AC/II(22-23).3.RUS9

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

Syllabus for S.Y

Program: BSc (Microbiology)

Program Code: RUSMIC

(Credit Based Semester and Grading System for academic year 2023-24)

GRADUATE ATTRIBUTES

GA	GA Description **A student completing Bachelor's Degree in Science program will be able to:**
GA 1	Recall and explain acquired scientific knowledge in a comprehensive manner and apply the skills acquired in their chosen discipline. Interpret scientific ideas and relate its interconnectedness to various fields in science.
GA 2	Evaluate scientific ideas critically, analyse problems, explore options for practical demonstrations, illustrate work plans and execute them, organise data and draw inferences.
GA 3	Explore and evaluate digital information and use it for knowledge upgradation. Apply relevant information so gathered for analysis and communication using appropriate digital tools.
GA 4	Ask relevant questions, understand scientific relevance, hypothesize a scientific problem, construct and execute a project plan and analyse results.
GA 5	Take complex challenges, work responsibly and independently, as well as in cohesion with a team for completion of a task. Communicate effectively, convincingly and in an articulate manner.
GA 6	Apply scientific information with sensitivity to values of different cultural groups. Disseminate scientific knowledge effectively for upliftment of the society.
GA 7	Follow ethical practices at work place and be unbiased and critical in interpretation of scientific data. Understand the environmental issues and explore sustainable solutions for it.
GA 8	Keep abreast with current scientific developments in the specific discipline and adapt to technological advancements for better application of scientific knowledge as a lifelong learner

PROGRAM OUTCOMES

PO	Description **A student completing Bachelor's Degree in Science program in the subject of Microbiology will be able to:**
PO 1	Recall, explain and summarize basic concepts related to cytology, biochemistry, physiology, genetics and reproduction of prokaryotes and compare it with eukaryotes.
PO 2	Appreciate and explain the diversity in the microbial world and evaluate their ecological role as well as state their significance to humankind.
PO 3	Elucidate the basic concepts associated with growth and control of microorganisms and apply it in pure culture and preservation techniques.
PO 4	Differentiate, classify and characterize microorganisms based on their morphological, cultural, biochemical, and molecular properties.
PO 5	Explore, compare and evaluate the role of microorganisms as symbionts in other life forms.
PO 6	Apply the understanding of microbial processes to diverse science areas such as medical, industrial, agricultural and food sciences and evaluate their potential for human well-being, for tackling environmental issues and exploring sustainable solutions
PO 7	Explain the nature of biomolecules and metabolic processes; the role and kinetics of enzymes as well as the thermodynamic laws that drive these reactions.
PO 8	Summarize the basic working principles of various bioanalytical techniques and tools and apply them to detect, estimate and structurally evaluate biomolecules present in the microbial cells.
PO 9	Explain the nature of genetic material and elaborate the molecular mechanisms underlying various genetic processes like replication,

	transcription, translation, gene transfer and recombination in bacteria; and explain basic concepts in virology.
PO 10	Apply the basics of genetics and molecular biology to understand and evaluate techniques in genetic engineering and also for the use of bioinformatic tools for presentation and processing of data.
PO 11	Recognize and explain the role of microorganisms in different diseases, attribute pathogenesis mechanisms to their properties and extrapolate it to disease diagnosis, treatment and prevention. Outline and recall concepts in epidemiology of diseases. Classify and evaluate different chemotherapeutic agents.
PO 12	Classify and summarize mechanisms of defense in humans, detail out the functioning of our immune system, correlate it to disease and its prevention and outline its association to health. Apply immunological principles for diagnosis of diseases.
PO 13	Understand and outline different biochemical mechanisms and their regulation; retrieve and construct biochemical pathways in microbial metabolism of major macromolecules and, recall and integrate the bioenergetics of metabolic reactions.
PO 14	Evaluate, exemplify and outline the role of microorganisms in different industrial fermentations, summarize technological aspects of bioprocesses, recall knowledge about patents, copyright and regulatory practices and QA.
PO 15	Demonstrate key practical skills/competencies in working with microbes for their study and use in the laboratory as well as outside, including the use of good microbiological practices. Analyze problems

	involving microbes, articulate them and devise innovative and creative solutions.
PO 16	Hypothesize, design experiments, construct experimental plans, execute them and analyze data with a basic understanding of statistics. Demonstrate an ability to be unbiased and critical in interpretation of scientific data
PO 17	Communicate effectively to express scientific ideas and/or their experimental data in an effective, precise and concise manner.

PROGRAM OUTLINE

YEAR	SEM	COURSE CODE	COURSE TITLE	CREDITS
FY	I	RUSMIC 101 Core course	Fundamentals of Microbiology	02
		RUSMIC 102 Core course	Techniques in Microbiology	02
		RUSMICP101 Core course	Practical based on above two courses	02
	II	RUSMIC 201 Core course	Microbial world: types and inter-relations	02
		RUSMIC 202 Core course	Microbial biomolecules, Growth & Control	02
		RUSMICP201 Core course	Practical based on above two courses	02
SY	III	RUSMIC 301	Microbial taxonomy and Introduction to Genetics and Molecular Biology	02
		RUSMIC 302	Introduction to Experimental Microbial Biochemistry	02
		RUSMIC 303	Environmental Microbiology	02
		RUSMICP301	Practicals based on above three courses	03
	IV	RUSMIC 401	Microbe interactions and host responses	02
		RUSMIC 402	Introduction to Metabolic Pathways and Enzymology	02

		RUSMIC 403	**Applied Microbiology**	**02**
		RUSMICP401	**Practicals based on above three courses**	**03**
TY	**V**	**RUSMIC 501**	**Microbial Genetics**	**2.5**
		RUSMIC 502	**Medical Microbiology**	**2.5**
		RUSMICP501	**Practical Based on Above Two Courses**	**3**
		RUSMIC 503	**Microbial Biochemistry: Part-I**	**2.5**
		RUSMIC 504	**Bioprocess Technology**	**2.5**
		RUSMICP502	**Practical Based on Above Two Courses**	**3**
	VI	**RUSMIC 601**	**Genetics, Bioinformatics & Virology**	**2.5**
		RUSMIC 602	**Immunology**	**2.5**
		RUSMICP601	**Practical Based on Above Two Courses**	**3**
		RUSMIC 603	**Microbial Biochemistry Part II**	**2.5**
		RUSMIC 604	**Industrial Microbiology**	**2.5**
		RUSMICP602	**Practical Based on Above Two Courses**	**3**

Course Code: RUSMIC 301

Course Title: MICROBIAL TAXONOMYAND INTRODUCTION TO GENETICS AND MOLECULAR BIOLOGY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Differentiate between vast pool of microbes on the basis of morphological, cultural, biochemical and genetic characteristics
CO 2	Demonstrate application of techniques in microbial taxonomy
CO 3	Construct and Interpret Microbial Phylogeny.
CO 4	Apply Classical Genetics and Neo Mendelian Genetics Principles
CO 5	Discriminate the structure of DNA and RNA and the different forms of DNA
CO6	Apply Knowledge of Gene Expression in Bacteria

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 301		**MICROBIAL TAXONOMY AND INTRODUCTION TO GENETICS AND MOLECULAR BIOLOGY**	**2 / 45**
I		**Techniques in Microbial Taxonomy**	**15**
	1.1	**Introduction to microbial Taxonomy and Taxonomic ranks**	**01**
	1.2	**Techniques for studying Microbial Taxonomy**	**08**
		a) Microscopic & macroscopic morphology and biochemical characteristics, b) Chemical Analysis c) Serological analysis d) Genetic & molecular analysis: i. Nucleic acid sequencing and finger printing ii. G+C content iii. Nucleic acid hybridization iv. Amino acid sequencing e) Community DNA analysis	
	1.3	**Introduction to Microbial Phylogeny**	**05**
		a) Phylogenetic Trees i. Types ii. Construction (an overview) b) Numerical Taxonomy	
	1.4	**Bergey's Manual of Systematic Bacteriology**	**01**
		a) Understanding classification and identification schemes for bacteria using Bergey's manual	
II		**Classical Genetics (Mendelian & Neomendelian) & Nucleic acid structure**	**15**
	2.1	**Mendelian genetics:**	**04**

		a) Genotype and Phenotype b) Mendel's Experiments design c) Monohybrid cross and dihybrid cross, Mendelian Laws of inheritance a) Trihybrid Cross	
	2.2	**Non-Mendelian genetics**	**05**
		a) Multiple alleles b) Modification of dominance relationships c) Incomplete dominance d) Codominance (both with their molecular explanations) e) Essential and lethal genes f) Gene expression and effect of environment g) Maternal effect h) Gene interactions and modified Mendelian ratios	
	2.3	**Structure of DNA:**	**03**
		Different 3D forms and unusual structures DNA methylation	
	2.4	**Structure of chromosomes**	**01**
	2.5	**Structure of RNA**	**02**
III		**Gene Expression in Bacteria**	**15**
	3.1	**Central dogma of Molecular Biology**	**01**
	3.2	**Transcription in prokaryotes**	**06**
		a) RNA biosynthesis b) Prokaryotic transcription i. Prokaryotic promoters ii. Initiation, elongation and termination	
	3.3	**Translation**	**06**
		a) Components of protein synthesis apparatus: Genetic code, mRNA, Ribosomes b) Degeneracy of genetic code c) Protein synthesis	

	3.4	**Comparison of eukaryotic & prokaryotic transcription & translation**	**01**
	3.5	**Introduction to the concept of Omics: Genomics and Proteomics**	**01**

References:

a) Prescott‟s Microbiology, Joanne M. Willey, Linda M. Sherwood, Christopher J.Woolverton, Edition, 7th Edition, 2011, McGraw Hill International
b) Madigan, Martinko, Dunlap and Clark, Brock Biology of Microorganisms, 12thedition, 2009, Pearson Education
c) Peter J. Russell, “iGenetics - A molecular approach”, 3rd edition, 2010, Benjamin Cummings.7
d) Stanier R.Y. And Other, MacMillan General Microbiology, 5th edition,1987, MACMILLAN PRESS LTD
e) D. Nelson & M. Cox, Lehninger‟s Principles Of Biochemistry,4th Edition ,2005, (W.H.Freeman& Co., (LPE)
f) James Watson, Molecular Biology of Gene, 5th edition,2004, Pearson Benjamin Cummings CSHL Press.
g) Benjamin A Pierce, Genetics: A conceptual approach ,2002, W.H. Freeman

Course Code: RUSMIC 302

Course Title: INTRODUCTION TO EXPERIMENTAL MICROBIAL BIOCHEMISTRY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Design experiments & analyse the experimental data statistically.
CO 2	Implement the use of web directories & databases for biochemical studies
CO 3	Recall & compare the different cell disintegration methods & elaborate the working principles of centrifugation, electrophoretic & chromatographic techniques used for studying cell analytes.
CO 4	Illustrate the principles of protein separation & purification.
CO 5	Compare the utility & perform the techniques for the estimation of biomolecules.
CO 6	Explain the principle, instrumentation & application of different laboratory instruments used in biochemical studies.
CO 7	Design an experiment for extraction, purification & estimation of biomolecules, & evaluate the statistical relevance of the data generated.

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 302		**INTRODUCTION TO EXPERIMENTAL MICROBIAL BIOCHEMISTRY**	**2/45**
I		**Designing and Analysis of experimental data, General laboratory techniques: Electrochemical sensors**	**15**
	1.1	**Designing experiments:**	**02**
		a) Aims of laboratory experiments b) Outline of Scientific method c) Experimental design d) Analytical considerations and experimental error	
	1.2	**Analysis of experimental data:**	**07**
		a) Data presentation: Dot diagram, Bar diagram, Histogram, Frequency curve, Calibration methods: Linear regression, Internal standards b) Assessment of precision -Mean, Median, Mode, Standard deviation, coefficient of variation and variance c) Assessment of performance of an analytical technique -performance indicators d) Poisson and Normal distribution e) Assessment of accuracy& Validation of analytical data population statistics, confidence limit and confidence interval; Students t factor, Q test, F test, ANOVA	
	1.3	**Using computers in biochemistry**	**02**
		Using web directories, biological databases and tools (eg. NCBI, EMBL)	
	1.4	**General and routine laboratory procedures:**	**04**
		Theoretical and practical aspects of: a) Preparation and use of buffers b) Electrochemical sensors: pH meter	

		c) Oxygen electrode d) Biosensors	
II		**Fractionation of microbial cells and separation techniques**	**15**
	2.1	**Disintegration of cells**	**02**
		a) Physical methods b) Chemical methods	
	2.2	**Separation Techniques**	**03**
		a) Centrifugation techniques: i. Basic principles of sedimentation ii. Types of centrifuges and their use: preparative & analytical, ultracentrifuges iii. Differential, Density Gradient & isopycnic centrifugation	
		b) Electrophoretic techniques: i. General Principles ii. Factors affecting electrophoresis iii. Support media- Agarose gels and PAGE	**03**
		c) Chromatographic Techniques: i. General principles ii. Types and applications- Partition, adsorption, ion exchange, affinity and size exclusion iii. Modes- Paper, TLC, HPLC, GC, Reverse Phase	**07**
III		**Purification & Estimation of biomolecules**	**15**
	3.1	**Separation and purification of proteins**	**03**
		a) Criteria for purity b) Methods of separation/ concentration of proteins based on: i. Size and mass ii. Polarity iii. Solubility iv. Specific binding sites v. Concentration of proteins - Dialysis, Ultrafiltration	

		c) Choice of methods	
	3.2	**Estimation of Biomolecules**	**12**
		a) Visible and UV spectrophotometry i. Principles ii. Instrumentation iii. Applications b) Preparation of bacteria for analysis c) Methods for chemical analysis (Basic principles of all methods to be covered) i. Methods of elemental analysis: Carbon by Slyke's method, Nitrogen by Microkjelhdahl method, Phosphorus by Fiske-Subbarow method ii. Estimation of Carbohydrates by Phenol and Anthrone Method iii. Estimation of Reducing Sugars iv. Estimation of Proteins v. Estimation of Amino acids vi. Extraction of Lipids and estimation of total lipid vii. Estimation of Nucleic acids	03 01 08

References:

a) Norris & Ribbon, Methods in Microbiology, Vol.5B, Edition,1971, Academic Press
b) J. Jayaraman, Laboratory Manual in Biochemistry, 2003, New Age International Publishers
c) D. Nelson & M. Cox, Lehninger's Principles Of Biochemistry,4th Edition, 2005, W.H.Freeman & Co., (LPE)
d) B.K. Mahajan. Jaypee brothers, Methods in biostatistics for medical & research workers. 6thedition, Medical Publishers (P) ltd.
e) Rodney Boyer, Modern experimental biochemistry by 3rd Edition ,2000, Benjamin Cummings
f) I.H. Segel, Biochemical calculations, 2nd Edition 2004, Wiley India
g) Wilson and Walker, Principles and Techniques of Biochemistry and Molecular Biology 7th Ed ,2010. Cambridge University Press
h) Stanier R.Y. And Other, General Microbiology, 5th edition, 1989 MacMillan Press.
i) Plummer David, An Introduction to Practical Biochemistry ,1979, TMH
j) Wayne Daniel, Biostatistics: A Foundation for Analysis in Health Sciences, 10th edition, 2013, Wiley.

Course Code: RUSMIC 303

Course Title: ENVIRONMENTAL MICROBIOLOGY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Comprehend the distribution and characterization of microbes in various habitats/ecosystems
CO 2	Elaborate role of air as a medium of microbial dispersion
CO 3	Differentiate between microbial flora of marine and freshwater environments
CO 4	Execute microbiological techniques for studying microbiota of air, aquatic and terrestrial environments
CO 5	Conduct routine bacteriological analysis techniques for assessing water quality and attribute the results to sources of contamination
CO 6	Retrieve steps in sewage treatment and check effectivity of treatment processes
CO 7	Implement microbiological analysis of a soil ecosystem with an understanding of the most appropriate technique
CO 8	Apply basic principles of environmental microbiology for understanding and solving environmental problems –bioremediation

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 303		**ENVIRONMENTAL MICROBIOLOGY**	**2/45**
I		**Air & Fresh Water Microbiology**	**15**
	1.1	**Air Microbiology**	**05**
		a) Origin, distribution, number and kinds of microorganisms in air, Factors affecting microbial survival in air b) Enumeration of microorganisms in air: Impingement in liquids, Impaction on solids, Filtration, Sedimentation, Centrifugation, Electrostatic Precipitation. c) Air borne pathogens and diseases, droplets and droplet nuclei d) Air sanitation- methods and application	
	1.2	**Fresh water microbiology**	**10**
		a) General: Groups of natural waters, factors affecting kinds of microorganisms found in aquatic environments and nutrient cycles in aquatic environments b) Fresh Water environments and microorganisms found in Lakes, ponds, rivers, marshes, bogs and springs c) Potable water: Definition, water purification and pathogens transmitted through water. d) Microorganisms as indicators of water quality e) Bacteriological examination of water-sampling, routine analysis, SPC, membrane filter technique, Standards for water quality	

II		**Marine and Sewage Microbiology**	**15**
	2.1	**Marine Microbiology**	**05**
		a) Characteristics of marine environments b) Diversity& characteristics of marine microorganisms and their importance c) Ecosystems of Deep-sea Hydrothermal vents and Subterranean Water	
	2.2	**Sewage Microbiology**	**10**
		a) Types of waste water b) Characteristics of waste water c) Modern waste water treatment: Primary, Secondary and tertiary treatment (oxidation ponds, activated sludge, trickling filters, anaerobic digestor). d) Removal of pathogens by sewage treatment Processes e) Sludge Processing f) Disposal of Solid Waste, Modern Sanitary Landfills, Composting	
III		**Soil & Geo Microbiology**	**15**
	3.1	**Soil Microbiology**	**03**
		a) Soil – Definition, composition, function, Textural Triangle Types of Soil microorganisms & their activities	
	3.2	**Methods of studying soil microorganisms**	**05**
		a) Sampling b) Cultural methods c) Physiological methods d) Immunological methods (Tabulation of the immunological methods)	

		e) NA based method f) Radioisotope technique	
	3.3	**Geo Microbiology**	**03**
		a) Carbon cycle b) Nitrogen cycle c) Sulphur cycle d) Phosphorus cycle	
	3.4	**Biodegradation and Bioremediation**	**4**
		a) Microbial leaching b) Metal transformations c) Petroleum degradation d) Degradation of xenobiotics	

References:

a) Raina M. Maier, Ian L. Pepper, Charles P. Gerba, Environmental Microbiology, 2nd Edition,2010, Academic Press
b) A.J. Salle, Fundamental Principles of Bacteriology, 7th Editon,1974, Tata McGraw Hill Publishing Company
c) Air Quality Standards - NAAQS Manual, Volume I, 2011
d) Joanne M. Willey, Linda M. Sherwood, Christopher J.Woolverton Prescott‟s Microbiology, 8th Edition,2011 , McGraw Hill International Edition
e) Frobisher, Hinsdill, Crabtree, Goodheart, Fundamentals of Microbiology, 9th Edition, 1974, Saunders College Publishing
f) Barbara Kolwzan, Waldemar Adamiak (E Book) Oficyna Wydawnicza Politechniki Wroclawskiej, Wroclaw, 2006
g) N.S Subba Rao, Introduction to Environmental Microbiology –Soil Microbiology -4th Edition ,2000, Oxford and IBH Publishing Co. Pvt Ltd
h) Michael T. Madigan & J.M. Martin, Brock’s Biology of Microorganisms 13th Ed. International edition 2012, Pearson Prentice Hall.

Course code	PRACTICALS	3 CREDITS
RUSMICP301	**PRACTICAL-1**	
	1. Isolation and identification of a bacterial isolate 2. Problems on Mendelian genetics 3. Extraction of DNA from onion and *E. coli* 4. Problems on genetic code 5. Construction of phylogenetic tree.	
RUSMICP302	**PRACTICAL -2**	
	1. Introduction to experimental design 2. Lab common sense workshop 3. Biostatistics problems 4. Study of pH meter and preparation of buffers 5. Density gradient centrifugation 6. Demonstration of agarose gel electrophoresis 7. Demonstration of PAGE 8. Separation of amino acids using paper chromatography 9. Separation of carbohydrates using TLC 10. Demonstration of column chromatography 11. Demonstration of HPLC, HPTLC and GC 12. Determination of λmax 13. Verification of Beer's law and determination of extinction coefficient 14. Large scale cultivation of bacteria /yeast/ fungi 15. Determination of Dry and wet Weight 16. Disintegration of cells using physical & chemical methods and separation of biomolecules 17. Estimation of Amino acids by Ninhydrin method 18. Estimation of Proteins by Biuret method 19. Bradford's Method for protein estimation	

	20. Estimation of Reducing Sugars by DNSA method 21. Estimation of RNA by orcinol method 22. Estimation of DNA by diphenylamine method Note: All the above methods will also be analyzed using statistical methods covered in theory	
RUSMICP303	**PRACTICAL-3**	
	1. Enumeration of microorganisms in air and study its load after fumigation 2. Determination of microbial load using air impinger 3. Study of halophilic and haloduric bacteria from marine samples 4. Routine analysis of water 5. Use of membrane filter technique for bacteriological analysis of water 6. Rapid detection of *E.coli* by MUG technique-Demo 7. Visit to a Sewage treatment plant 8. BOD of untreated and treated sewage 9. Buried slide technique to study soil flora 10. Enrichment and isolation of Cellulose degraders, Sulphate reducers and Phosphate solubilizers from soil 11. Setting up Winogradsky's Column 12. Developing compost pits	

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks per paper

Sr No	Evaluation type	Marks
1	One Assignment/Case study/Project/ Presentation	20
2	One class Test (multiple choice questions / objective)	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks per paper

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be three questions each of 20 marks one on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1) A)	Any 3 out of 5	15	Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.2) A)	Any 3 out of 5	15	Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.3) A)	Any 3 out of 5	15	Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 60 Marks

Particulars	Paper I	Paper II	Paper III
Journal	05	05	05
Experimental tasks	15	15	15
Total	**20**	**20**	**20**

B) External Examination: 60%- 90 Marks

Semester End Practical Examination:

Particulars	Paper I	Paper II	Paper III
Laboratory work	25	25	25
Spots/Quiz/Viva	05	05	05
Total	**30**	**30**	**30**

PRACTICAL BOOK/JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / Incharge of the department, failing which the student will not be allowed to appear for the practical examination.

Overall Examination & Marks Distribution Pattern

Semester III

Course	301			302			303			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**300**
Practicals	**20**	**30**	**50**	**20**	**30**	**50**	**20**	**30**	**50**	**150**

Course Code: RUSMIC 401

Course Title: Microbe Interactions and Host Responses

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Summarize microbial interactions with plants, animals and other microorganisms
CO 2	Evaluate the ecological, medical and evolutionary significance of microbial interactions with plants, animals and other microorganisms
CO 3	Outline the strategies through which pathogens develop infections and demonstrate presence of some virulence factors in known isolates
CO 4	Categorize cases of diseases on the basis of the epidemiological concepts and terminologies and explain the transmission of diseases
CO 5	Apply the principles and practices of epidemiological studies in solving public health issues
CO6	Explain the key components of innate and acquired immune system and summarize their role in overcoming disease
CO7	Differentiate between immunoglobulins and explain their function in immunity

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 401		**MICROBE INTERACTIONS AND HOST RESPONSES**	**2/45**
I		**Microbial interactions with plants, animals and other microbes**	**15**
	1.1	**Microbial associations with plants**	**08**
		a) Phyllosphere b) Rhizosphere & Rhizoplane c) Mycorrhizae d) Nitrogen fixation: Biochemistry of nitrogen fixation, nodulation in *Rhizobia*, *Azolla-Anabena* symbiosis, Actinorhizae, Stem nodulating *Rhizobia* e) Fungal & Bacterial endophytes f) Plant pathogens -Fungal, bacterial and viral diseases	
	1.2	**Microbial interactions with animals**	**05**
		a) Microbial symbionts in invertebrates b) Bacterial flora in the Rumen c) Microbe- insect interactions d) Introduction to Zoonotic diseases	
	1.3	**Microbe - Microbe interactions**	**02**
		a) Lichen b) Endosymbionts of Protozoa c) Parasitism in microbes	
II		**Microbial invasion in Human hosts**	**15**
	2.1	**Virulence Mechanisms**	**08**
		a) Bacterial virulence factors i. Adherence factors ii. Invasion of host cells and tissues iii. Toxins- Exotoxins and Endotoxins iv. Enzymes	

		v. Evading host defense- Antigenic variation, Antiphagocytic factors and Intracellular pathogenicity vi. Iron sequestration vii. The role of Biofilms	
		b) Measuring bacterial virulence: Infective dose & Lethal dose, limulus amoebocyte assay c) Pathogenic properties of viruses, fungi and protozoa	
	2.2	**Introduction to epidemiological concepts**	**07**
		a) Reservoirs of infection b) Modes of disease transmission c) Nosocomial infections d) Epidemiological terminology: epidemic, endemic, pandemic, sporadic, incidence rate, prevalence rate, mortality, morbidity e) Controlling epidemics: Controlling reservoirs, controlling transmission- Immunization strategies- passive and active, Surveillance	
III		**Host responses to infection**	**15**
	3.1	**Cells, Tissues and Organs of the Immune System**	**04**
		a) Cells of the immune system- Lymphoid and Myeloid cells, NK cells b) Organs of the immune system- Introduction to primary and secondary lymphoid organs and their roles	
	3.2	**Immune responses- Innate defense mechanisms**	**04**
		a) Phagocytosis – Recognition, Destruction, b) Inflammation- Acute and Chronic c) Fever d) Molecular defenses- IFN, complement, ACP	
	3.3	**Immune responses- Acquired Defense**	**07**
		a) Outline and characteristics of Adaptive Immune response b) Immunoglobulins – basic and fine structure c) Immunoglobulin classes and biological activities d) Antigenic determinants on immunoglobulins – isotypes, allotypes, idiotypes	

		e) Protective functions of antibodies- Opsonization, Complement mediated lysis, viral neutralization and toxin neutralization f) Introduction to Cell mediated immunity	

References:

a) Willey, Sherwood and Woolverton, Prescott's Microbiology, 9th edition, 2013, International edition, McGraw Hill.
b) Michael T. Madigan & J.M. Martin, Brock's Biology of Microorganisms 13th Ed. International edition 2012, Pearson Prentice Hall.
c) Stanier, General microbiology 5th edition ,1987, Macmillan publication
d) Tortora, Funke and Case, Microbiology: An Introduction, 10th Edition, 2010, Pearson.
e) Kathleen Park Talaro & Arthur Talaro - Foundations in Microbiology International edition 2002, McGraw Hill.
f) Jacquelyn Black, Laura Black, Microbiology, Principles and Explorations, 9th Ed, 2015, Wiley
g) Brooks, Carroll, et al, Jawetz, Melnick &Adelberg's Medical Microbiology, 26th Ed McGraw Hill Lange 2013
h) https://www.eurofins.com.au/biopharma-services/testing-solutions/sterile-products-testing/endotoxin-or-lal-test/
i) Ingraham and Ingraham, Introduction to Microbiology, by 2nd Ed ,2000, Brooks/Cole
j) Thomas J. Kindt, Barbara A. Osborne, Richard A. Goldsby, Kuby Immunology, 6th ed, W. H. Freeman & Company 2005

Course Code: RUSMIC 402

Course Title: INTRODUCTION TO METABOLIC PATHWAYS AND ENZYMOLOGY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Demonstrate comprehension of metabolic concepts and classifications, and differentiate between various metabolic strategies. Recall the importance of Omics in biochemical research.
CO 2	Analyze the regulatory points within metabolic pathways.
CO 3	Retrieve information regarding enzyme properties and categories. Illustrate models of enzyme-substrate interaction and identify the significance of cofactors and coenzymes.
CO 4	Evaluate enzyme kinetics and assess changes in activity under different variables.
CO 5	Explain the principles of Bioenergetics and attribute the function of energy currency molecules.
CO 6	Apply the laws of thermodynamics to microbial metabolism.
CO 7	Execute experimental protocols for enzyme purification and conduct studies on enzyme kinetics.

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 402		**INTRODUCTION TO METABOLIC PATHWAYS AND ENZYMOLOGY**	**2/45**
I		**Introduction to Metabolism**	**15**
	1.1	**Introduction to biochemical reactions:**	**04**
		a) Key reactions involved in metabolism. b) Weak interactions involved in determining the structures and functions of macromolecules.	
	1.2	**Introduction to metabolism:**	**06**
		a) Metabolism- Catabolism & Anabolism b) Types of Metabolic pathways c) Metabolic networks, use of different software d) Primary and secondary metabolism e) Energy and reducing power requirements	
	1.3	**Metabolic strategies: Managing metabolic network**	**04**
		a) Role of enzymes, enzyme clustering & multienzyme complexes b) Functional coupling c) Compartmentalization in cells	
	1.4	**Introduction to omics: Metabolome & Metabolomics**	**01**
II		**Enzymology**	**15**
	2.1	**Introduction to enzymes:**	**06**
		a) General properties of enzymes b) How do enzymes accelerate reactions? c) Classification of enzymes d) Enzyme kinetics: Rate law for a simple catalyzed reaction, Michaelis-Menten equation and its derivation, other plots to determine velocity of reactions	
	2.2	**Modifying enzyme catalysis rates**	**05**

		a) Effect of temperature and pH b) Effect of Inhibitors- Reversible and irreversible, competitive, Non-competitive and uncompetitive inhibitors c) Allosteric effects in enzyme catalyzed reactions d) Multi-substrate reactions- Ordered, Random and ping-pong reactions e) Koshland- Nemethy and Filmer model f) Monod, Wyman and Chageux model	
	2.3	**Coenzymes& Co-factors:**	**04**
		a) Different types and reactions catalyzed by coenzymes (in tabular form) b) Water soluble coenzymes (NAD, Nicotinic acid) c) Fat soluble vitamins and their examples. d) Inorganic cofactors	
III		**Principles of Bioenergetics**	**15**
	3.1	**Bioenergetics & thermodynamics:**	**06**
		a) Energy transformations b) Thermodynamic quantities, standard –free energy c) Difference between ΔG & ΔGo‟	
	3.2	**ATP and it's role**	**05**
		a) Structure of ATP, phosphoryl group transfer and ATP b) Types of energy –rich compounds c) Multi-roles of ATP inorganic phosphoryl group donor	
	3.3	**Biological oxidation-reduction reactions**	**04**

References:

a) Principles of Biochemistry by Geoffery Zubay (1988) 4th Edition Wm.C. Brown Publishers
b) Outlines Of Biochemistry,5/E,Conn P.Stumpf, G.Bruening & R.Doi,John Wiley & Sons, New York 1995
c) Fundamentals of Enzymology: Cell and Molecular Biology of Catalytic Proteins 3rd Edition Nicholas Price and Lewis Stevens
d) Lehninger: Principles Of Biochemistry,4th Ed., D. Nelson & M. Cox, W.H.Freeman & Co., (LPE)
e) A biologist's Physical Chemistry by John Gareth Morris.
f) Concepts of Biochemistry, Rodney Boyer
g) Stanier, General microbiology 5th edition ,1987, Macmillan publication
h) Principles of Biochemistry by Robert Horton (2011) 5th Edition Pearson Publishers.

Course Code: RUSMIC 403

Course Title: APPLIED MICROBIOLOGY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Analyse the importance of microbes in fermentation industry and compare the techniques used for their screening
CO 2	Compare different types of fermentations and fermentation processes used for industrial productions
CO 3	Explain the role of components used in industrial fermentation media
CO 4	Summarize the general principles of food spoilage by microorganisms and compare methods used for food preservation
CO 5	Execute experimental procedures for detection of microbes in food and dairy products and comment on its quality
CO 6	Identify the sources of microorganisms in milk and explain the significance of pasteurization techniques
CO7	Outline and analyze the manufacturing processes of different fermented dairy products
CO 8	Apply contamination control, preservation methods, and quality control procedures to foods and dairy products

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 403		**APPLIED MICROBIOLOGY**	**2/45**
I		**Industrial Microbiology**	**15**
	1.1	**Strains of industrially important microorganisms**	**04**
		a) Desirable characteristics of an industrial strain b) Principles and methods of primary and secondary screening	
	1.2	**Types of fermentations:**	**02**
		a) Aerobic b) Anaerobic c) Solid state fermentation	
	1.3	**Types of fermentation processes:**	**02**
		a) Surface and Submerged b) Batch, continuous, fed-batch fermentation process	
	1.4	**Media for industrial fermentations**	**05**
		a) Production and Inoculum media b) Media components: - Carbon source, nitrogen source, amino acids and vitamins, minerals, water, buffers, antifoam agents, precursors, inhibitors and inducers	
	1.5	**Inoculum development**	**02**
II		**Food Microbiology**	**15**
	2.1	**Introduction:**	**01**
		Significance, food as a substrate and sources of microorganisms in food	
	2.2	**Intrinsic and extrinsic factors affecting the microbial growth in food**	**02**
	2.3	**General Principles of spoilage**	**04**

		Spoilage of fresh foods: fruits and vegetables, eggs, meat, poultry and seafood	
	2.4	**General principles of food preservation**	**04**
		(principle of each method and example of foods only) High temperature, low temperature, drying, radiations and food additives and preservatives (tabular representation), Asepsis, introduction to HACCP, Regulation	
	2.5	**Food borne diseases**	**1**
	2.6	**Methods of detection of microorganisms in food:**	**3**
		Overview of cultural, microscopic, physical, chemical and bioassay methods	
III		**Dairy Microbiology**	**15**
	3.1	**Milk- Definition, composition, sources of contamination of milk**	**2**
	3.2	**Pasteurization of milk** LTHT, HTST, UHT	**3**
	3.3	**Milk products: production and spoilage of:**	**7**
		a) Yoghurt b) Butter c) Cheese-Cheddar and Cottage cheese d) Fermented milks	
	3.4	**Quality control of milk**	**3**
		a) Rapid platform tests b) Microbiological analysis of milk : SPC, Coliform count, LPC, Psychrophiles, Thermophilic count, DRT	

References:

a) Fundamental Food Microbiology by Bibek Ray, Arun Bhunia (2007), 4th edition CRC Press
b) Food Microbiology by Frazier 5th ed (1971), McGraw-Hill Education.
c) Modern Food Microbiology by James Jay 6th ed(2000), Springer US.
d) Applied Dairy Microbiology by Marth & Steele(2001), CRC Press
e) BIS standards, FSSAI
f) Casida L. E., "Industrial Microbiology" 2009 Reprint, New Age International (P) Ltd,Publishers, New Delhi
g) Stanbury P. F., Whitaker A. & Hall--S. J., 1997, "Principles of Fermentation,Technology", 2nd Edition,Aditya Books Pvt. Ltd, New Delhi.
h) Prescott and Dunn's „"Industrial Microbiology"".1982 4th Edition, McMillan Publishers
i) H. A. Modi, 2009. „"Fermentation Technology"" Vol 2, Pointer Publications, India.
j) Milk and milk products. C. H. Eckles 1943 edition
k) Sukumar De, Outlines of dairy technology , 1st edition,1983, O.U.P
l) James Jay Frazier 5th. Ed Okafor Waites & Morgan

Course code	PRACTICALS	3 Credits
RUSMICP 401	**PRACTICAL-1**	
	1. Isolation of *Rhizobium* from root nodules 2. Demonstration of fungi and algae in lichens 3. Study of virulence factors – Enzymes – Streptokinase, Coagulase, Hemolysin, Lecithinase 4. Demonstration of biofilm formation by pathogens on catheters 5. Assignment on classical stages, signs and symptoms of any one microbial disease 6. Staining of blood film to demonstrate different types of leucocytes 7. Phagocytosis (Demonstration) 8. Study of plant microbe interactions: Screening for Auxin production (PGP from Rhizosphere) 9. Case studies and problems on Epidemiology 10. How to develop epidemiological surveys	
RUSMICP 402	**PRACTICAL-2**	
	1. Using KEGG, Ecocyc, metacyc, biocyc and Brenda for understanding metabolic networking 2. Qualitative detection of a. Amylase b. Lipase c. Protease d. DNase e. Catalase f. Oxidase	

	g. Carbohydrate fermentation h. Dehydrogenase 3. Production and purification of an enzyme 4. Assay of an enzyme and determination of enzyme units 5. Determination of km and Vmax of an enzyme 6. Effect of environment on enzyme activity: a. Effect of temperature b. Effect of pH c. Effect of enzyme concentration 7. Effect of inhibitors	
RUSMICP 403	**PRACTICAL-3**	
	1. Isolation of antibiotic producers from soil- Wilkin's overlay method. 2. Determination of microbial counts in food using dip slide technique (demonstration) 3. Isolation of food spoilage agent 4. Determination of TDT and TDP 5. Determination of Salt and sugar tolerance 6. Determination of MIC of a preservative 7. Visit to Food/Dairy industry 8. Rapid platform tests of raw and pasteurized milk. 9. Microbiological analysis of raw and pasteurized Milk. 10. Microbiological analysis of Butter, Cheese. 11. Surface and submerged fermentation. 12. Testing a packaged meat product for its microbial load.	

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks per paper

Sr No	Evaluation type	Marks
1	One Assignment/Case study/Project/ Presentation	20
2	One class Test (multiple choice questions / objective)	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks per paper

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be three questions each of 20 marks one on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1) A)	Any 3 out of 5	15	Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.2) A)	Any 3 out of 5	15	Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.3) A)	Any 3 out of 5	15	Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 60 Marks

Particulars	Paper I	Paper II	Paper III
Journal	05	05	05
Experimental tasks	15	15	15
Total	**20**	**20**	**20**

B) External Examination: 60%- 90 Marks

Semester End Practical Examination:

Particulars	Paper I	Paper II	Paper III
Laboratory work	25	25	25
Spots/Quiz/Viva	05	05	05
Total	**30**	**30**	**30**

PRACTICAL BOOK/JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / Incharge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination & Marks Distribution Pattern
Semester IV

Course	401			402			403			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**300**
Practicals	**20**	**30**	**50**	**20**	**30**	**50**	**20**	**30**	**50**	**150**
