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

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

Syllabus for T.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 501

Course Title: Microbial Genetics

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Explain and differentiate between population and quantitative genetics and compare model organisms used in genetic studies.
CO 2	Summarize different natural plasmids and transposons present in prokaryotes and be able to compare and contrast between different plasmids.
CO 3	Summarize the coherence of the molecular mechanisms involved in DNA replication and outline different enzymes and proteins associated with both prokaryotic and eukaryotic DNA replication
CO 4	Outline different enzymes and proteins associated with both prokaryotic and eukaryotic DNA replication
CO 5	Identify, interpret and classify mutations in DNA followed by mechanism of DNA repair
CO 6	Test the effect of mutagens on bacteria and identify mutants
CO 7	Solve and interpret problems based on mapping of bacterial genes using transformation, transduction and conjugation
CO 8	Retrieving basic concepts of homologous recombination and genetic exchange among prokaryotes

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 501		**MICROBIAL GENETICS**	**2.5/60**
I		**Branches of Genetics, Plasmids, Transposons**	**15**
	1.1	**Overview of branches of Genetics**	**04**
		a) Transmission, Molecular, b) Population Genetics: Hardy-Weinberg Law-principle and violation of assumptions (Mutation, Migration, Genetic Drift, Natural Selection) c) Quantitative Genetics: Characteristics, concept of Heritability, QTLs, Response to selection	
	1.2	**Model Organisms**	**03**
		a) Characteristics of a model organism b) Examples of select model organisms used in study: *E.coli,* Yeast, Mouse, *Caenorhabditis elegans*, *Arabidopsis thaliana*	
	1.3	**Plasmids**	**04**
		a) Physical nature b) Detection and isolation of plasmids c) Plasmid incompatibility and Plasmid curing d) Cell to cell transfer of plasmids e) Types of plasmids i. Resistance Plasmids ii. Plasmids encoding Toxins and other Virulence characteristics iii. col factor iv. Degradative plasmids	
	1.4	**Transposable elements in Prokaryotes**	**04**
		a) Insertion sequences b) Transposons i. Types ii. Structure and properties iii. Mechanism of transposition	

		iv. Transposon mutagenesis v. Integrons	
II		**DNA Replication**	**15**
	2.1	**Historical perspective**	**04**
		a) Conservative b) Dispersive c) Semi-conservative d) Bidirectional e) Semi-discontinuous DNA replication	
	2.2	**Prokaryotic DNA replication**	**`04**
		Details of molecular mechanism involved in Initiation, Elongation and Termination	
	2.3	**Enzymes and proteins associated with DNA replication**	**04**
		a) Primase b) Helicase c) Topoisomerase d) SSB e) DNA polymerases f) Ligases g) Ter and Tus proteins	
	2.4	**Eukaryotic DNA replication**	**02**
		a) Molecular details of DNA synthesis b) Replicating the ends of the chromosomes	
	2.5	**Rolling circle mode of replication**	**01**
III		**Mutation and Repair**	**15**
	3.1	**Mutation**	**10**
		a) Terminology: alleles, homozygous, heterozygous, genotype, phenotype, Somatic mutation, Germline mutation, Gene mutation, Chromosome mutation, phenotypic lag, hotspots and mutator genes b) Fluctuation test. c) Types of mutations: Point mutation, reverse mutation, suppressor mutation, frameshift mutation, conditional lethal mutation, base pair substitution, transition, transversion, missense mutation, nonsense mutation, silent mutation, neutral mutation, pleiotropic mutations. d) Causes of mutation: Natural/spontaneous mutation--replication error, depurination,	

		deamination. Induced mutation: principle and mechanism with illustrative diagrams for – i. Chemical mutagens- base analogues, nitrous acid, hydroxyl amine, intercalating agents and alkylating agents. ii. Physical mutagen iii. Biological mutagen (only examples) e) Ames test f) Detection of mutants	
	3.2	**DNA Repair**	**05**
		a) Mismatch repair b) Light repair c) Repair of alkylation damage d) Base excision repair e) Nucleotide excision repair f) SOS repair	
IV		**Genetic Exchange**	**15**
	4.1	**Gene transfer mechanisms in bacteria & homologous recombination**	
		a) Transformation i. Introduction and History ii. Types of transformation in prokaryotes—Natural transformation in *Streptococcus pneumoniae, Hemophilus influenzae* and *Bacillus subtilis* iii. Mapping of bacterial genes using transformation iv. Problems based on transformation.	**04**
		b) Conjugation i. Discovery of conjugation in bacteria ii. Properties of F plasmid/Sex factor iii. The conjugation machinery iv. Hfr strains, their formation and mechanism of conjugation v. F‘ factor, origin and behavior of F‘ strains, Sexduction. vi. Mapping of bacterial genes using conjugation (Wolman and Jacob experiment). vii. Problems based on conjugation	**05**
		c) Transduction i. Introduction and discovery ii. Generalized transduction iii. Use of Generalized transduction for mapping genes iv. Specialized transduction v. Problems based on transduction	**03**

	4.2	**Recombination in bacteria**	**03**
		a) General/Homologous recombination i. Molecular mechanism ii. Holliday model of recombination b) Site–specific recombination	

References:

a) Peter J. Russell, “Genetics-A molecular approach”, 2nd edition, 2006.
b) Benjamin A. Pierce, “Genetics a conceptual approachll”, 3rdedition, 2008, W. H. Freeman and company.
c) R. H. Tamarin, “Principles of genetics”, 2004, Tata McGraw Hill.
d) D, Nelson and M. Cox, “Lehninger‘s Principles of biochemistry” 4th edition,2005, Macmillan worth Publishers.
e) M.Madigan, J. Martinko, J.Parkar, “Brock Biology of microorganisms”, 12th edition, 2009, Pearson Education International.
f) Fairbanks and Anderson, “Genetics”,1999, Wadsworth Publishing Company.
g) Willey, Sherwood and Woolverton, Prescott’s Microbiology, 7th edition, 2013, International edition, McGraw Hill.
h) Robert Weaver, “Molecular biology”, 3rd edition, McGraw Hill international edition.
i) Nancy Trun and Janine Trempy, “Fundamental bacterial genetics”, 2004, Blackwell Publishing.
j) Snustad, Simmons, “Principles of genetics” 3rd edition, John Wiley & sons, Inc.
k) Stanier, Ingraham, “General Microbiology”,5th edition, Macmillan
l) Benjamin Lewin, “Genes IX”, Jones and Bartlett publishers.
m) JD Watson, Bake, Bell, Gann, Levine, Losick, “Molecular biology of the gene”, 5th edition, Person

Course Code: RUSMIC 502

Course Title: Medical Microbiology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Interpret modern alternatives to Koch's postulates
CO 2	Summarize the basic aspects of clinical and diagnostic microbiology and implement bacteriological investigations using good laboratory practices
CO 3	Interpret and explain the coherence between pathogenesis mechanisms of microorganisms, clinical manifestation of disease and prophylactic measures of representative bacterial, fungal and parasitic infections in various organ systems
CO 4	Extrapolate the understanding of representative infections of skin, respiratory system, urinary tract, gastro intestinal tract central nervous system to other infections within the same system
CO 5	Given a few key clinical features, design and execute lab diagnostic procedures for any given pathological specimen and test antibiotic susceptibility of the isolated pathogen
CO6	Differentiate between the different classes of antibiotics on the basis of their mechanism of action
CO7	Attribute strategies through which microbes acquire anti-microbial resistance
CO8	Check and evaluate drugs/ antibiotics for their efficacy by demonstrating their action on microorganisms

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 502		**MEDICAL MICROBIOLOGY**	**2.5/60**
I		**Study of Infectious diseases-I**	**15**
	1.1	**Associating Microbes to disease**	**02**
		a) Koch's Postulate and modern alternatives to it b) Molecular Koch's postulates	
	1.2	**Introduction to Clinical and diagnostic Microbiology**	**05**
		a) Phases of diagnostic cycle- Pre analytic, analytic and post analytic b) Introduction to Molecular and immunological methods	
	1.3	**Study of Infectious Diseases-I** (With Emphasis on Characteristics of the Aetiological Agent, Pathogenesis & clinical features, Laboratory Diagnosis and Prevention)	**08**
		Respiratory diseases: a) Strep throat by *S. pyogenes* b) Diphtheria c) Common cold d) Tuberculosis *e)* Pneumonia caused by *K. pneumoniae*	
II		**Study of Infectious Diseases II** (With emphasis on cultural characteristics of the aetiological agent, pathogenesis, laboratory diagnosis and prevention**)**	**15**
	2.1	**Study of skin infections**	**05**
		a) Leprosy b) Pyogenic skin infections caused by *Pseudomonas, S. pyogenes* and *S. aureus*. c) Fungal infections- Oral Thrush, Dermatophytosis	
	2.2	**Study of gastrointestinal tract infections**	**08**
		a) Enteric fever- *Salmonella* b) Shigellosis c) Infections due to pathogenic *E. coli* strains d) Rotavirus diarrhoea	

		e) Dysentery due to *Entamoeba histolytica*	
	2.3	. **Study of urinary tract infections**	**02**
		a) Predisposing factors b) List of causative agents c) Pathogenesis and laboratory diagnosis	
III		**Study of Infectious Diseases III** (With emphasis on cultural characteristics of the aetiological agent, pathogenesis, laboratory diagnosis and prevention)	**15**
	3.1	**Study of vector-borne infections**	**03**
		a) Rickettsial diseases b) Malaria	
	3.2	**Study of sexually transmitted infectious diseases**	**07**
		a) Syphilis b) AIDS c) Gonorrhea	
	3.3	**Study of central nervous system infectious diseases**	**05**
		a) Tetanus b) Polio c) Meningococcal meningitis	
IV		**Chemotherapy of infectious agents**	**15**
	4.1	**Introduction to Chemotherapeutic agents**	**03**
		a) Attributes of an ideal chemotherapeutic agent and related definitions b) Selection and testing of antibiotics for bacterial isolates by Kirby-Bauer method and other assays (E-test & Checker Board Assay)	
	4.2	**Mode of action of antibiotics**	**08**
		a) Cell wall (Beta-lactams- Penicillin and Cephalosporins, Carbapenems) b) Cell Membrane (Polymyxin and Imidazole) c) Protein Synthesis Aminoglycosides (Streptomycin), Macrolide (Erythromycin), Tetracycline and Chloramphenicol d) Nucleic acid (Quinolones, Nalidixic acid, Rifamycin) e) Enzyme inhibitors (Sulfa drugs, Trimethoprim)	

	4.3	**List of common antibiotics** used for treating viral, fungal and parasitic diseases, New antibiotics	**01**
	4.4	**Mechanisms of drug resistance** Its evolution, pathways and origin	**03**

References:

a) Brenda Wilson, Abigail Salyer And Dixie Whitt, Bacterial Pathogenesis –A molecular approach 3rdEd ASM press 2011
b) Gary. W. Procop, Dierdre Church et al, Koneman's Color Atlas and Textbook of Diagnostic Microbiology, Seventh Ed, Walters Kluwer, 2017
c) Willey, Sherwood and Woolverton, Prescott's Microbiology, 9th edition, 2013, International edition, McGraw Hill.
d) Brooks, Carroll, et al, Jawetz, Melnick &Adelberg's Medical Microbiology, 26th Ed McGraw Hill Lange 2013
e) Ananthanarayan and Panicker's, Textbook of Microbiology, 10th edition, Ed by Reba Kanugo, Universities Press, 2017
f) Goering, Dockerel et al, Mim's Medical microbiology, 5th Ed 2013, Saunders

Course code	PRACTICALS	3 Credits
RUSMICP 501	**PRACTICAL 1**	
	1. UV survival curve – determination of exposure time leading to 90% reduction 2. Isolation of mutants using UV mutagenesis 3. Replica plate technique for selection & characterization of mutants – auxotroph & antibiotic resistant 4. Isolation and detection of plasmid DNA. 5. Preparation of competent cells and transformation 6. Demonstration of conjugation. 7. Assignment on sample collection, transport and processing of any one pathological sample 8. Rapid detection of infection in samples from CNS 9. Rapid Direct tests for identification of pathogens- a. Acid fast staining of *M. tuberculosis/ M.leprae*. b. Metachromatic granule staining for *C.diphtheriae* c. Catalase test d. Bile solubility test e. Slide coagulase test for *S.aureus* f. Spot indole test g. Oxidase test h. Modern methods for identification of pathogens. 10. Identification of isolates obtained from following samples by morphological, cultural and biochemical properties from- a. Nasal/ throat swabs (URT infection) b. Sputum (LRT infection) c. Skin swab/ pus (Skin infection) d. Identification of *Candida* species using the germ tube test and growth on HiChrom agar e. Stool (GI tract infection) f. Urine (UTI infection) 11. Demonstration of malarial parasite in blood film	

	12. Selection and testing of antibiotics using the Kirby-Bauer method 13. Determination of MIC of an antibiotic by E-test 14. Synergistic action of two drugs 15. Determination of MBC of an antibiotic. 16. Detection of β lactamase in *S.aureus.* 17. Role of plasmids in antibiotic resistance through curing of the plasmid	

Course Code: RUSMIC503

Course Title: Microbial Biochemistry Part I

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Explain the membrane architecture & critique the modes of solute transportation.
CO 2	Compare & contrast the mechanism of ATP synthesis in Prokaryotes & Eukaryotes.
CO 3	Summarize & differentiate the catabolic pathways of carbohydrates & deconstruct its amphibolic nature.
CO 4	Outline & evaluate the different fermentative pathways in bacteria.
CO 5	Delineate the anabolic pathways for carbohydrate synthesis.
CO 6	Organize the tally sheet of energetics for different catabolic substrates and solve problems based on these.
CO 7	Perform & evaluate the experimental aspects of metabolic reactions & differentiate organisms on the basis of their metabolic differences.

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 503		**MICROBIAL BIOCHEMISTRY PART I**	**2.5/60**
I		**Biological Membranes & Transport**	**15**
	1.1	**Composition and architecture of membrane**	**02**
		a) Lipids b) Integral & peripheral proteins & interactions with lipids c) Permeability and outer membrane- a barrier d) Aquaporins e) Mechanosensitive channels	
	1.2	**Methods of studying solute transport**	**02**
		a) Using whole cells b) Using Liposomes c) Using Proteoliposome	
	1.3	**Solute transport across membrane**	**08**
		a) Passive transport facilitated by membrane proteins. b) Transporters grouped into Superfamilies' ' c) Co transport across plasma membrane (Uniport, Antiport, Symport) d) Active transport & electrochemical gradient e) Ion gradient provides energy for secondary Active transport e.g. Lactose transport f) ATPases and transport g) ABC transporters e.g. Histidine transport h) Shock sensitive system – Role of binding proteins e.g. Maltose uptake i) Phosphotransferase system j) Schematic representation of various Membrane transport mechanisms in. *E. coli*	
	1.4	**Other examples of solute transport**	**03**
		a) Iron transport: A special problem b) Bacterial protein export c) Bacterial membrane fusion central to many biological processes	

II		**Bioenergetics and Bioluminescence**	**15**
	2.1	**Biochemical mechanism of generating ATP**	**01**
		a) Substrate level b) Oxidative c) Photo Phosphorylation	
	2.2	**Electron transport chain**	**03**
		a) Universal Electron acceptors that transfer Electrons to ETC. b) Carriers in ETC i. Hydrogen carriers – Flavoproteins, Quinones ii. Electron carriers-Iron sulphur proteins, Cytochromes c) Mitochondrial ETC i. Biochemical anatomy of mitochondria ii. Complexes in Mitochondrial ETC iii. Schematic representation of Mitochondrial ETC	
	2.3	**Prokaryotic ETC**	**03**
		a) Organization of electron carriers in bacteria b) Generalised electron transport pathway in bacteria c) Different terminal oxidases d) Branched bacterial ETC e) Pattern of electron flow in *E. coli*– aerobic an anaerobic f) Pattern of electron flow in *Azotobacter vinelandii*	
	2.4	**ATP synthesis**	**04**
		a) Explanation of terms – Proton motive force, Proton Coupling sites, P: O ratio, Redox potential b) Free energy released during electron transfer from to O_2. c) Chemiosmotic theory d) Structure & function of Mitochondrial ATP synthase (No Kinetics) e) Mechanism by Rotational catalysis f) Structure of bacterial ATP synthase g) Inhibitors of ETC, Inhibitors of ATPase, Uncouplers, Ionophores	
	2.5	**Other modes of generation of electrochemical energy**	**02**
		a) ATP hydrolysis b) Oxalate formate exchange c) Product efflux, Definition- Lactate efflux d) Bacteriorhodopsin - Definition, Significance, Function as proton pump	

	2.6	**Bioluminescence**	**02**
		a) Brief survey of bioluminescent systems b) Biochemistry of light emission c) Schematic diagram d) Significance / Application	
III		**Methods of Studying Metabolism & Catabolism of Carbohydrates**	**15**
	3.1	**Experimental Analysis of metabolism**	**03**
		a) Goals of the study b) Levels of organization at which metabolism is studied. c) Metabolic probes d) Use of radioisotopes in biochemistry i. Pulse labelling ii. Assay & study of radio respirometry –to differentiate EMP & ED e) Use of biochemical mutants. f) Sequential induction technique	
	3.2	**Catabolism of Carbohydrates**	**12**
		a) Breakdown of polysaccharides – glycogen, starch, cellulose. b) Breakdown of oligosaccharides– lactose, maltose, sucrose, cellobiose c) Utilization of monosaccharides – fructose, Galactose. d) Major pathways- i. Glycolysis (EMP) & its regulation ii. HMP Pathway & Significance of the pathway iii. ED pathway, iv. TCA cycle, Significance & its regulation v. Anaplerotic reactions vi. Glyoxylate bypass, vii. Incomplete TCA in anaerobic bacteria viii. Amphibolic role of EMP and TCA cycle ix.Energetics of Glycolysis, ED and TCA-Balance sheet and efficiency calculation	
IV		**Fermentative Pathway & Anabolism of Carbohydrates**	**15**
	4.1	**Fermentative pathways** (With structures and enzymes)	**04**
		a) Lactic acid fermentation – i. Homofermentors ii. Heterofermentors iii. Bifidobacterium pathway (Schematic) b) Alcohol fermentation	

		i. by ED pathway in bacteria ii. by EMP in yeasts	
	4.2	**Other modes of fermentations in microorganisms**	**05**
		a) Mixed acid b) Butanediol c) Butyric acid d) Butanol-acetone e) Propionic acid (Acrylate pathway and succinate propionate pathway)	
	4.3	**Anabolism of Carbohydrates**	**06**
		a) General pattern of metabolism leading to synthesis of a cell from Glucose b) Gluconeogenesis c) Biosynthesis of Glycogen d) Biosynthesis of Peptidoglycan e) Role of carriers in synthesis of LPS and capsule	

References:

a) Stanier R. Y., Ingraham. J. L, Wheelis. M. L, Painter. P. R., General Microbiology, 5th edition, 1987, The Macmillan press Ltd.

b) Conn, E.E., P. K. Stumpf, G.Bruening and R. Y. Doi, Outlines of Biochemistry, 5th edition, 1987. John Wiley &Sons. New York.

c) Gottschalk, G., Bacterial Metabolism, 2nd edition, 1985, Springer Verlag.

d) White, D., The Physiology and Biochemistry of Prokaryotes, 3rd edition, 1995, Oxford University Press.

e) Nelson, D. L. and M.M. Cox, Lehninger, Principles of biochemistry. 4th edition, 2005, W. H. Freeman and Company.

f) Rose, A.H. Chemical Microbiology, 3rd edition, 1976, Butterworth-Heinemann.

g) Zubay, G. L, Principles of Biochemistry, 4th edition, 1996, Wm. C. Brown publishers

h) Mathews, C.K., K.E. van Holde, D.R. Appling, S.J. Anthony-Cahill, Biochemistry, 4th edition, 2012, Pearson.

i) Wilson and Walker, Principles & techniques of Biochemistry & Molecular Biology, 7th edition, 2010, Cambridge University Press.

j) Madigan, M.T. and J.M. Martinko, Brock Biology of Microorganisms, 11th edition, 2006, Pearson Prentice Hall;

k) Cohen, G.N. , Microbial Biochemistry. 2nd edition, 2006, Springer.

Course Code: RUSMIC 504

Course Title: Bioprocess Technology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Plan and execute the process for isolation and strain improvement of industrially important microorganisms
CO 2	Outline the types and significance of sterilization process in fermentation industry
CO 3	Design the process of Inoculum development at various levels of scale-up
CO 4	Explain the assembly and working of typical fermenters and apply the knowledge to operate fermenters in microbiological industries
CO 5	Explain and apply methods of recovery and purification of fermentation products
CO 6	Explain methods in industrial effluent treatment and apply the same for environment protection
CO 7	Explain principles of different spectroscopic techniques
CO 8	Substantiate the role of different organizations related to Intellectual Property Rights, and categorize types of intellectual property rights

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 504		**BIOPROCESS TECHNOLOGY**	**2.5 /60**
I		**Upstream Processing**	**15**
	1.1	**Strains and Strain Improvement of industrial microorganisms**	**11**
		a) Isolation of industrially important microorganisms b) Improvement of industrial microorganisms i. Selection of induced mutants for primary metabolites ii. Isolation of induced mutants for secondary metabolites	
	1.2	**Sterilization**	**04**
		a) Introduction to the concept of media sterilization and Nabla factor b) Design and methods of batch sterilization c) Design and methods of continuous sterilization	
II		**Fermenter equipment and control**	**15**
	2.1	**Design of fermenter**	**05**
		a) Inoculum development b) Basics of fermenter i. Aseptic operation and containment ii. Body construction iii. Aeration and agitation c) Achievement and maintenance of aseptic condition i. Valves- function in general and examples ii. Steam Traps- function in general and examples	
	2.2	**Types of fermenters**	**05**
		a) Acetator b) Cavitator c) Tower fermenter d) Cylindro conical fermenters e) Air lift fermenters i. Outer loop fermenters ii. Inner loop fermenters f) Cyclone column g) Packed tower (generator) h) Rotating disc fermenters i) Bubble cap fermenters	
	2.3	**Control of Variables**	**05**

		a) Types of variables b) Sensing and control of i. pH ii. Temperature iii. Dissolved oxygen iv. Flow measurement v. Pressure vi. Inlet/ Exit gas analysis vii. Foam sensing	
III		**Downstream processing**	**15**
	3.1	**Downstream processing**	**12**
		a. Recovery & Purification of fermentation products: i. Introduction ii. Precipitation iii. Filtration - theory, filter-aids, batch filters (Plate and frame filters), continuous filters (Rotary vacuum), iv. Centrifugation: flocculating agent, range of centrifuges - Basket, tubular bowl. b. Cell disruption methods: Physico-chemical. c. Liquid – Liquid extraction, Solvent recovery, d. Chromatography –Ion exchange &Adsorption e. Membrane processes – Ultrafiltration, reverse osmosis, liquid membranes. f. Drying, Crystallization, Whole broth processing	
	3.2	**Environmental aspects**	**3**
		a) Modern methods of effluent treatment b) Carbon Credits	
IV		**Bioinstrumentation And IPR**	**15**
	4.1	**Bioinstrumentation**	**8**
		Principles, working and applications of**:** a) Spectrophotometry (I. R) b) Atomic absorption (AAS) & Atomic Emission spectroscopy (Flame photometry) c) Mass Spectroscopy- MALDI ToF, ESI	
	4.2	**Intellectual Property Rights**	**7**
		a) Introduction to Intellectual Property b) Genesis of IPR - GATT, WTO, TRIPS, World Intellectual Property Organization (WIPO)	**1** **3** **3**

		c) Types of Intellectual Property – Patents, Copyright, Trademark, Trade secret, Plant varieties protection act, Industrial Designs, Geographical Indications	

References:

a) Casida L. E., "Industrial Microbiology'" (2009) Reprint, New Age International (P)Ltd, Publishers, New Delhi

b) Stanbury P. F., Whitaker A. & HaII S. J., (1997), "Principles of Fermentation Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.

c) H. A. Modi, (2009). _ 'Fermentation Technology ''Vols 1 & 2, Pointer Publications, India

d) Okafor Nduka (2007) _ 'Modern Industrial Microbiology and Biotechnology '', Science Publications Enfield, NH, USA.

e) G Y Shitole and Ram Sable (2012) Environmental Degradation Issues and Challenges (Research publication)

f) Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial Microbiology", 2nd Edition, Panima Publishing Corporation, New Delhi.

g) Principles and Techniques of Biochemistry and Molecular Biology by Wilson/Walker 7th Edition

h) Brian McNeil & Linda M. Harvey, Practical Fermentation Technology, John Wiley and Sons. Pvt. Ltd. (2008).

i) WIPO Publication No. 450(E) ISBN 978-92-805-1555-0 https://www.wipo.int/edocs/pubdocs/en/intproperty/450/wipo_pub_450.pdf

Course code	PRACTICALS	3 Credits
RUSMICP502	**PRACTICAL 2**	
	1. Isolation and detection of Mitochondria 2. Isolation and study of Bioluminescent organisms 3. Study of oxidative and fermentative metabolism 4. Carbohydrate fermentation tests 5. Mixed acid fermentations- Detection of organic acids by TLC 6. Study of Homo and Hetero fermentation in Lactic acid bacteria 7. Detection of enzyme phosphatase 8. Quantitative assay of Phosphatase 9. Stormy fermentation 10. Strip Plate Technique 11. Streak Plate Technique 12. Gradient plate technique for isolation of mutants. 13. Production and detection of vitamin B12 by bioautography. 14. Demonstration of IR spectroscopy and analysis of IR spectrum of one compound 15. Demonstration of GC-MS/ LC-MS	

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 **four** questions each of **15** marks on each unit.
    b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Questions	Options	Marks	Total marks	Questions on
Q.1) A)	Any 2 out of 3	10		Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.2) A)	Any 2 out of 3	10		Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.3) A)	Any 2 out of 3	10		Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.4) A)	Any 2 out of 3	10		Unit IV
Q.4) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	

Practical Examination Pattern:

A. Internal Examination: 40%- 80 Marks

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

B. External Examination: 60%- 120 Marks

Semester End Practical Examination:

Particulars	Practical I	Practical II
Laboratory work	50	50
Spots/Quiz/Viva	10	10
Total	**60**	**60**

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 / In charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern
Semester V

Course	501			502			503			504			Grand Total
	In	Ex	Total	In	Ex	Total	In	Ex	Total	In	Ex	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practical	20	30	50	20	30	50	20	30	50	20	30	50	200

Course Code: RUSMIC 601

Course Title: Gene Manipulation, Bioinformatics, & Virology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Explain the fundamentals of gene manipulation
CO 2	Implement bioinformatics tools for genetic analysis and structure building
CO 3	Correlate structure and function of important cell components of prokaryotic and eukaryotic cells
CO 4	Summarizing and categorising various genes and proteins involved in functioning of prokaryotic and eukaryotic structures
CO 5	Summarizing the structure, classification, enumeration, cultivation and life cycle of viruses.
CO 6	Recognise and compare the commonly used terms like cancer, prions, viroids and their replication mechanisms
CO 7	Independently illustrate regulation of lytic and lysogenic pathway of lambda phage
CO 8	Test the presence of coliphages and execute experiments for their enumeration

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 601		**GENE MANIPULATION, BIOINFORMATICS, &VIROLOGY**	**2.5/60**
I		**Gene Manipulation**	**15**
	1.1	**Basic Principles of Gene Manipulation**	**12**
		a) Cutting and joining DNA: Restriction endonucleases, Ligases, Linkers and Adapters b) Cloning vectors: Characteristics of a good vector, Plasmid vectors, Bacteriophage λ, Expression vectors c) Cloning strategies: Genomic libraries, cDNA libraries, PCR	
	1.2	**Emerging techniques in Genome sciences**	**03**
		a) Microarray technologies b) Karyotyping c) CRISPR-based technologies and applications	
II		**Bioinformatics & Cell Biology**	**15**
	2.1	**Bioinformatics**	**06**
		a) Introduction i. Definition, aims, tasks and applications of Bioinformatics. ii. Overview of prominent Databases, tools and their uses iii. Importance, Types and classification of databases iv. Nucleic acid sequence databases- EMBL, GenBank, Ensembl v. Protein sequence databases-PIR, SWISS-PROT, TrEMBL vi. Protein structure databases: PDB, Cn3D. vii. Pathway analysis: KEGG. b) Applications: i. Transcriptome, Metabolomics, Pharmacogenomics,	

		ii. Phylogenetic analysis, Phylogenetic tree, Annotation, SNPs iii. Sequence alignment-- global v/s local alignment, FASTA file format, BLAST. iv. Genomics- structural, functional and comparative genomics. v. e. Proteomics- structural and functional proteomics.	
	2.2	**Cell Biology of Prokaryotes and Eukaryotes**	**09**
		a) Revision of structure and function of Cell wall, capsule, flagella and endospore of prokaryotes b) Cytoskeleton and cell motility i. Prokaryotic cytoskeleton: ftsZ and its role in cell division ii. Structure and function: Microtubules, Microfilaments, Intermediate filaments iii. Microtubular organelles – Cilia, Flagella and centrioles iv. Molecular motors: Myosins, Kinesins, Dyenin	
III		**Basic Virology**	**15**
	3.1	**Viral architecture**	**04**
		a) Capsid, viral genome and envelope b) Structure of TMV, T4, Influenza virus, HIV	
	3.2	**Viral classification**	**02**
	3.3	**The viral replication cycle**	**04**
		a) attachment, b) penetration, c) uncoating, d) types of viral genome and their replication, e) assembly, f) maturation and release	
	3.4	**Life cycle of viruses**	**05**
		a) T4 phage, b) TMV, c) Influenza Virus and d) HIV	
IV		**Advanced Virology**	**15**
	4.1	**Cultivation of viruses**	**05**
		a) Cell culture techniques,	

		b) embryonated egg, c) laboratory animals, d) Cell culture methods: e) Equipment required for animal cell culture, f) Isolation of animal tissue	
	4.2	**Visualization and enumeration of virus particles**	**03**
		a) Measurement of infectious units i. Plaque assay ii. Fluorescent focus assay iii. Infectious centre assay iv. Transformation assay v. Endpoint dilution assay. b) Measurement of virus particles and their components i. Electron microscopy ii. Atomic force microscopy iii. Haemagglutination iii. Measurement of viral enzyme activity.	
	4.3	**Regulation of lytic and lysogenic pathway of lambda phage**	**03**
	4.4	**Role of viruses in cancer**	**02**
		a) Definitions, b) characteristics of cancer cell, c) cancer multi step process, d) Human DNA tumor viruses- i. EBV, ii. Kaposi's sarcoma virus, iii. Hepatitis B and C virus, iv. Papilloma Virus	
	4.5	**Prions and viroids**	**02**

References:

a) R. H. Tamarin, (2004), “Principles of genetics”, Tata McGraw Hill.
b) M. Madigan, J. Martinko, J. Parkar, (2009), “Brock Biology of microorganisms”, 12th ed., Pearson Education International.
c) Fairbanks and Anderson, (1999), “Genetics”, Wadsworth Publishing Company.
d) Prescott, Harley and Klein, “Microbiology” 7th edition McGraw Hill international edition.
e) Edward Wagner and Martinez Hewlett, (2005) “Basic Virology”, 2nd edition, Blackwell Publishing
f) Teri Shors, (2009), “Understanding viruses”, Jones and Bartlett publishers.
g) S.Ignacimuthu, (2005), “Basic Bioinformatics”, Narosa publishing house.
h) Robert Weaver, (2008), “Molecular biology”, 3rd ed. McGraw Hill international edition.
i) Primrose and Twyman, (2001), “Principles of gene manipulation and genomics”, 6thed, Blackwell Publishing
j) Arthur Lesk, (2009), “Introduction to Bioinformatics”, 3rd Edition, Oxford University Press
k) Snustad, Simmons, “Principles of genetics”, 3rdedn. John Wiley & sons, Inc.
l) Lodish, Scott.” Molecular cell biology,7th edn, Macmillan higher education, International ed.
m) Flint, Enquist, Racanillo and Skalka, “Principles of virology”, (2009)3rdedn. ASM press
n) T. K. Attwood & D. J. Parry-Smith, (2003), “Introduction to bioinformatics”, Pearson education
o) Benjamin Lewin, (2014) 9th edition, “Genes IX”, Jones and Bartlett publishers.
p) JD Watson, Baker (2004) 5thedn. “Molecular biology of the gene”, CSHL Press and Benjamin Cummings
q) Jonathan Pevsner, Bioinformatics and Functional Genomics, 3rd Edition, 2015, Wiley Blackwell
r) Jin Xiong, Essential Bioinformatics, 1st Edition, 2006, Cambridge University Press

Course Code: RUSMIC 602

Course Title: Immunology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Evaluate molecules for their antigenicity and explain role of haptens in elucidating molecular nature of antigens
CO 2	Outline mechanisms of antigen processing and presentation and the molecules involved thereof
CO 3	Explain the mechanisms of receptor-ligand interactions between cells involved in acquired as well as innate immune mechanisms
CO 4	Retrieve the process of T and B cell activation and proliferation in response to antigenic stimuli
CO 5	Summarize and compare the effector responses- Humoral Immunity & Cell Mediated Immunity
CO 6	Extrapolate the role of immune system in disease: Unregulated response- Hypersensitivity; exemplify the different types
CO 7	Explain the mechanism of Antigen-Antibody interaction & illustrate and execute immunological techniques for disease diagnosis
CO 8	Apply the concept of immunity for protection from disease by development of vaccine

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 602		**IMMUNOLOGY**	**2.5/60**
I		**Antigens and Antigen- antibody reactions**	**15**
	1.1	**Overview of innate and acquired immunity, cells and organs in immune responses**	**02**
	1.2	**Antigens**	**05**
		a) Immunogenicity versus antigenicity b) Factors that influence immunogenicity, Contribution of the biological system to immunogenicity c) Epitopes / antigen determinants (only concepts) d) Haptens and antigenicity e) Immunogenicity of some natural substances – native globular proteins, polysaccharides, lipids, nucleic acids Types of antigens – heterophile antigens, isophile antigens, sequestered antigens, super antigens, bacterial and viral antigens	
	1.3	**Antigen-Antibody reactions**	**08**
		a) Generation of Antibodies for experimental systems- Monoclonal antibodies b) Western Blotting c) Immunoprecipitation based assays d) Agglutination, passive agglutination, agglutination inhibition, e) Solid Phase assays- Radioimmunoassay (RIA), Enzyme immunoassays (EIA), f) Immunofluorescence, Immunohistochemistry g) Flow Cytometry, Fluorescence Activated Cell Sorting	
II		**Antigen presentation and Activation of Immune cells**	**15**
	2.1	**MHC complex and MHC molecules**	**03**

		a) Structure of class I, and class II molecules; class III molecules b) Peptide – MHC interaction	
	2.1	**Antigen processing and presentation**	**02**
		a) Antigen presentation- professional and nonprofessional cells b) Antigen processing and presentation	
	2.2	**Receptor Ligand interactions and activation in T cells**	**05**
		a) TcR, (alpha-beta, gamma-delta TcR), TcR-CD3 complex structure & functions, Accessory molecules. b) T cell activation, T cell differentiation, Subsets of T cells (TH1, TH2, TH17, T reg), Formation of Memory cells	
	2.3	**Receptor Ligand interactions and activation in B cells**	**05**
		a) B- cell receptors, Receptor associated molecules, receptor clustering. Antigen processing by B cells B cell activation and differentiation –Antigen recognition and presentation by B cells, Formation of germinal centres and memory cells. b) B-cell responses to Thymus dependent and independent antigens	
III		**Acquired Immune Responses and Innate Immune Mechanisms**	**15**
	3.1	**Cytokines**	**02**
		a) Properties, types and functions b) Cytokines secreted by Th1 and Th2 cells	
	3.2	**Humoral Response**	**04**
		a) Introduction of Humoral response, Primary and secondary responses b) Affinity maturation and somatic hyper mutation, Ig diversity, class switching	
	3.3	**Cell mediated effector response**	**03**
		a) Generation and target destruction by Cytotoxic T cells.	

		b) Killing mechanism of NK cells.	
	3.4	**Innate Immune mechanisms**	**04**
		a) Role of PAMPs and PRRs in phagocytosis eg LPS b) Role of cytokines and chemokines in phagocytosis c) Induced proteins by PRR signalling d) Innate immunity and septic shock	
	3.5	**Interactions between Innate and Acquired immunity**	**02**
IV		**Vaccines, Immunohematology And Hypersensitivity**	**15**
	4.1	**Vaccines**	**05**
		a) Active and passive immunization b) Types of vaccines - Killed and attenuated vaccines, Whole organism vaccines, Purified macromolecules as vaccines, recombinant viral vector vaccines, DNA vaccines c) Use of adjuvants in vaccine d) New vaccine strategies, Ideal vaccine	
	4.2	**Immunohematology**	**05**
		a) Human blood group systems, ABO, secretors and non-secretors, Bombay Blood group b) Rhesus system and list of other blood group systems. c) Haemolytic disease of new born, Coombs test.	
	4.3	**Hypersensitivity**	**05**
		Coombs and Gell's classification Type I to Type IV hypersensitivity - Mechanism and manifestation.	

References:

a) Thomas J. Kindt, Barbara A. Osborne, Richard A. Goldsby, Kuby Immunology, 6th ed, W. H. Freeman & Company 2005

b) Oven, Punt, Stranford, Kuby Immunology,7th ed W.H. Freeman, 2013

c) Sulabha Pathak, Urmi Palan, Immunology: Essential and Fundamental, 3rd Ed, Anshan Ltd, 2011

d) Davis, Dulbecco, Eisen and Ginsberg, Microbiology, 4th ed, Lippincott Williams and Wilkins, 1990.

e) Fahim Halim Khan, The Elements of Immunology, Pearson Education, 2009

COURSE CODE	PRACTICALS	3 Credits
RUSMIC P601	**PRACTICAL 1**	
	1. Isolation of genomic DNA of *E. coli* and measurement of its concentration by UV-VIS. 2. Restriction digestion of plasmid DNA 3. Demonstration of PCR 4. Bioinformatics practical On Line Practical a. Visiting NCBI and EMBL websites & list services available, software tools available and databases maintained b. Visiting & exploring various databases mentioned in syllabus i. Using BLAST and FASTA for sequence analysis ii. Fish out homologs for given specific sequences (by teacher – decide sequence of some relevance to their syllabus and related to some biological problem e.g. evolution of a specific protein in bacteria, predicting function of unknown protein from a new organism based on its homology) iii. Six frame translation of given nucleotide sequence iv. Restriction analysis of given nucleotide sequence v. Pair-wise alignment and multiple alignment of a given protein sequences vi. Formation of phylogenetic tree 5. Enrichment of coliphages from sewage 6. Enumeration of phages- Phage assay (pilot & proper). 7. Demonstration of chick embryo inoculation 8. Antigen Preparation: 'O'& 'H' antigen preparation of Salmonella. Confirmation by slide agglutination 9. Electrophoresis of serum. 10. Demonstration of soluble antigens by precipitation reaction. 11. Immunodiagnostics- Dreyer's drop Widal test 12. Diagnosis of syphilis- TRUST antigen kit 13. Demonstration of ELISA 14. Blood grouping – Direct & Reverse typing 15. Major and minor compatibility test 16. Determination of Isoagglutinin titre 17. Coomb's Direct test	

Course Code: RUSMIC 603

Course Title: Microbial Biochemistry Part II

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Categorize lipids into different classes based on their structure
CO 2	Map the steps in the biochemical pathway for metabolism of lipids
CO 3	Outline pathways for biochemical synthesis, degradation and recycling of nucleic acids
CO 4	Explain mechanisms of catabolism of protein and synthesis of amino acid synthesis in the cell
CO 5	Compare and contrast between various levels of metabolic regulation
CO 6	Explain process of prokaryotic photosynthesis and attribute it to photosynthetic pigments, photochemical apparatus and light and dark reactions
CO 7	Compare and contrast metabolism of different inorganic compounds and outline the concept of Lithotrophy
CO 8	Execute and implement enzyme assays and testing of metabolic processes

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 603		**MICROBIAL BIOCHEMISTRY PART II**	**2.5/60**
I		**Lipid Metabolism & Catabolism Of Hydrocarbons**	**15**
	1.1	**General introduction to Lipids**	**02**
		a) Lipids and their functions b) Action of lipases on triglycerides /tripalmitate c) Phospholipids and their properties d) Common phosphoglycerides in bacteria	
	1.2	**Catabolism of Lipids**	**05**
		a) Oxidation of saturated fatty acid- β oxidation pathway, Energetics of β oxidation of Palmitic acid b) Oxidation of propionic acid. c) Degradation of poly beta hydroxy butyrate	
	1.3	**Anabolism of Lipids**	**05**
		a) Biosynthesis of straight chain even carbon saturated fatty acid (palmitic acid) b) Biosynthesis of phosphoglycerides in bacteria c) Biosynthesis of PHB	
	1.4	**Catabolism of aliphatic hydrocarbons**	**03**
		a) Oxidation of saturated aliphatic hydrocarbon (n-alkane) b) Omega oxidation pathway- c) Pathway in Corynebacterium and yeast d) Pathway in Pseudomonas	
II		**Metabolism Of Proteins And Nucleic Acids**	**15**
	2.1	**Protein catabolism**	**05**
		a) Enzymatic degradation of proteins b) Metabolic fate of amino acids (schematic only c) Metabolism of single amino acids – i. Deamination reactions ii. Decarboxylation iii. Transamination e) Fermentation of single amino acid -Glutamic acid by Clostridium	

		f) Fermentation of pair of amino acids -Stickland reaction	
	2.2	**Amino acid synthesis**	**04**
		a) Schematic representation of amino acid families b) Synthesis of amino acids of Aspartate family	
	2.3	**Nucleic acid Catabolism**	**03**
		a) Degradation of purine nucleotides up to uric acid formation b) Recycling of purine and pyrimidine nucleotides by salvage pathway	
	2.4	**Anabolism of Nucleic Acids**	**03**
		a) Metabolic origin of atoms in purine and pyrimidine ring b) Biosynthesis of pyrimidine nucleotides. c) Biosynthesis of purine nucleotides. d) Formation of deoxyribonucleotides. e) Synthesis of nucleotide diphosphates and triphosphates. f) Role of nucleotides (high energy triphosphates)	
III		**Metabolic Regulation**	**15**
	3.1	**Overview and major modes of regulation**	**01**
		Examples of cellular control mechanism acting at various levels of metabolism (tabulation only)	
	3.2	**Allosteric proteins**	**04**
		a) Definition b) Allosteric enzymes - Role of allosteric enzymes using ATCase as example (no kinetic study) c) Regulatory allosteric proteins i. Interaction of proteins with DNA ii. Structure of DNA Binding proteins iii. Examples - Lac repressor, Trp repressor, CAP protein iv. Definition and examples of alarmones	
	3.3	**Regulation of gene expression (Transcription)**	**06**
		a) Introduction to operon model b) Common patterns of regulation of transcription – General concept of positive and negative regulation of operons i. Lac operon - Mechanism of regulation - Induction - Catabolite repression	

		ii Trp operon - End Product Repression - Attenuation c) Regulation of gene expression i. Multiple Sigma Factors ii. Riboswitches	
	3.4	**Regulation of enzyme activity (Post translational regulation)**	**04**
		a) End-Product Inhibition and Mechanism of End Product Inhibition in branched pathways with examples i. Isofunctional enzymes ii. Concerted feedback inhibition iii. Sequential feedback inhibition iv. Cumulative Feedback inhibition v. Combined activation and inhibition b) Covalent modifications of enzymes i. General examples without structure ii. Monocyclic cascade &inter-convertible enzyme definition iii. Glutamine synthetase system of *E .coli* iv. Regulation by proteolytic cleavage	
		Prokaryotic Photosynthesis & Inorganic Metabolism	**15**
	4.1	**Prokaryotic photosynthesis**	**09**
IV		a) Early studies on photosynthesis i. Light and dark reactions ii. Bacterial photosynthesis iii. Hill reaction b) Phototrophic prokaryotes -Oxygenic, Anoxy phototrophs examples only c) Photosynthetic pigments d) Location of photochemical apparatus e) Photophosphorylation f) Light reactions in i. Purple photosynthetic bacteria ii. Green sulphur bacteria ii. Cyanobacteria (with details) g) Dark reaction i. Calvin Benson cycle ii. Reductive TCA	
	4.2	**Inorganic Metabolism**	**06**
		a) Assimilatory pathways- i. Assimilation of nitrate, ii. Ammonia fixation – Glutamate dehydrogenase,	03

		iii. Glutamine synthetase, GS-GOGAT, Carbamoyl phosphate synthetase iv. Biological nitrogen fixation (Mechanism for N2 fixation and protection of nitrogenase) v. Assimilation of sulphate b) Dissimilatory pathways- i. Nitrate as an electron acceptor (Denitrification in *Paracoccus denitrificans*) ii. Sulphate as an electron acceptor c) Lithotrophy– Enlist organisms and products formed oxidation of Hydrogen, carbon monoxide, Ammonia, Nitrite, Sulphur, Iron.	2 1

References:

a) Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition, The Macmillan press Ltd

b) Conn, E.E., P. K. Stumpf, G. Bruening and R. Y. Doi. 1987. Outlines of Biochemistry, 5th edition, 1987. John Wiley & Sons. New York.

c) Gottschalk, G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag

d) White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rd edition, Oxford University Press

e) Nelson, D. L. and M.M. Cox (2005), Lehninger, Principles of biochemistry. 4th edition, W. H. Freeman and Company.

f) Salle, A.J. Fundamental Principles of Bacteriology, 7thedn McGraw Hill Book Co.

g) Cohen, G.N. (2011). Microbial Biochemistry. 2ndedn, Springer

h) Madigan, M.T. and J.M. Martinko 2006. Brock Biology of Microorganisms. Pearson Prentice Hall;

i) Biochemistry 3rd edition, Mathew, Van Holde and Ahern, Pearson Education

j) Zubay, G. L (1996), Biochemistry, 4th edition, Wm. C. Brown publishers

k) Principles of Biochemistry, Lehninger, 5thednW. H. Freeman and Company

Course Code: RUSMIC 604

Course Title: Industrial Microbiology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Outline the processes of fermentation for the bulk production of primary and secondary metabolites and summarize the significance of each step
CO 2	Outline the production of commercially important fermentation products like fermented foods, alcoholic beverages, SCP, probiotics etc.
CO 3	Design and execute conventional fermentation processes and collaborate to establish a business using the examples studied
CO 4	Explain the principles underlying Bioassays and compare the methods of Biological assays
CO 5	Test and evaluate activity of fermentation products using microbiological assays
CO 6	Summarize factors responsible for contamination during production of sterile products, execute preventive measures against contamination
CO 7	Evaluate effectiveness of sterilization procedures and assess the Microbiological Quality of pharmaceutical products
CO 8	Outline the salient features of quality management and Good Manufacturing Practices

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 604		**INDUSTRIAL MICROBIOLOGY**	**2.5 /60**
I		**Industrial Fermentations: I**	**15**
		a) Types of alcoholic beverage. b) Beer –Ale and Lager c) Wine –Red and white & Champagne d) Vinegar (acetator& Generator) e) Bioethanol production- -From feedstock to fermentable sugars - *Zymomonas mobilis* as an alternate ethanol producer f) Acetone Butanol Fermentation	**1** **3** **4** **2** **3** **2**
II		**Industrial Fermentations: II**	**15**
	2.1	**Production of secondary metabolites-** Antibiotics- Penicillin& Semisynthetic Penicillins	**04**
	2.2	**Production of primary metabolites-** a) Vitamin B_{12} from *Propionibacterium & Pseudomonas* b) Amino acids- Methods for manufacture, Glutamic Acid (direct) c) Organic acids- Citric acid d) Enzymes- Uses of enzymes in industry, Production of Fungal amylase by solid substrate fermentation, Stabilization of enzymes- Immobilization techniques e) Biotransformation of steroids	 **03** **01** **02** **04** **01**
III		**Industrial Fermentations: III**	**15**
	3.1	a) Mushroom cultivation b) SCP- Substrates used, Organisms and safety c) Fermented foods- Bread, Fermented cassava, Kombucha tea d) Mold modified foods- Types (list only), Production of Soya sauce e) Lactic acid starter cultures, Probiotics, Prebiotics and Synbiotics	**03** **03** **03** **02** **04**
IV		**Bioassays & Quality Assurance**	**15**
	4.1	**Bioassays**	**05**
		a) Comparison of Chemical and Biological assays	

		b) Microbiological assays- Test organisms, types of assay methods and factors affecting. c) Modern methods for assay of fermentation products	
	4.2	**QA, QC, GMP**	**07**
		a) Definitions- Manufacture, Quality, Quality Control, In-Process Control, Quality Assurance, Good Manufacturing Practices. b) Chemicals & Pharmaceutical production: The five variables, Raw materials, in process Items, Finished Products, Labels and Labelling, Packaging materials, Documentation, Regulations. c) Control of Microbial contamination during manufacture: Premises and contamination control Manufacture of sterile products, Clean and Aseptic Area, Important publications related to QA	
	4.3	**Sterilization Control and Sterility Assurance**	**03**
		a) Bio-burden determinations b) Environmental monitoring c) Sterilization Monitors – Physical, Chemical and Biological indicators d) Sterility Testing	

References:

a) Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial Microbiology", 2nd Edition, Panima Publishing Corporation, New Delhi.
b) Casida L. E., "Industrial Microbiology 2009 Reprint, New Age International (P) Ltd, Publishers, New Delhi
c) H. A. Modi, 2009. 'Fermentation Technology ''Vol: 1 & 2, Pointer Publications, India
d) Prescott and Dunn's 'Industrial Microbiology' (1982) 4th Edition, McMillan Publishers
e) Hugo & Russell's, Pharmaceutical Microbiology Blackwell Science, Seventh Edition
f) Peppler, H. J. and Perlman, D. (1979), "Microbial Technology''. Vol 1 & 2, Academic Press.
g) Michael J. Waites, 2001 —Industrial Microbiology: An Introduction, Blackwell Science Publications
h) Naduka Okafor, —Modern Industrial Microbiology, Science Publications, 2007
i) R. W. Hutkins, "Microbiology and Technology of Fermented Foods (2006) Blackwell Publications p067-105
j) https://www.dairyscience.info/index.php/cheese-starters/49-cheese-starters.html
k) Marth and Steele, "Applied Dairy Microbiology", Lactic acid starter cultures, (2001)
l) Probiotics and Prebiotics https://www.spg.pt/wp-content/uploads/2015/11/2011-Probiotics_FINAL_20110116.pdf

COURSE CODE	PRACTICALS	3 Credits
RUSMICP602	**Practical Based on 603**	
	1. Qualitative detection of Lipase 2. Estimation of proteins by Lowry's method 3. Qualitative detection of Protease 4. Assay of enzyme Protease 5. Study the breakdown of amino acids – Lysine decarboxylase and Deaminase activity 6. Estimation of uric acid 7. To study catabolite repression 8. Study of Hill reaction 9. Study of photosynthesis in microalgae 10. Study of Lithotrophs – Nitrification 11. Alcohol tolerance for yeast. 12. Sugar tolerance for yeast. 13. Inoculum Development for alcohol fermentation 14. Alcohol fermentation.. -Efficiency of fermentation 15. Chemical estimation –Sugar by Cole's Ferricyanide method 16. Chemical estimation –Alcohol Estimation-Dichromate method 17. GC demonstration of ethanol 18. Production of fungal amylase using solid substrate fermentation 19. Immobilization of yeast invertase 20. Mushroom cultivation 21. Production of Spirulina SCP 22. Bioassay of an antibiotic Ampicillin 23. Bioassay of Cyanocobalamin. 24. Chemical assay of Ampicillin 25. Sterility testing of water for injection.	

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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 **four** questions each of **15** marks on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Questions	Options	Marks	Total marks	Questions on
Q.1) A)	Any 2 out of 3	10		Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.2) A)	Any 2 out of 3	10		Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.3) A)	Any 2 out of 3	10		Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.4) A)	Any 2 out of 3	10		Unit IV
Q.4) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	

Practical Examination Pattern:

A. Internal Examination: 40%- 80 Marks

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

B. External Examination: 60%- 120 Marks

Semester End Practical Examination:

Particulars	Practical I	Practical II
Laboratory work	50	50
Spots/Quiz/Viva	10	10
Total	**60**	**60**

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 / In charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern
Semester VI

Course	601			602			603			604			Grand Total
	In	Ex	Total	In	Ex	Total	In	Ex	Total	In	Ex	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practical	20	30	50	20	30	50	20	30	50	20	30	50	200
