Royal College of Arts Science and Commerce (Autonomous)

Affiliated to University of Mumbai

Program: B.Sc.

Course: Microbiology

Major

VSC / SEC

Syllabus for Semester: III and IV

Syllabus for Undergraduate Programme as per National Education Policy (NEP-2020) with effect from Academic year **2024-2025**

NEP Credit Structure for Science

Level	Sem	Major		Minor	OE	VSC	SEC	AEC	IKS	VEC	OJT/FP /RP/CC /CEP	Cumulative Credits	
		DSC	DSE										
4.5	I	6 (2*2T+2P)		6 (2*2T+2P)	2	2		2	2	2		22	**UG Certificate Cumulative Credit:44**
	II	6 (2*2T+2P)		6 (2*2T+2P)	2		2	2		2	2	22	
Exit Option: Award of UG Certificate in Major with 40-44 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5	III	8 (3*2T+2P)		4 (2T+2P)	2+2		2	2			2	22	**UG Diploma Cumulative Credit:88**
	IV	8 (3*2T+2P)		4 (2T+2P)	2+2		2	2			2	22	
Exit Option: Award of UG Diploma in Major and Minor with 80-88 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5.5	V	10 (4*2T+2P)	4 (2T+2P)			4					4	22	**UG Degree Cumulative Credit:132**
	VI	10 (4*2T+2P)	4 (2T+2P)			4					4	22	
	Total	**48**	**8**	**20**	**12**	**10**	**6**	**8**	**2**	**4**	**14**	**132**	

List of All Courses offered from Semesters I – VI in MICROBIOLOGY

Level	Sem	Major subject Course titles	Electives Course titles	Minor subject Course titles	VSC Course title/s	SEC Course title/s
4.5 100 - 199	I	Fundamentals of Microbiology	–	–	Basic Tools and Techniques in Microbiology	–
		Growth and Control of Microorganisms	–	–	–	–
		Practical based on above	–	–	–	–
	II	Major Groups of Microorganisms	–	–	–	Measurement Techniques in Microbiology
		Biomolecules and Host Microbe Interaction	–	–	–	–
		Practical based on above	–	–	–	–
5 200 - 299	III	Molecular Biology	–	Applied Microbiology I	Microbiology of Water and Waste water	–
		Introduction to Immunology	–	–	–	–
		Environmental Microbiology	–	–	–	–
		Practical based on above	–	–	–	–
	IV	Introduction to Genetics and Metabolism	–	Applied Microbiology II	–	Food and Dairy Microbiology
		Infection, Epidemiology and Industrial Microbiology	–	–	–	–
		Enzymology and Separation Techniques	–	–	–	–
		Practical based on above	–	–	–	–

Level	Sem	Major subject Course titles	Electives Course titles	Minor subject Course titles	VSC Course title/s	SEC Course title/s
5.5 300 - 399	V	Genetic and Virology	Nutrition and Health	–	Clinical Microbiology	–
		Ancient Indian System of Medicine	Or	–	Food Safety and Management System	–
		Microbial Biochemistry I	Food Production	–	–	–
		Bioprocess Technology I	–	–	–	–
		Practical based on above	–	–	–	–
	VI	Recombinant DNA Technology	Fermented Food	–	Techniques in Molecular Biology	–
		Medical Microbiology and Immunology	Or	–	Entrepreneurship in Microbiology	–
		Microbial Biochemistry II	Food Processing	–	–	–
		Bioprocess Technology II	–	–	–	–
		Practical based on above	–	–	–	–

Programme Outcomes (POs) for B.Sc.

Sr. No.	On completing B.Sc. Microbiology, the student will have:
PO1	Acquired the basic knowledge related to the subject offered.
PO2	Understood the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevance in day-to-day life.
PO3	Acquired the skills in handling scientific instruments.
PO4	Acquired the skills of planning and performing laboratory experiments, recording observations and drawing logical inferences from the scientific experiments.
PO5	Developed scientific outlook not only with respect to science subjects but also in all aspects related to life.

Programme Specific Outcomes (PSOs) for MICROBIOLOGY

Sr. No.	On completing B.Sc. Microbiology, the student will be able to:
PSO1	Demonstrate an understanding of the concepts in basic and applied microbiology
PSO2	Acknowledge the role of microorganisms in medicine, health, food, industry, waste management, environment monitoring, agriculture and genetic manipulation
PSO3	Apply theoretical knowledge to conceptualize experiments in laboratory setting
PSO4	Use relevant tools, equipment and instruments in laboratory
PSO5	Develop observational and analytical skills necessary for interpretation of experiments and projects
PSO6	Exhibit critical thinking, problem solving skills and interdisciplinary approach in addressing microbiological problems
PSO7	Effectively communicate scientific information with clarity and precision
PSO8	Demonstrate ethical awareness and professional responsibility
PSO9	Demonstrate the ability to engage in self-directed learning and collaborative team work

Semester III

Course/ Paper Title	**Molecular Biology**
Course offered as	**Discipline Specific Major Course I**
Course Code	RUSMBMJ301
Semester	III
No. of Credits	2 (30 hours)
No. of lecture Hours/week	2

Sr No.	Learning Objectives:
	To enable the students
1	Appreciate historical discoveries and understand chemistry of nucleic acids.
2	Evaluate the factors influencing DNA conformation and assess the role of various conformational forms of DNA.
3	Understand the organization of nucleic acids in prokaryotic and eukaryotic cells.
4	Understand applications of various experimental techniques used for nucleic acid study for diagnostics and research.
5	Comprehend the functional roles of nucleotides and nucleic acids in cellular processes.
6	Understand the molecular mechanisms of DNA replication in prokaryotes and eukaryotes.

	Course Outcome
	On completing the course, the student will be able to:
CO1	Explain the historical discoveries, fundamental chemistry and organization of nucleic acids.
CO2	Evaluate the factors influencing DNA conformation.*
CO3	Apply various experimental techniques to study nucleic acid.*
CO4	Explain the functional roles of nucleotides and nucleic acids in cellular processes.
CO5	Describe the molecular mechanisms of DNA replication.*
CO6	Compare and contrast DNA replication processes in prokaryotic and eukaryotic systems.

Detailed Syllabus

Module	Title with content **Molecular Biology**	No. of lectures
I	**Nucleic Acid Structure and Chemistry**	15
	1.1 Structure and Chemistry of DNA a) Historical background: Contribution of Friedrich Miescher, Erwin Chargaff, Rosalind Franklin & Maurice Wilkins, James Watson & Francis Crick b) Chemical composition- Nitrogenous bases, pentose sugar, phosphate group c) Structure and nomenclature of nucleosides and Nucleotides d) Watson-Crick model of DNA e) Reasons for Conformational variations in DNA structure f) Differences among A-DNA, B-DNA, and Z-DNA g) Unique DNA structures: Triple helix DNA, G-quadruplex structures h) Unusual DNA sequences-Palindromes and mirror sites i) DNA supercoiling and topology (positive & negative supercoiling, topoisomerases)	6
	1.2 Structure and Chemistry of RNA a) Chemical composition: Differences between RNA and DNA b) 3D structures of RNAs c) Regulatory RNAs (siRNA, miRNA, snRNA)	3
	1.3 Nucleic Acid Structure in Prokaryotic & Eukaryotic Cells a) Organization of DNA in prokaryotes: Nucleoid, plasmids b) Organization of DNA in eukaryotes: Histones, Nucleosome, Chromatin, c) Euchromatin vs. heterochromatin	3
	1.4 Experimental Techniques for Nucleic Acid Study –and their application a) Denaturation of double helical DNA and UV absorption b) Spectrophotometric quantification of nucleic acids (A260/A280 ratio), c) Nucleic Acid Hybridization	2
	1.5 Functions of Nucleotides and Nucleic acids	1
II	**DNA Replication**	**15**
	2.1. Introduction and Historical perspective Conservative, dispersive, semi-conservative nature of replication a) Meselson & Stahl experiment b) Modes of replication: Linear, Theta and Rolling Circle models	3
	2.2 Enzymes and Proteins Involved in DNA Replication a) DNA polymerases (Types in prokaryotes and eukaryotes) b) Helicase, Primase, Ligase, Topoisomerases (Gyrase in prokaryotes)	4

	c) Single-strand binding proteins (SSBs) d) Ter site and Tus proteins	
	2.3 Prokaryotic DNA replication – a) Details of molecular mechanisms involved b) **Initiation:** ○ Origin of replication (OriC in prokaryotes, multiple origins in eukaryotes) ○ Formation of the replication fork ○ Role of initiator proteins (DnaA, DnaB) c) **Elongation:** ○ Leading and lagging strand synthesis ○ Okazaki fragments & RNA primer removal ○ Proofreading & error correction d) **Termination:** ○ Termination sequences (Ter sites in prokaryotes) ○ Role of Tus proteins in bacteria	4
	2.4 Eukaryotic DNA replication a) Number of origins of replication b) Enzymes and replication rates c) Replicating the ends of the chromosomes d) Assembling newly replicated DNA into nucleosomes.	**4**

References:

1. Nelson, D.L., & Cox, M. M. (2005). *Lehninger: Principles of Biochemistry* (4th ed.). W.H. Freeman & Co.
2. Nelson, D. L., & Cox, M. M. (2008). *Lehninger Principles of Biochemistry* (5th ed.). W.H. Freeman & Co.
3. Campbell, M. K., Farrell, S. O., & McDougal, O. M. (2017). *Biochemistry* (9th ed.). Cengage Learning.
4. Abali, E. E., Cline, S. D., Franklin, D. S., & Viselli, S. M. (2021). *Lippincott Illustrated Reviews: Biochemistry* (8th ed.). Wolters Kluwer.
5. Voet, D., & Voet, J. (2016). *Fundamentals of Biochemistry* (5th ed.). Wiley.
6. Zubay, G. L (1996), Biochemistry, 4th edition, Wm. C. Brown publishers
7. Conn, E. E., Stumpf, P. K., Bruening, G., & Doi, R. Y. (1987). *Outlines of Biochemistry* (5th ed.). John Wiley & Sons.
8. Russell, P. J. (2009). *iGenetics: A molecular approach* (3rd ed.). Pearson.
9. Benjamin A. Pierce. (2024). *Genetics: A conceptual approach* (7th ed.). Macmillan
10. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2021). *Brock biology of microorganisms* (16th ed.). Pearson.

Course/ Paper Title	**Introduction to Immunology**
Course offered as	**Discipline Specific Major Course II**
Course Code	RUSMBMJ302
Semester	III
No. of Credits	2 (30 hours)
No. of lecture Hours/week	2

Sr No.	Learning Objectives:
	To enable the students
1	Understand immunity and explain its role in defense against pathogens
2	Elaborate on physical and chemical components of innate immunity
3	Analyze the mechanisms of innate immunity
4	Appreciate the role of different cells and organs of immune system
5	Understand the difference between innate and acquired immunity

	Course Outcome
	On completing the course, the student will be able to:
CO1	Define and explain various terms in immunity
CO2	Recognize and describe various physical and chemical components of innate immunity
CO3	Explain the various mechanisms of innate immunity
CO4	Describe the role of different cells and organs of immune system
CO5	Differentiate between innate and acquired immunity

Detailed Syllabus

Module	Title with content **Introduction to Immunology**	No. of lectures
I	**Overview of Immune System**	15
	1.1 Introduction to Immunology Historical perspective Types of immunity: Active, passive, innate, acquired	3
	1.2 Physical barriers Skin Mucous membrane of respiratory, intestinal, genitourinary tract	4
	1.3 Chemical barriers Antimicrobial peptides, complement, cytokines, acute phase proteins	3
	1.4 Inflammation, fever	2
	1.5 Phagocytosis Pathogen recognition, TLR, intracellular digestion, exocytosis	3
II	**Cells, Organs and Tissues of Immune System**	15
	2.1 Cells of the immune system Haematopoiesis Granulocytes, Mast cells Monocytes and macrophages Dendritic cells Lymphocytes, NK cells	8
	2.2 Organs and tissues of the immune system Primary lymphoid organs – Thymus, Bone marrow Secondary lymphoid organs – Lymph node, spleen Lymphoid tissues – MALT, BALT, GALT, SALT	5
	2.3 Overview of acquired immunity	2

References:

1. Willey, J., Sherwood, L., & Woolverton, C. (2011). *Prescott's Microbiology* (ISE) (8th ed.). McGraw-Hill Education.
2. Willey, J., Sandman, K., & Wood, D. (2019). *Prescott's Microbiology* (ISE) (11th ed.). McGraw-Hill Education.
3. Madigan, M. T., Martinko, J. M., Stahl, D., & Clark, D. P. (2012). *Brock Biology of Microorganisms* (13th Global ed.). San Francisco: Pearson International.
4. Madigan, M. T., Bender, K., & Buckley, D. (2021). *Brock Biology of Microorganisms* (16th Global ed.). San Francisco: Pearson International.
5. Tortora, G. J., Funke, B. R., & Case, C. L. (2016). *Microbiology: An introduction* (12th ed.). Pearson.
6. Owen, J. A., Jones, P. P., Kuby, J., Punt, J., & Stranford, S. A. (2013). *Kuby immunology* (7th ed.). New York: W.H. Freeman

Course/ Paper Title	**Environmental Microbiology**
Course offered as	**Discipline Specific Major Course III**
Course Code	RUSMBMJ303
Semester	III
No. of Credits	2 (30 hours)
No. of lecture Hours/week	2

Sr No.	Learning Objectives:
	To enable the students
1	Recognize major fields in environmental microbiology.
2	Comprehend factors affecting presence of microorganisms.
3	Understand the diversity of microorganisms
4	Appreciate the role of microorganisms in the environment.
5	Evaluate methods of studying microorganisms.

	Course Outcome
	On completing the course, the student will be able to:
CO1	Recognize and differentiate between beneficial and harmful microorganism
CO2	Exhibit the knowledge of the importance of microorganisms in air and soil.
CO3	Demonstrate the understanding of biogeochemical cycles.
CO4	Identify and select appropriate sampling and analysis methods.
CO5	Differentiate between the methods available for the study of microorganisms.

Detailed Syllabus

Module	Title with content **Environmental Microbiology**	No. of lectures
I	**Air Microbiology**	15
	1.1 Introduction to Environmental Microbiology	1
	1.2 Aeromicrobiology: Important airborne pathogens and toxins, Aerosols, nature of bioaerosols Aeromicrobiological pathway Microbial survival in the air Extramural aeromicrobiology and intramural aeromicrobiology	6
	1.3 Sampling Devices for the Collection of Air Samples	4
	1.4 Detection of microorganisms on fomites	1
	1.5 Air Sanitation	2
	1.6 Air Quality Standards (NAQS)	1
II	**Soil Microbiology**	15
	2.1 Soil- Definition, Composition, function , Textural triangle	2
	2.2 Types of soil microorganisms and their activities	2
	2.3 Methods of studying soil microorganisms: Sampling, Cultural methods Principles of: Physiological methods, Immunological methods, Nucleic acid-based methods, Radioisotope techniques	5
	2.4 Biogeochemical Cycles: Carbon cycle, Nitrogen cycle, Sulphur cycle, Phosphorus Cycle	4
	2.5 Soil Bioremediation	1
	2.6 Biofertilizers: Introduction and applications	1

References:

1. Environmental Microbiology, 2nd Edition; Raina M. Maier, Ian L. Pepper, Charles P. Gerba, 2010 Academic Press
2. Introduction to Environmental Microbiology – Barbara Kolwzan, Waldemar Adamiak
3. Air Quality Standards- NAAQS Manual, Volume I
4. Fundamental Principles of Bacteriology, 7th Editon; A.J. Salle ,Tata Mc Graw Hill Publishing Company
5. Fundamentals of Microbiology, 9th Edition, Frobisher, Hinsdill, Crabtree, Goodheart, 1974, Saunders College Publishing
6. Agricultural Microbiology, Indian Council of Agriculture Research. www.AgriMoon.com

Course/ Paper Title	**Practical based on RUSMBMJ301, RUSMBMJ302 and RUSMBMJ303**
Course offered as	**Discipline Specific Major Course**
Course Code	RUSMBMJP3
Semester	III
No. of Credits	2 (60 hours)
No. of lecture Hours/week	4

Sr No.	Learning Objectives:
	To enable the students
1	Learn the techniques for isolation of genomic DNA and quantification of nucleic acids
2	Use spectrophotometric technique for nucleic acid quantification
3	Recognize different immune cells in blood
4	Learn methods of antigen / antibody detection
5	Understand the importance of microorganisms in air and soil.
6	Evaluate methods of studying microorganisms.

	Course Outcome
	On completing the course, the student will be able to:
CO1	Demonstrate the ability to isolate genomic DNA and quantify DNA and RNA.
CO2	Interpret and analyze nucleic acid purity and concentration
CO3	Identify different immune cells in blood
CO4	Detect antigen / antibody
CO5	Analyze microorganisms present in air and soil
CO5	Determine the quality of air

Detailed Syllabus

Title with content **Practical based on** **RUSMBMJ301, RUSMBMJ302 and RUSMBMJ303**	No. of lectures
1. Isolation of Genomic DNA from Bacteria / Plant 2. UV Spectrophotometric Quantification of DNA and RNA (A260/A280 Ratio) 3. Quantitative detection of DNA by DPA method 4. Quantitative detection of RNA by Orcinol method 5. Demonstration of phagocytosis 6. Differential Staining of Blood cells 7. Detection of antigen / antibody by precipitation and agglutination 8. Study of air microflora 9. Determination of sedimentation rate 10. Study of load before and after fumigation 11. Preparation of Winogradskys column and isolation of Nitrosifiers, Nitrifiers, Cellulose degraders, Sulphate reducers from it 12. Isolation of Azotobacter and phosphate solubilizer 13. Preparation of biofertilizer 14. Effect of biofertilizers on plant growth	60

References:

1. Sambrook, J., & Russell, D. W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.). Cold Spring Harbor Laboratory Press.
2. Wilson, K., & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology* (7th ed.). Cambridge University Press.
3. Jayaraman (2003). Laboratory Manual in Biochemistry. New Age International Publisher
4. Norris and Ribbons Methods in Microbiology Volm 5B, Academic Press
5. Benson, Microbiological Application – Laboratory Manual, 8E
6. Agricultural Microbiology, Indian Council of Agriculture Research. www.AgriMoon.com

Course/ Paper Title	**Microbiology of Water and Wastewater**
Course offered as	**Skill Enhancement Course**
Course Code	RUSMBSEC301
Semester	III
No. of Credits	2 (60 hours)
No. of lecture Hours/week	4

Sr No.	Learning Objectives:
	To enable the students
1	Understand the importance of microorganisms in water and wastewater.
2	Apply the knowledge of routine analysis to evaluate the quality of water and wastewater
3	Evaluate methods of studying microorganisms.
4	Appreciate the treatment process of water and wastewater.
5	Understand the standards and regulations.

	Course Outcome
	On completing the course, the student will be able to:
CO1	Identify relevant standards and regulations.
CO2	Appreciate the role of microorganisms in environment
CO3	Perform tests to analyze quality of water and wastewater
CO4	Interpret the results and comment on the quality
CO5	Select appropriate methods to analyze water and wastewater.

Detailed Syllabus

Module	Title with content **Microbiology of Water and Wastewater**	No. of lectures
I	**Microbiology of Water**	60
	1. Sources of fresh water 2. Microscopic organisms present in water 3. Organoleptic, Physical, Chemical Parameters 4. Quality of water for drinking, industrial and pharmaceutical use 5. Treatment of Drinking water. 6. Bacteriological Quality of Drinking Water 7. Sampling and Collection 8. Routine analysis of water: a. Standard Plate Count b. Coliform Count c. Detection of Coliforms in water: d. Presumptive Test, Confirmed Test and Completed Test e. Membrane filter technique	
II	**Microbiology of Wastewater**	
	1. Study of microbial flora in raw and treated sewage 2. Treatment of wastewater 3. Determination of TS, TDS, TSS in wastewater 4. Determination of TOC 5. Determination of BOD 6. Determination of COD	
	Visit to water or waste water treatment plant	

References:

1. Willey, J., Sandman, K., & Wood, D. (2019). *Prescott's Microbiology* (ISE) (11th ed.). McGraw-Hill Education.
2. IS 10500: 2012, Drinking Water — Specification,
3. Environmental Microbiology, 2nd Edition; Raina M. Maier, Ian L. Pepper, Charles P.Gerba, 2010 Academic Press
4. Fundamental Principles of Bacteriology, 7th Ed; A.J. Salle, Tata Mc Graw Hill

Semester IV

Course/ Paper Title	**Gene Expression and Metabolism**
Course offered as	**Discipline Specific Major Course I**
Course Code	RUSMBMJ401
Semester	IV
No. of Credits	2 (30 hours)
No. of lecture Hours/week	2

Sr No.	Learning Objectives:
	To enable the students
1	Understand the basis of gene expression and the Central Dogma
2	Identify the molecular basis of translation and transcription.
3	Learn the different steps of translation and transcription.
4	Understand the fundamental concepts of metabolism, biochemical reactions, bioenergetics, and thermodynamics.
5	Apply thermodynamic principles for calculating energy changes in biochemical reactions.
6	Develop analytical skills for assessing the role of redox reactions in ATP generation.

	Course Outcome
	On completing the course, the student will be able to:
CO1	Differentiate between the process of transcription and translation
CO2	Appreciate the characteristics of genetic code.
CO3	Describe the process of translation and transcription.
CO4	Describe the fundamental principles of metabolism, biochemical reactions, bioenergetics, and thermodynamics.
CO5	Apply thermodynamic equations to determine energy changes in biochemical processes.
CO6	Analyze the significance of redox reactions in ATP synthesis and energy metabolism.

Detailed Syllabus

Module	Title with content **Gene Expression and Metabolism**	No. of lectures
I	**Gene Expression**	15
	1.1 Central Dogma: An Overview	1
	1.2 Genetic code -Nature of genetic code and characteristics of genetic code	3
	1.3 **Transcription process** Introduction Transcription in bacteria Initiation of transcription at promoters, Elongation of an RNA chain, Termination of an RNA chain	 1 4
	1.4 **Translation process –** Transfer RNA - structure of tRNA, tRNA genes, recognition of the tRNA anticodon by the mRNA codon, adding of amino acid to tRNA, Ribosomal RNA and Ribosomes, Ribosomal RNA Genes, Translation in bacteria Initiation of translation, Elongation of the polypeptide chain and Termination of translation.	6
II	**Introduction to Metabolism**	15
	2.1. Fundamentals of Metabolism • Concept of metabolism • Anabolic vs. catabolic pathways • General pattern of metabolism leading to the synthesis of a cell of E. coli from glucose. • An overview of central metabolic pathways: Glycolysis and TCA cycle • Nature and significance of regulation of metabolic pathways	6
	2.2. Bioenergetics and Thermodynamics • Concept of bioenergetics and energy flow in biological systems • Laws of thermodynamics in biological reactions • Gibbs free energy, entropy, and enthalpy • Thermodynamics of life • ATP as the energy currency of the cell • Other high energy compounds	6
	2.3. Redox Reactions and ATP generation • Redox potential and its determination • Redox reactions and their role in ETC • Oxidative phosphorylation and ATP synthesis • Other modes of ATP synthesis - Substrate level phosphorylation and photophosphorylation (Only Definition)	3

	• Anaerobic respiration and Fermentation (Only definition)	

References:

1. Peter J. Russell (2010), "iGenetics-A molecular approach", Third edition. Pearson.
2. Benjamin A. Pierce (2008), "Genetics a conceptual approach", 3rd ed., W. H. Freeman and company.
3. R. H. Tamarin, (2004), "Principles of genetics", Tata McGraw Hill.
4. Nelson, D.L., & Cox, M. M. (2005). *Lehninger: Principles of Biochemistry* (4th ed.). W.H. Freeman & Co.
5. Nelson, D. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry* (5th ed.). W.H. Freeman & Co..
6. Voet, D., & Voet, J. (2016). *Fundamentals of Biochemistry* (5th ed.). Wiley.
7. Conn, E. E., Stumpf, P. K., Bruening, G., & Doi, R. Y. (1987). *Outlines of Biochemistry* (5th ed.). John Wiley & Sons.
8. Zubay, G., Parson, W. W., & Vance, D. E. (1995). *Principles of Biochemistry*. Wm. C. Brown Publishers.
9. Willey, J., Sherwood, L., & Woolverton, C. (2011). *Prescott's Microbiology (ISE)* (8th ed.). McGraw-Hill Education.
10. Madigan, M. T., Martinko, J. M., Stahl, D., & Clark, D. P. (2012). *Brock Biology of Microorganisms* (13th Global ed.). Pearson International.

Course/ Paper Title	**Introduction to Medical and Industrial Microbiology**
Course offered as	**Discipline Specific Major Course II**
Course Code	RUSMBMJ402
Semester	IV
No. of Credits	2 (30 hours)
No. of lecture Hours/week	2

Sr No.	Learning Objectives:
	To enable the students
1	introduce various terminologies related to infection, pathogenicity and epidemiology
2	To describe how the pathogen invades the host
	To give an overview of how infectious diseases spread in a community
3	To familiarize students to the fundamental concepts of industrial fermentation technology
4	To enable the students to design media using crude raw materials.
5	To explain the construction of bioreactors for various types of fermentation.
6	To chalk out methods to isolate & study industrially important microorganisms.

	Course Outcome
	On completing the course, the student will be able to:
CO1	Define various terminologies associated with infection, pathogenicity and epidemiology
CO2	Analyze the mechanisms of invasion and establishment of the pathogen
CO3	Comprehend the spread of infections leading to an epidemic.
CO4	Describe the basic concepts of fermentation technology.
CO5	Apply knowledge in formulating a medium for any fermentation process.
CO6	Research on new strains for industrial fermentation
CO7	Design a basic fermenter.

Detailed Syllabus

Module	Title with content **Introduction to Medical and Industrial Microbiology**	No. of lectures
I	**Introduction to Medical Microbiology**	15
	1.1 Host – parasite relationship Various terminologies associated	1
	1.2 Entry of pathogen into the host Portal of entry – skin, mucous membrane, parenteral route Preferred portal Adherence factors	2
	1.3 Penetration through host defenses Capsule, cell wall components, enzymes, antigenic variation	2
	1.4 Damage to host cells Using host nutrients, direct damage, toxin production	2
	1.5 Etiology of infectious disease Koch postulates Classification of infectious diseases	2
	1.6 Pattern of a disease, predisposing factors, Development of disease	2
	1.7 Spread of infection Reservoirs transmission	2
	1.8 Nosocomial infections	1
	1.9 Epidemiologists' tools	1
II	**Introduction to Industrial Microbiology**	15
	2.1 Definition & Scope History Range of fermentation products (Schematic)	2
	2.2 Types of fermentations Aerobic, Anaerobic, Surface, Submerged, Batch, Continuous, Fed batch & SSF (Brief description with at least one example each)	2
	2.3 Fermentation medium: Features, Raw material – Molasses, Corn steep liquor, Sulphite waste liquor, Precursors, Buffers, Antifoams, OR reducing agents.	4
	2.4 Inoculum development Basic principle & schematic representation.	1
	2.5 Bioreactors: Features, Construction materials, Basic Design with parts (Diagram), Impellers, Spargers & Baffles (Description & function)	3

	2.6 Production strains Characteristics of production strains Screening – Definition Primary Screening The Crowded Plate Technique, Wilkins Overlay Method, Auxanography, Enrichment Culture Technique, Use of pH indicator Dye Secondary Screening	3

References:

1. Willey, J., Sherwood, L., & Woolverton, C. (2011). *Prescott's Microbiology* (ISE) (8th ed.). McGraw-Hill Education.
2. Willey, J., Sandman, K., & Wood, D. (2019). *Prescott's Microbiology* (ISE) (11th ed.). McGraw-Hill Education.
3. Madigan, M. T., Martinko, J. M., Stahl, D., & Clark, D. P. (2012). *Brock Biology of Microorganisms* (13th Global ed.). San Francisco: Pearson International.
4. Madigan, M. T., Bender, K., & Buckley, D. (2021). *Brock Biology of Microorganisms* (16th Global ed.). San Francisco: Pearson International.
5. Tortora, G. J., Funke, B. R., & Case, C. L. (2016). *Microbiology: An introduction* (12th ed.). Pearson.
6. Waites & Morgan, *Industrial Microbiology – An Introduction,* Printed by T.J. International Ltd, Padstow, Cornwall.
7. Sivakumar, Joe & Sukesh, (2010). *An Introduction to Industrial Microbiology*, S. Chand & Company Ltd.
8. Patel, A. H. (2016). *Industrial Microbiology* (2nd ed.). New Delhi.
9. Casida L.E., (2004). *Industrial Microbiology*, Published by New age International (P) ltd.
10. Stanbury & Whittaker, *Principles of fermentation Technology*, Second edition, MPG Books Ltd, Bodmin, Cornwall

Course/ Paper Title	**Enzymology and Separation Techniques**
Course offered as	**Discipline Specific Major Course III**
Course Code	RUSMBMJ403
Semester	IV
No. of Credits	2 (30 hours)
No. of lecture Hours/week	2

Sr No.	Learning Objectives:
	To enable the students:
1	Learn the properties & classification of enzymes & the enzyme kinetics.
2	Understand the role of coenzymes, cofactors and allosteric enzymes.
3	Evaluate the different methods for separation of biomolecules
4	Set up the chromatography, centrifugation & electrophoretic systems.
5	Understand the different component parts of a device & handle the separation equipment & components with care.

	Course Outcome
	On completing the course, the student will be able to:
CO1	Explain the properties of enzymes, classify them, understand the kinetics of a simple enzyme catalyzed reaction & emphasize the role of coenzymes & cofactors.
CO2	Derive Michaelis Menton & Lineweaver Burk plot
CO3	Differentiate between Simple & Allosteric enzymes.
CO4	Use Chromatography, centrifugation & electrophoretic techniques to separate biomolecules.
CO5	Follow safety guidelines & protocols whilst using the separation systems.

Detailed Syllabus

Module	Title with content **Enzymology and Separation Techniques**	No. of lectures
I	**Enzymology**	15
	1.1 Basic concepts: Definition of Enzyme. General properties of enzymes. How do enzymes accelerate reactions? Rate law for a simple catalyzed reaction. Michaelis-Menten equation and its derivation, Lineweaver Burke plot Classification of enzymes.	5
	1.2 Coenzymes & Cofactors. Different types and reactions catalyzed by coenzymes (in tabular form) Nicotinic acid: structure, occurrence & biochemical function. Examples of Cofactors in enzyme activity.	2
	1.3 Enzyme Kinetics: Effect of Substrate Saturation, Effect of temperature and pH Effect of Inhibitors- Reversible and irreversible, competitive, Noncompetitive and uncompetitive inhibitors Multi-substrate reactions- Ordered, Random and ping pong reactions	4
	1.4 Allosteric enzymes Features, Effect of modulators with ATCase enzyme as example. Koshland-Nemethy and Filmer model & Monod, Wyman and Changeux model	3
	1.5 Ribozymes	1
II	**Separation Techniques**	15
	2.1 Precipitation Principle and methods Ammonium sulphate precipitation	2
	2.2 Chromatography • Definition, types of chromatography • Paper chromatography: Principle, circular, ascending and descending. Separation of amino acids by Paper Chromatography. • Thin layer chromatography: principle, preparation of TLC plates, procedure for TLC, preparative TLC, 2D TLC [one paragraph], HPTLC • Separation of amino acids and sugars by TLC. • Column chromatography: Introduction & principle & setting of column of different types	5
	2.3 Centrifugation • Basic principles of sedimentation, Factors affecting centrifugation.	5

	• Types, care and safety aspects of centrifuges • Types of rotors. • Preparative centrifugation - Differential & Density Gradient & its applications • Analytical centrifugation and its application	
	2.4 Electrophoresis • General principles • Component parts of electrophoretic unit • Horizontal & Vertical Systems • Support media –agarose gels, polyacrylamide gels	3

References:

- Lehninger- *Principles of Biochemistry*- David Nelson, Michael Cox. 4th edition W.H. Freeman & Company [Low price edition- for sale in India, Pakistan, Sri Lanka, Bangladesh, Nepal & Bhutan]
- V.K. Ahluwalia, *Instrumental Methods of chemical analysis*, Ane Books Pvt.Ltd; 2015.
- Keith Wilson & John Walker, *Principles & techniques of Biochemistry & Mol biology* 6th ed, Cambridge University press, 2006.
- J. Jayaraman, *Laboratory manual in Biochemistry*, New Age International Publishers
- Conn & Stumpf, *Outlines of Biochemistry*, 5th Edition. John Wiley & Sons

Course/ Paper Title	**Practicals based on RUSMBMJ401, RUSMBMJ402 and RUSMBMJ403**
Course offered as	**Discipline Specific Major Course IV**
Course Code	RUSMBMJP4
Semester	IV
No. of Credits	2 (60 hours)
No. of lecture Hours/week	4

Sr No.	Learning Objectives:
	To enable the students
1.	Understand application of thermodynamic principles in calculations involving free energy change
2	Isolate microorganisms from natural sources by screening methods & determine their real potential as industrial strains.
3	Learn the different types of fermentation modes.
4	Study different enzyme activity & enzyme kinetics
5	Understand the basic electrophoretic technique.
6	Master the method of separation of amino acids by chromatography method.
7	Recognize virulence factors of pathogens

	Course Outcome
	On completing the course, the student will be able to:
CO1	Apply thermodynamic laws to solve problems related to energy transformations and free energy changes
CO2	Screen for industrially important strains
CO3	Identify different enzyme activity & understand their role in industries.
CO4	Calculate Km & Vmax using Michaelis & Menton & Lineweaver Burke plots.
CO5	Use separation techniques like chromatography & electrophoresis.
CO6	Identify virulence factors of pathogens

Detailed Syllabus

Title of experiment **Practicals based on** **RUSMBMJ401, RUSMBMJ402 and RUSMBMJ403**	60
1. Calculations based on Thermodynamic laws	
2. Calculations based on Free energy change.	
3. Determination of virulence factors - coagulase, haemolysin, lecithinase	
4. Amylase production by Surface, Submerged & SSF method.	
5. Primary screening for Antibiotic producers from soil - Crowded plate & Wilkins Overlay.	
6. Secondary screening - Giant Colony/Streak plate method & Agar Strip methods	
7. Isolation of amylase, protease, lipase producers.	
8. Extracellular production of invertase from yeast and precipitation with ammonium sulphate.	
9. Effect of pH, Temp, substrate and enzyme concentration on activity of invertase.	
10. Determination of Km and Vmax of an enzyme.	
11. Separation and identification of amino acids by ascending paper chromatography	
12. Electrophoresis -Setting of Gel & Loading of wells	
13. Centrifugation - Density gradient - Separation of yeast	

References:

- Nelson, D.L., & Cox, M. M. (2005). *Lehninger: Principles of Biochemistry* (4th ed.). W.H. Freeman & Co.
- Voet, D., & Voet, J. (2016). *Fundamentals of Biochemistry* (5th ed.). Wiley.
- V.K. Ahluwalia, *Instrumental Methods of chemical analysis,* Ane Books Pvt.Ltd; 2015.
- Casida L.E., (2004). *Industrial Microbiology,* Published by New age International (P) ltd.
- Keith Wilson & John Walker, *Principles & techniques of Biochemistry & Mol biology* 6th ed, Cambridge University press, 2006.
- J. Jayaraman, *Laboratory manual in Biochemistry*, New Age International Publishers
- Conn & Stumpf, *Outlines of Biochemistry,* 5th Edition. John Wiley & Sons

Course/ Paper Title	**Microbiology of Food and Dairy and Biostatistics**
Course offered as	**Skill Enhancement Course III**
Course Code	RUSMBSEC401
Semester	IV
No. of Credits	2 (60 hours)
No. of lecture Hours/week	4

Sr No.	Learning Objectives:
	To enable the students
1	Isolate and study characteristics of spoilage organisms.
2	Determine methods to control microbial growth in food to prolong the shelf life.
3	Carry out rapid tests on perishable foods like milk to assess microbiological quality.
4	Understand basic concepts in biostatistics including data presentation, central tendency and dispersion.
5	Appreciate the use of test of significance including t test, F test and Q test.

	Course Outcome
	On completing the course, the student will be able to:
CO1	Identify spoilage organisms in foods.
CO2	Decide the parameters (time -Temp and chemical preservatives) for food preservation.
CO3	Grade Milk on the basis of Rapid tests & Microbiological counts.
CO4	Use basic statistical tools for data presentation and data analysis.
CO5	Apply tests of significance.

Detailed Syllabus

Module	Title with content
	Food Microbiology
	1. Estimation of proteins in food –Direct and Indirect Biuret method
	2. Estimation of reducing sugar – Cole's ferricyanide method
	3. Extraction of lipids – Soxhlet method
	4. Isolation of spoilage organisms from foods (Amylolytic, Proteolytic & Lipolytic)
	5. Determination of TDT & TDP
	6. Salt and Sugar tolerance
	7. MIC of Sodium Benzoate, Metabisulphite
	Dairy Microbiology
	1. Estimation of lactose – DNSA method
	2. Estimation of proteins – Formol titration
	3. Rapid Platform Test - MBRT, RRT & DMC
	4. Microbiological quality of Milk- SPC, LPC, Thermophilic count, Psychrophilic count, Coliform count
	Biostatistics
	1. General terminologies
	2. Sampling techniques
	3. Data presentation -common methods and problems based on the same
	4. Central Tendency & problem based on the same.
	5. Standard deviation and Variance
	6. Hypothesis testing
	7. Test of significance - t-test, F-test, Q test
	Visit to any food or dairy industry

References:

- FSSAI Manuals on Methods of analysis- Microbiological examination of food and water
- Khanal, A. B. (Ed.). (2024). *Mahajan's Methods in Biostatistics for Medical Students and Research Workers* (10th ed.). Jaypee Brothers Medical Publishers. ISBN: 978-9356966512.
- Arora, P. N., & Malhan, P. K**.** (2009). *Biostatistics* (Revised ed.). Himalaya Publishing House. ISBN: 978-1642875621.

Royal College of Arts, Science and Commerce (Autonomous)

Examination Pattern

(**Major and VSC/SEC**)

Theory Examination Pattern

I	**Internal Assessment**	**20 Marks**
a	One class test (Short answers/Objectives/ Multiple Choice)	10 Marks
b	Assignment/ Project/ Presentation/Book or research paper Review	05 Marks
c	Active Participation, Overall performance	05 Marks
II	**Semester End Examination**	**30 Marks**
	Duration	**1 Hours**
	Q 1. Answer any two of four (subjective based on module I)	10 Marks
	Q 2. Answer any two of four (subjective based on module II)	10 Marks
	Q 3. Do as directed (ten objective based on module I and II)	10 Marks

Practical examination Pattern

	External Assessment for Practical	**50 Marks**
	Experiment –I*	20
	Experiment –II*	20
	Viva / Quiz	5
	Journal	5

*(one experiment of 20 marks or two experiments of 10 marks each)

Board of studies in Microbiology

	Category	Name and Designation	Affiliation
1	Chairperson (Head of Department)	Ms. Vilasini Gaode Associate Professor	Royal College of Arts, Science and Commerce
2	Full time teachers of the Department	Ms. Radhika D'souza Associate Professor	
		Ms. Zamanat Syed Associate Professor	
		Mr. Farhaan Makba Associate Professor	
3	Two subject experts from outside the Parent University nominated by the Academic Council.	Dr. Ulhas Patil Professor	Institute of Science, Dr. Homi Bhabha State University
		Dr. Vivek Tanawade Associate Professor Associate Dean of Undergraduate Studies	School of Arts and Science Ahmedabad University
4	One expert nominated by the Vice-Chancellor from a panel of six recommended by the College Principal.	Dr. S. V. Raut Professor and Head,	Dept. of Microbiology, Bhavan's College,
5	One representative from industry / corporate sector/ allied area relating to placement.	Dr. Nirmla Devi Thakur Senior Manager	Excel Innovation Centre, Excel Industries Ltd.
6	One postgraduate meritorious alumnus nominated by the Principal. (Please give three to four names of your alumnus)	Ms. Mukta Kuyare Manager, CSSD and Paramedical Services	Central Sterile Supplies Department, Bhakti Vedanta Hospital
7	One expert from outside the parent college nominated by the College Principal	Dr. Rajbinder Kaur Dehiya Associate Professor	Dept. of Microbiology, Sophia College for Women