or Honours with Research, as per the University Guidelines

Semester – 8 (Honours)

Course Name: Microbial Biotechnology Course Code: BSCMCBMJ801					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-18**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Learning Outcomes:

By the conclusion of this course, the students have -

- Developed an understanding of how microbiology is relevant to technological developments for agriculture and the environment.
- Developed an understanding of how microbiology is relevant to technological developments for industries related to food and fermentation.
- Developed an understanding of how developments in recombinant DNA technology are juxtaposed with microbially-based technological developments for agriculture, industry, and the environment.

Course Content:

Theory

Unit – 1: Microbial biotechnology: Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental and food technology. Genetically engineered microbes for industrial applications: Bacteria and yeast.

Unit – 2: 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.

Unit – 3: Microbial-based transformation of steroids and sterols. Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute.

Unit – 4: Microbial product purification: filtration, ion exchange & affinity chromatography techniques. Immobilization methods and their applications: Whole cell immobilization. RNAi and its applications in silencing genes, drug resistance, therapeutics, and host-pathogen interactions.

Unit – 5: Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture. Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents.

Practical

1) Visit a microbiology-related pharmaceutical, fermentation industry, or organizations related to microbiology.
2) Study yeast cell immobilization in calcium alginate gels.
3) Study enzyme immobilization by the sodium alginate method.
4) Production of curd and microbial examination of curd.
5) Alcohol production.

Reference Books:

1. Baltz RH, Davies JE, Demain AL. Manual of Industrial Microbiology and Biotechnology. 3rd edition, ASM Press (2010).
2. Forciniti D. Industrial Bioseparation: Principles and Practice. 1st edition, Wiley-Blackwell (2008).
3. Reed G. Prescott and Dunn's Industrial Microbiology. CBS Publishers (1999).
4. Demain AL. Industrial Microbiology and Biotechnology. 2nd Edition. (2001).
5. El-Mansi EMT, Bryce CFA, Demain AL, Allman AR (editors). Fermentation Microbiology and Biotechnology. 2nd Edition, CRC Taylor & Francis (2007).
6. Waites MJ, Morgan NL, Rockey JS, Higton G. Industrial Microbiology: An Introduction. Blackwell Science Publishers (2002).

<table>
<tr><th colspan="5">Course Name: Pharmaceutical Microbiology
Course Code: BSCMCBMJ802</th></tr>
<tr><td>Course Type:
Major (Theoretical & Practical)</td><td colspan="2">Course Details: MJC-19</td><td colspan="2">L-T-P: 2 - 0 - 4</td></tr>
<tr><td rowspan="3">Credit: 4</td><td rowspan="3">Full Marks:
100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>15</td><td>20</td><td>35</td></tr>
</table>

Course Learning Outcomes:

Upon completion of the subject, the student shall be able to:

- Explain the principles and stages of drug discovery, including target identification, lead discovery, and optimization. Apply basic concepts of rational drug design, pharmacogenomics, and screening approaches in identifying potential drug candidates.
- Describe preclinical evaluation methods, including toxicity studies, mutagenicity testing, and safety assessment of drugs. Interpret drug metabolism, pharmacokinetics, drug interactions, and adverse drug reactions in biological systems.
- Understand regulatory requirements, validation practices, and phases of clinical trials involved in drug development. Analyze drug delivery systems, bioavailability, and distribution of drugs in the body.
- Evaluate antimicrobial agents based on their mechanism of action and laboratory screening methods.
- Perform and interpret basic bioassays and assess the effects of drug combinations, including synergism and antagonism.

Course Content:

Theory

Unit – 1: Drug discovery: Historical perspective, Current approaches to drug discovery: Rational Drug design, receptor/target concept in drug designing, Introduction to pharmacogenomics, Combinatorial chemistry, High Throughput Screening. Phases of drug discovery: Lead discovery, Lead compound optimization, Candidate drug selection.

Unit – 2: Preclinical development: Safety profile of drugs (Pyrogenicity, Toxicity - hepato, nephro, cardio and neuro). Toxicological evaluation of drug: LD50, acute, subacute and chronic toxicity. Mutagenicity (Ames test, micronucleus test), Carcinogenicity and Teratogenicity. Drug interactions, metabolism, activity, inhibition of drugs in vivo and adverse drug reactions.

Unit – 3: Clinical development of biologicals: Regulatory authorities for introduction of medicines in market – Role of Food and Drug Administration, FDA guidelines for drugs/biologicals, Validation (GMP, GLP, GCP, etc.). Clinical studies: Phase I, Phase II, Phase III and Phase IV of clinical trials – Objectives, Conduct of trials, Outcome of trials. Delivery systems – formulations, targeted drug delivery, Sustained release drugs. Drug distribution in the body, bioavailability, and pharmacokinetic studies.

Unit – 4: Development of antimicrobial agents: Screening strategies for new antimicrobial agents acting on bacterial cell wall, cell membrane, nucleic acid and protein metabolism. Bioassay of antibacterial agents in liquid media and in agar media using standard guidelines [e.g., National Committee for Clinical Laboratory Standards (NCCLS)/ Clinical and Laboratory Standards Institute (CLSI)].

Unit – 5: Factors affecting bioassay, Laboratory methods to assess activity of antimicrobial combinations (antagonism, synergism and additive effect). Methodologies for testing of antibacterial, antifungal, antiparasitic and antiviral drugs (in vivo and in vitro infectivity models).

Practical:

1) Simulated LD50 Determination (Data Analysis Based).
2) Drug Combination Study (Synergism and Antagonism).
3) Literature survey & bibliography management using software tools.
4) Drafting a research paper and review.
5) Plagiarism detection & similarity analysis.
6) Journal selection & Open access evaluation- using tools like Sherpa/ RoMEO and Elsevier Journal Finder.
7) Calculating Research Metrics (h-index, i10-index) - to analyze researcher impact using Scopus and Web of Science.
8) Documentation of Traditional Knowledge (IKS) - Document the preparation and benefits of a traditional food/drink.

Recommended Books:

1. Hugo WB, Russel AD. Pharmaceutical Microbiology. Blackwell Scientific Publications, Oxford, London.
2. Reed G. Prescott and Dunn's Industrial Microbiology. CBS Publishers (1999).
3. Pelczar MJ, Chan ECS, Krieg NR. Microbiology, McGraw-Hill.
4. Malcolm Harris, Balliere Tindall and Cox: Pharmaceutical Microbiology.
5. Rose: Industrial Microbiology.

6. Probisher M. et al: Fundamentals of Microbiology, 9th ed. Saunders.
7. Cooper and Gunn's: Tutorial Pharmacy. CBS Publisher and Distribution Pvt Ltd.
8. Peppler: Microbial Technology.
9. I.P., B.P., U.S.P. - latest editions.
10. Ananthnarayan: Text Book of Microbiology. Orient-Longman, Chennai
11. Edward: Fundamentals of Microbiology. 1977.
12. Jain NK: Pharmaceutical Microbiology. Vallabh Prakashan, Delhi.
13. Bergey's Manual of Systematic Bacteriology. Springer.

Course Name: Research Methodology and Ethics **Course Code: BSCMCBMJ803**					
Course Type: **Major (Theoretical)**	Course Details: **MJC-20**			L-T-P: **4 - 0 - 0**	
Credit: **4**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		-	**30**	-	**70**

Course Learning Outcomes:

Upon completion of the course, students shall be able to:

- Explain the fundamental concepts, nature, and scope of research ethics and apply ethical principles in scientific conduct. Demonstrate integrity in research by identifying and avoiding scientific misconduct, including plagiarism, fabrication, and falsification.
- Evaluate publication practices, including authorship criteria, predatory journals, and ethical issues in scientific publishing. Utilize open access resources, journal selection tools, and indexing databases to identify appropriate platforms for publication and dissemination of research.
- Analyze research impact using citation metrics such as impact factor, h-index, and i10-index.
- Understand and apply the principles of intellectual property rights, including patents, copyrights, and trademarks, in research and innovation.
- Appreciate the significance of Indian knowledge systems, including traditional foods, medicinal plants, and their scientific relevance.

Course Content:

Theory

Unit – 1. Research and Publication Ethics: Philosophy of ethics - Definition, nature and scope, concept, branches; Scientific conduct - Ethics with respect to science and research; Intellectual honesty and research integrity, Scientific misconducts, falsification and fabrication, plagiarism, Redundant publications: Duplicate and overlapping publications, salami slicing, selective reporting and mis-presentation of data, Violation of publication ethics, authorship and contributorship, Predatory publishers and journals.

Unit – 2: Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright & self-achieving policies. Journal finder/journal suggestion tool, viz., ZAME, Elsevier journal finder, Springer journal suggester.

Unit – 3: Indexing databases, citation databases: Web of Science, Scopus; Impact Factor of journal as per Journal Citation Report, Metrics: h-index, i10-index.

Unit – 4: Principles of IPR, Patent Law and Practices, Copyright Law and Practices, Trademark Law and Practices.

Unit – 5: Introduction to Indian Knowledge System, traditional fermented foods (sour rice, Dahi, fermented soyabean) and drinks (Kanji, Chach); Use of medicinal plants for the treatment of various diseases (Tulsi, Basak, Neem, Turmeric).

Reference Books:

1. Kothari CR, Garg G. Research Methodology: Methods and Techniques. 4th Edition. New Age International Publishers.
2. Kumar R. Research Methodology: A Step-by-Step Guide for Beginners. 5th Edition. Sage Publications.
3. Creswell JW, Creswell JD. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. 5th Edition. Sage Publications.
4. Booth WC, Colomb GG, Williams JM. The Craft of Research. 4th Edition. University of Chicago Press.
5. Publication Manual of the American Psychological Association. American Psychological Association.
6. Sharma M. Research Methodology for UGC NET SLET and PhD Entrance. Anmol Publications Pvt Ltd, 2012.

<table>
<tr><th colspan="6">Course Name: Project Work on Microbiology of Societal Importance
Course Code: BSCMCBMJ804</th></tr>
<tr><td colspan="2">Course Type:
Major (Practical)</td><td colspan="2">Course Details: MJC-20</td><td colspan="2">L-T-P: 0 - 0 - 8</td></tr>
<tr><td rowspan="3">Credit: 4</td><td rowspan="3">Full Marks:
100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>60</td><td></td><td>40</td><td></td></tr>
</table>

Course Learning Outcomes:

By the conclusion of this course, the students have –

- Understand the role of microorganisms in addressing societal challenges related to health, agriculture, environment and industry.
- Develop the ability to design and conduct microbiological experiments to investigate problems of societal importance.
- Apply appropriate laboratory techniques for isolation, characterization and analysis of microorganisms from environmental or clinical samples.
- Interpret experimental results and evaluate the potential applications of microbial processes in solving real-world problems.
- Demonstrate scientific communication skills through preparation of project reports and presentation of research findings.

Discipline-Specific Guideline for the Faculties & Students:

- Students have to perform hands-on work on a specific relevant topic as directed in the syllabus, under the guidance of the respective departmental faculty.
- The project can be carried out either in the microbiology department of the home college or at the microbiology department of other colleges affiliated with Kazi Nazrul University through collaboration.
- It can be completed either individually or in groups.
- Students must prepare a report on the project they worked on individually or in groups.
- ESE and CA will be conducted on the same day in the presence of both the assigned external and internal examiners.
- Students have to present their project with a PowerPoint Presentation on the day of the examination, individually or in groups.
- Presentation will be followed by a viva voce on the topic and related area to evaluate the understanding of the students.

Discipline-Specific Guidelines for the Preparation of the Project Report:

1) Frontpage
   - (Title of the project)
   - Submitted for partial completion of (degree name) in Microbiology

   - Submitted by: (name of the student)
   - Registration no.: _____ of _____
   - Roll no.:
   - 8th Semester Examination, (year)
   - Course Name: Project Work on Microbiology of Societal Importance
   - Course Code: BSCMCBMJ804

   - Logo of the institution
   - Under the supervision of Dr./Mr./Mrs./Ms. _____
   - Name and full address of the Institution

2) Certificate from supervisor
3) Signed declarations from the student
4) Acknowledgments
5) Abstract (250 words)
6) Introduction (within 1000 words) (includes hypothesis, literature review, objectives, etc.)
7) Materials and Methods
8) Results (including figures, tables, and pictures)
9) Discussion
10) Conclusion
11) References
12) Appendix

Note: Except for the front page, the body of the text should be typed in Times New Roman, font size 12, and line spacing 1.5. Headings and subheadings should be in font size 14, Bold, and italics (if required).

Marks Distribution for the Evaluation Process:

	Project Report	Presentation	*viva-voce*	Performance & involvement in regular project work
ESE (40)	10	20	10	x
CA (60)	20	10	10	20

Course Name: Pharmaceutical Microbiology **Course Code: BSCMCBMN801**					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MNC-7**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Content same as BSCMCBMJ802

Semester - 8

(Honours with Research)

Course Name: Microbial Biotechnology Course Code: BSCMCBMJ801					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MJC-18**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Content same as BSCMCBMJ801 (in Honours syllabus)

Course Name: Research Methodology Course Code: BSCMCBRP801					
Course Type: **Research Project (Theoretical)**	Course Details: **RPC-1**			L-T-P: **4 - 0 - 0**	
Credit: **4**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
			30		**70**

Course Content same as BSCMCBMJ803 (in Honours syllabus)

Course Name: Dissertation Course Code: BSCMCBRP802					
Course Type: **Research Project (Practical)**	Course Details: **RPC-2**			L-T-P: **0 - 0 - 16**	
Credit: **8**	Full Marks: **200**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		120		80	

Follow the University Guidelines.

Discipline-specific guidelines of BSCMCBMJ804 (in Honours syllabus) may be followed, if not specified otherwise in the University guidelines.

Marks Distribution for the Evaluation Process:

	Project Report	Presentation	*viva-voce*	Performance & involvement in regular project work
ESE (100)	20	40	20	x
CA (150)	50	40	30	30

Course Name: Pharmaceutical Microbiology Course Code: BSCMCBMN801					
Course Type: **Major (Theoretical & Practical)**	Course Details: **MNC-7**			L-T-P: **3 - 0 - 4**	
Credit: **5**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

Course Content same as BSCMCBMJ802 (in Honours syllabus)