AC/II(18-19).2.RUS9

S.P. Mandali's
Ramnarain Ruia Autonomous College

Syllabus for T.Y.B.Sc
Program: BSc
Course: Microbiology (RUSMIC)

(Credit Based Semester and Grading System with effect from the academic year 2019–2020)

SEMESTER V

COURSE CODE	UNIT	TITLE	CREDITS	LEC/WEEK
RUSMIC 501		MICROBIAL GENETICS	2.5	4
	I	BRANCHES OF GENETICS, PLASMIDS AND TRANSPOSONS		
	II	DNA REPLICATION		
	III	MUTATION AND REPAIR		
	IV	HOMOLOGOUS RECOMBINATION &GENETIC		
RUSMIC 502		MEDICAL MICROBIOLOGY	2.5	4
	I	GENETICS OF PATHOGENICITYANDSTUDY OF INFECTIOUS DISEASES-I		
	II	STUDY OF INFECTIOUSDISEASES-II		
	III	STUDY OF INFECTIOUS DISEASES-III		
	IV	CHEMOTHERAPY OF INFECTIOUS DISEASES		
RUSMICP 501		PRACTICALS BASED ON ABOVE TWO COURSES	3	4

SEMESTER V

COURSE CODE	UNIT	TITLE	CREDITS	LEC/WEEK
RUSMIC 503		MICROBIAL BIOCHEMISTRY: PART- I	2.5	4
	I	BIOLOGICAL MEMBRANES & TRANSPORT		
	II	BIOENERGETICS & BIOLUMINESCENCE		
	III	METHODS OF STUDYING METABOLISM & CATABOLISM OF CARBOHYDRATES		
	IV	FERMENTATIVE METBOLISM & ANABOLISM OF CARBOHYDRATES		
RUSMIC 504		BIOPROCESS TECHNOLOGY	2.5	4
	I	UPSTREAM PROCESSING		
	II	FERMENTER EQUIPMENT AND CONTROL		
	III	DOWNSTREAM PROCESSING		
	IV	BIOINSTRUMENTATION AND IPR		
RUSMICP 502		PRACTICALS BASED ON ABOVE TWO COURSES	3	4

SEMESTER VI

COURSE CODE	UNIT	TITLE	CREDITS	LEC/WEEK
RUSMIC 601		GENETICS, BIOINFORMATICS & VIROLOGY	2.5	4
	I	GENE MANIPULATION AND BIOINFORMATICS		
	II	CELL BIOLOGY		
	III	BASIC VIROLOGY		
	IV	ADVANCED VIROLOGY		
RUSMIC 602		IMMUNOLOGY	2.5	4
	I	ANTIGENS, ANTIBODIES AND ANTIGEN PRESENTATION		
	II	ACTIVATION OF IMMUNE CELLS		
	III	IMMUNE RESPONSES AND THEIR DETECTION		
	IV	VACCINES, IMMUNOHEMATOLOGY AND HYPERSENSITIVITY		
RUSMICP 601		PRACTICALS BASED ON ABOVE TWO COURSES	3	4

SEMESTER VI

COURSE CODE	UNIT	TITLE	CREDITS	LEC/WEEK
RUSMIC 603		MICROBIAL BIOCHEMISTRY PART II	2.5	4
	I	LIPID METABOLISM & CATABOLISM OF HYDROCARBONS		
	II	METABOLISM OF PROTEINS AND NUCLEIC ACIDS		
	III	METABOLIC REGULATION		
	IV	PROKARYOTIC PHOTOSYNTHESIS & INORGANIC METABOLISM		
RUSMIC 604		INDUSTRIAL MICROBIOLOGY	2.5	4
	I	INDUSTRIAL FERMENTATIONS-I		
	II	INDUSTRIALFERMENTATIONS-II		
	III	INDUSTRIALFERMENTATIONS III		
	IV	BIOASSAYS, QUALITY ASSURANCE		
RUSMICP 602		PRACTICALS BASED ON ABOVE TWO COURSES	3	4

Course Code: RUSMIC 501
Course Title: MICROBIAL GENETICS
Academic year 2019-20

Learning Objectives:
With a background of nucleic acids in FYBSc and Mendelian genetics, DNA structure and transcription, translation and genetic code at the SYBSc level, the undergraduate T.Y. B.Sc. Microbiology course under the Paper on Microbial Genetics introduces the learner to the underlying theories of genetics by elaborating both conceptual and practicaltoolsforquantitative genetics and use of model organisms. It elaborates on extrachromosomal DNA – plasmids and on nature and role of transposons. The course then deals in detail with generating, processing and understanding biological genetic information. It develops knowledge of the underlying theories of genetics by elaborating on various concepts related to DNA replication, mutations and genetic exchange among prokaryotes.

Learning Outcomes: Students should be able to-

- Understand population and quantitative genetics and get introduced to different model organisms used in genetic studies.
- Understand different natural plasmids and transposons present in prokaryotes
- Understand the molecular mechanism involved in DNA replication
- Understand how to identify and classify mutations in DNA followed by mechanism of DNA repair
- Understand basic concepts of homologous recombination and genetic exchange among prokaryotes

Detailed Syllabus

Course Code	Title	Credits
RUSMIC 501	**MICROBIAL GENETICS**	**2.5 Credits(65 lectures)**
Unit I	**BRANCHES OF GENETICS, PLASMIDS, TRANSPOSONS**	**15 lectures**
	1.1. **Overview of branches of Genetics** i. Transmission, Molecular, ii. Population Genetics: Hardy-Weinberg Law- principle and violation of assumptions (Mutation, Migration, Genetic Drift, Natural Selection) iii. Quantitative Genetics: Characteristics, concept of Heritability, QTLs, Response to selection	**4**
	1.2**. Model Organisms** i. Characteristics of a model organism ii. Examples of select model organisms used in study: *E.coli,* Yeast, Mouse.	**3**
	1.3. **Plasmids** 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	**4**
	1.4.**Transposable Elements in Prokaryotes** a. Insertion sequences b. Transposons i. Types ii. Structure and properties iii. Mechanism of transposition iv. Transposon mutagenesis v. Integrons	**4**

Unit II	**DNA REPLICATION**	**15 lectures**
	2.1. **Historical perspective—** conservative, dispersive, semi-conservative, Bidirectional and semi-discontinuous replication	**4**
	2.2. **Prokaryotic DNA replication** – Details of molecular mechanism involved in Initiation, Elongation and Termination	**4**
	2.3. **Enzymes and proteins associated with DNA replication**- primase, helicase, topoisomerase, SSB, DNA polymerases, ligases, Ter and Tus proteins	**4**
	2.4. **Eukaryotic DNA replication--** Molecular details of DNA synthesis, replicating the ends of the chromosomes	**2**
	2.5. **Rolling circle mode of replication**	**1**
Unit III	**Mutation and Repair**	**15 lectures**
	3.1**. Mutation** 3.1. a.**Terminology:** alleles, homozygous,heterozygous, genotype, phenotype, Somatic mutation, Germline mutation, Gene mutation, Chromosome mutation, phenotypic lag, hotspots and mutator genes	**1**
	3.1. b. Fluctuation test.	**1**
	3.1. 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.	**1**
	3.1.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)	**5**
	3.1.e. Ames test	**1**
	3.1.f. Detection of mutants	**1**

	3.2**. DNA Repair** a.Mismatch repair b.Light repair c.Repair of alkylation damage d.Base excision repair e.Nucleotide excision repair f.SOS repair	**5**
Unit IV	**Genetic Exchange**	**15 lectures**
	4.1**. Gene transfer mechanisms in bacteria & homologous recombination** 4.1. a. Transformation i. Introduction and History ii. Types of transformation in prokaryotes--Natural transformation in *Streptococcus pneumoniae, Haemophilus influenzae* and *Bacillus subtilis* iii. Mapping of bacterial genes using transformation. iv. Problems based on transformation. 4.1. 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 behaviour of F' strains, Sexduction. vi. Mapping of bacterial genes using conjugation (Wolman and Jacob experiment). vii. Problems based on conjugation 4.1.c. Transduction i. Introduction and discovery ii. Generalised transduction iii. Use of Generalised transduction for mapping genes iv. Specialised transduction v. Problems based on transduction 4.2. **Recombination in bacteria** 4.2.a. General/Homologous recombination i. Molecular mechanism ii. Holliday model of recombination b. Site –specific recombination	**4** **5** **3** **3**

References:

1. Peter J. Russell (2006), “Genetics-A molecular approach”, 2nd ed.
2. Benjamin A. Pierce (2008), “Genetics a conceptual approach”, 3rd ed., W. H. Freeman and company.
3. R. H. Tamarin, (2004), “Principles of genetics”, Tata McGraw Hill.
4. D,.Nelson and M.Cox, (2005), “Lehninger’s Principles of biochemistry”, 4th ed., Macmillan worth Publishers.
5. M.Madigan, J.Martinko, J.Parkar, (2009), “Brock Biology of microorganisms”, 12th ed., Pearson Education International.
6. Fairbanks and Anderson, (1999), “Genetics”, Wadsworth Publishing Company.
7. Prescott, Harley and Klein, “Microbiology”,. 7th edition McGraw Hill international edition.
8. Robert Weaver, “Molecular biology”, , 3rd edn. McGraw Hill international edition.
9. Nancy Trun and Janine Trempy, (2004), “Fundamental bacterial genetics”, Blackwell Publishing
10. Snustad, Simmons, “Principles of genetics”, 3rd edn. John Wiley & sons, Inc.
11. Stanier,Ingraham.”General Microbiology”,5 edn.
12. Benjamin Lewin, “Genes IX”, , Jones and Bartlett publishers.
13. JD Watson, “Molecular biology of the gene”, , 5th edn.

Course Code: RUSMIC 502

Course Title: MEDICAL MICROBIOLOGY
Academic year 2019-20

Learning objectives:
Classical medical microbiology is the study of aetiology, transmission, pathogenesis, clinical manifestations, laboratory diagnosis, prophylaxis and treatment of various bacterial, viral, fungal and parasitic infections. The course on Medical Microbiology introduces the students to all these parameters of representative diseases from each category. The course also includes one of the most important areas of modern medical microbiology that is -understanding genetic modification and pathogen evolution.
As a part of understanding chemotherapeutic agents for destruction of pathogens, the students are introduced to different classes of chemotherapeutic agents and their mechanisms of action. As development of resistance to antibiotics is a very burning issue in the field of clinical microbiology, the syllabus also includes mechanisms of resistance to drugs.

Learning Outcomes: Students should be able to-

- Understand modern alternatives to Koch's Postulates and understand Genetic modification and pathogen evolution
- Study pathogenesis and clinical features of different diseases
- Comment on the mode of transmission, epidemiology and therefore modes of prophylaxis of these diseases
- Given a few key clinical features, identify the likely causative agent.
- Comment on the methods of diagnosis of the disease.
- Correlate classes of antibiotics with their mechanism of action
- Comment on drug resistance mechanisms
- Evaluate drugs and antibiotics for their efficacy

Detailed Syllabus

Course Code	Title	Credits
RUSMIC502	**MEDICAL MICROBIOLOGY**	**2.5 Credits(65 lectures)**
Unit I	**GENETICS OF PATHOGENICITYAND STUDY OF INFECTIOUSDISEASES-I**	**15 lectures**
	1.1.Associating Microbes to disease 1.1.1: Koch's Postulate and modern alternatives to it 1.1.2: Molecular Koch's postulates **1.2: Genetic modification and pathogen evolution:** 1.2.1: Point mutations, gene duplication, chromosomal rearrangements, phase variation and antigenic variation 1.2.2: Horizontal gene transfer through Mobile genetic elements 1.2.3: Pathogenicity islands **1.3: Sample collection, transport and processing and diagnostic cycles** **1.4. Study of Infectious Diseases-I** (with Emphasis on Characteristics of the Aetiological Agent, Pathogenesis & clinical features, Laboratory Diagnosis and Prevention) **Study of Respiratory diseases** 1.4.1. Strep throat by *S. pyogenes* 1.4.2. Diphtheria 1.4.3. Common cold 1.4.4. Tuberculosis 1.4.5. Pneumonia caused by *K .pneumoniae*	**02** **03** **02** **08**
Unit II	**STUDY OF INFECTIOUS DISEASES II**	**15 lectures**
	(With emphasis on cultural characteristics of the aetiological agent,pathogenesis, laboratory diagnosis and prevention) **2.1 Study of skin infections** 2.1.1 Leprosy 2.1.2 Fungal infections- Oral Thrush, Dermatophytosis	**05**

	2.1.3 Pyogenic skin infections caused by *Pseudomonas, S.pyogenes* and *S. aureus.* **2.2 Study of gastrointestinal tract infections** 2.2.1 Enteric fever- *Salmonella* 2.2.2 Shigellosis 2.2.3 Rotavirus diarrhoea 2.2.4 Dysentery due to *Entamoeba histolytica* 2.2.5 Infections due to pathogenic *E.coli* strains **2.3 Study of urinary tract infections** Predisposing factors, List of causative agents, Pathogenesis and laboratory diagnosis	**08** **02**
Unit III	**STUDY OF INFECTIOUS DISEASES III**	**15 lectures**
	(With emphasis on cultural characteristics of the aetiological agent, pathogenesis, laboratory diagnosis and prevention) **3.1 Study of vector-borne infections-** Rickettsial diseases (Tabular form), Malaria **3.2 Study of sexually transmitted infectious diseases** a. Syphilis b. AIDS c. Gonorrhoea **3.3 Study of central nervous system infectious diseases** a. Tetanus b. Polio a. Meningococcal meningitis	**03** **07** **05**
Unit IV	**CHEMOTHERAPY OF INFECTIOUS AGENTS**	**15 lectures**
	Attributes of an ideal chemotherapeutic agent and related definitions ection 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 on-** a. Cell wall (Beta-lactams- Penicillin and Cephalosporins, Carbapenems) b. Cell Membrane (Polymyxin and Imidazole) c. Protein Synthesis (Streptomycin,	**03** **08**

	d. Tetracycline and Chloramphenicol) e. Nucleic acid (Quinolones, Nalidixic acid, Rifamycin) f. Enzyme inhibitors (Sulfa drugs, Trimethoprim) **4.3: List of common antibiotics** used for treating viral, fungal and parasitic diseases, New antibiotics **4.4: Mechanisms of drug resistance-** Its evolution, pathways and origin	**01** **03**

References:

1. Jawetz, Melnick and Adelberg's Medical Microbiology, 26th Edition, Lange publication
2. Bacterial Pathogenesis –A molecular approach Abigail Salyer And Dixie Whitt 2nd Ed ASM press
3. Ananthanarayan and Panicker's, Textbook of Microbiology, 9th edition
4. Goering, Dockerel et al,Mim's Medical microbiology, 5th Ed 2013 , Saunders
5. Baron Samuel , Medical Microbiology, 4th edition
6. http://www.ncbi.nlm.nih.gov/books/NBK7627/

Course Code: RUSMIC503
Course Title: MICROBIAL BIOCHEMISTRY PART I
Academic year 2019-20

Learning objectives:

This course is designed for T.Y.B.Sc. Microbiology students such that the students achieve a basic understanding of solute transport and metabolism. The course has been designed to expose students to methods of studying energy generation, fermentative metabolism as well as anabolism.

There has been a lot of importance attached to biochemical reactions in living cells. The student must be exposed to the mechanism of solute transport and methods to study the same. The students are already exposed to laws of thermodynamics in the lower level however, they should be made aware of the electron transport chain in Prokaryotes and Mitochondria. ATP synthesis and anabolic mechanisms need to be explained to the students to understand the breakdown of mono, di- and oligosaccharides. The students will also be exposed to the fermentative pathways and anabolic reactions.

Learning Outcomes: Students should be able to-

- Understand the architecture of the membrane and how solute is transported inside the cell.
- Describe and explain the electron transport chains in prokaryotes and mitochondria and understand the mechanism of ATP synthesis.
- Explain bioluminescence mechanism and its significance
- Discuss the experimental aspect of studying catabolism and anabolism and the various pathways for the breakdown of carbohydrates along with reactions in amphibolic pathways.
- Describe various other pathways which produce different end products.
- Describe anabolic reactions in carbohydrate synthesis.
- Apply the concepts of energetics and catabolism in biodegradation of various substrates.

Detailed Syllabus

Course Code	Title	Credits
RUSMIC503	**MICROBIAL BIOCHEMISTRY PART I**	**2.5 Credits(65 lectures)**
Unit I	**BIOLOGICAL MEMBRANES & TRANSPORT**	**15 lectures**
	1.1 Composition and architecture of membrane 1.1.1 Lipids 1.1.2 Integral & peripheral proteins & interactions with lipids 1.1.3 Permeability and outer membrane- a barrier 1.1.4 Aquaporins 1.1.5 Mechanosensitive channels	**02**
	1.2 Methods of studying solute transport 1.2.1. Using whole cells 1.2.2. Using Liposomes 1.2.3. Using Proteoliposome	**02** **08**
	1.3 Solute transport across membrane 1.3.1. Passive transport facilitated by membrane proteins. 1.3.2. Transporters grouped into Superfamilies' 1.3.3. Co transport across plasma membrane (Uniport, Antiport, Symport) 1.3.4. Active transport & electrochemical gradient 1.3.5. Ion gradient provides energy for secondary Active transport e.g. Lactose transport 1.3.6. ATPases and transport 1.3.7. ABC transporters e.g. Histidine transport 1.3.8. Shock sensitive system – Role of binding proteins e.g. Maltose uptake 1.3.9. Phosphotransferase system 1.3.10. Schematic representation of various Membrane transport mechanisms in*. E. coli*	
	1.4 Other examples of solute transport- 1.4.1. Iron transport: A special problem 1.4.2. Bacterial protein export 1.4.3. Bacterial membrane fusion central to many biological processes	**03**
Unit II	**BIOENERGETICS AND BIOLUMINESCENCE**	**15 lectures**
	2.1. Biochemical mechanism of generating ATP- Substrate level, Oxidative, and Photo Phosphorylation **2.2. Electron transport chain** 2.2.1. Universal Electron acceptors that transfer Electro ETC.	**01** **03**

	2.2.2. Carriers in ETC i. Hydrogen carriers – Flavoproteins, Quinones ii. Electron carriers-Iron sulphur proteins, Cytochromes 2.2.3. Mitochondrial ETC i. Biochemical anatomy of mitochondria ii. Complexes in Mitochondrial ETC iii. Schematic representation of Mitochondrial ETC **2.3: Prokaryotic ETC** 2.3.1. Organization of electron carriers in bacteria 2.3.2. Generalised electron transport pathway in bacteria 2.3.3. Different terminal oxidases 2.3.4. Branched bacterial ETC 2.3.5. Pattern of electron flow in *E. coli*– aerobic and anaerobic 2.3.6. Pattern of electron flow in *Azotobacter vinelandii* **2.4. ATP synthesis** 2.4.1. Explanation of terms – Proton motive force, Proto pump, Coupling sites, P: O ratio, Redox potential 2.4.2. Free energy released during electron transfer from N to O_2 2.4.3. Chemiosmotic theory 2.4.4. Structure & function of Mitochondrial ATP synthas (No Kinetics) 2.4.5. Mechanism by Rotational catalysis 2.4.6. Structure of bacterial ATP synthase 2.4.7. Inhibitors of ETC, Inhibitors of ATPase, Uncouple Ionophores **2.5 Other modes of generation of electrochemical energy** 2.5.1. ATP hydrolysis 2.5.2. Oxalate formate exchange 2.5.3. Product efflux, Definition- Lactate efflux 2.5.4. Bacteriorhodopsin - Definition, Significance, Function a proton pump, **6.Bioluminescence** 2.6.1. Brief survey of bioluminescent systems 2.6.2. Biochemistry of light emission 2.6.3. Schematic diagram 2.6.4. Significance / Application	**03** **04** **02** **02**
Unit III	**METHODS OF STUDYING METABOLISM & CATABOLISM OF CARBOHYDRATES**	**15 lectures**
	1. Experimental Analysis of metabolism 2. Goals of the study 3. Levels of organization at which metabolism is studied.	**03**

	1. Metabolic probes 2. Use of radioisotopes in biochemistry i. Pulse labeling ii. Assay & study of radiorespirometry –to differentiate EMP & ED 5. Use of biochemical mutants. 6. Sequential induction technique **3.2. Catabolism of Carbohydrates** 3.2.1. Breakdown of polysaccharides – glycogen, starch, cellulose. 3.2.2. Breakdown of oligosaccharides– lactose, maltose, sucrose, cellobiose 3.2.3. Utilization of monosaccharides – fructose, Galact 3.2.4. Major pathways- i. Glycolysis (EMP) ii. HMP Pathway & Significance of the pathway iii. ED pathway, iv. TCA cycle & Significance of the cycle 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	**10** **01** **01**
Unit IV	**FERMENTATIVE PATHWAY& ANABOLISM OF CARBOHYDRATES**	**15 lectures**
	1.Fermentative pathways (With structures and enzyme 4.1.1. Lactic acid fermentation – i. Homofermentors ii. Heterofermentors iii. Bifidobacterium pathway (Schematic) 4.1.2. Alcohol fermentation i. by ED pathway in bacteria	**04**

	ii. by EMP in yeasts **2. Other modes of fermentations in microorgani** 4.2.1. Mixed acid 4.2.2. Butanediol 4.2.3. Butyric acid 4.2.4. Butanol-acetone 4.2.5. Propionic acid (Acrylate pathway and succinate propionate pathway) **3. Anabolism of Carbohydrates** 4.3.1. General pattern of metabolism leading to synthesis of a cell from Glucose 4.3.2. Gluconeogenesis 4.3.3. Biosynthesis of Glycogen 4.3.4. Biosynthesis of Peptidoglycan 4.3.5. Role of carriers in synthesis of LPS and capsule	**05** **06**

References:

1. Stanier, R. Y.,M.Doudoroff and E. A. Adelberg. General Microbiology, 5th edition, The Macmillan press Ltd
2. Conn, E.E., P. K.Stumpf, G.Bruening and R. Y.Doi. 1987**.** Outlines of Biochemistry, 5th edition, 1987. John Wiley &Sons. New York.
3. Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag
4. White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rd edition, Oxford University Press
5. Nelson, D. L. and M.M. Cox(2005), Lehninger, Principles of biochemistry. 4th edition, W. H. Freeman and Company
6. Rose, A.H. (1976) Chemical Microbiology, 3rdednButterworth-Heinemann
7. Zubay, G. L (1996), Biochemistry, 4th edition, Wm. C. Brown publishers
8. Mathews, C.K., K.E. van Holde, D.R. Appling, S,J, Anthony-Cahill (2012) Biochemistry, 4thedn. Pearson
9. Wilson and Walker , 4thedn
10. Madigan, M.T. and J.M. Martinko 2006. Brock Biology of Microorganisms. Pearson Prentice Hall;
11. Zubay, G. L (1996), Principles of Biochemistry, Wm. C. Brown publishers
12. Cohen, G.N. (2011). Microbial Biochemistry. 2ndedn, Springer

Course Code: RUSMIC504
Course Title: BIOPROCESS TECHNOLOGY
Academic year 2019-20

Learning Objectives

Bioprocess Technology course is designed to develop thelearner's ability to study the techniques used in the different phases of industrial microbiologysuch as strain improvement, basic fermentation equipment & its sterilization aspects. It gives anin-depth focus of the different types of fermenters used in industry for production of differentproducts, and emphasizes its process parameters. It includes the principles and describes themain steps and processes in the industrial production of beverages and enzymes.The downstreamprocess and the environmental aspects of the final product are also included.

The last unit appraises the learner with instrumental techniques used in industry for analysis of products or intermediates during product development/ during fermentation/ during purification. It also introduces the learner to the legal aspects associated with fermentation industry in the form of Intellectual property rights.

Learning Outcomes: Students should be able to-

- Describe the applications of microbes and its strain improvement in Industrial Microbiology.
- Apply kinetic formula to determine growth and productivity parameters of batch and continuous fermentations
- Describe the design of bioreactors for different applications and its process parameters
- Design media, growth conditions and techniques for producing and recovering different types of products of commercial value
- Design an industrial process by keeping in view the strict guidelines for its recovery &disposal
- Learner will be well –versed with the environmental aspects such as effluent treatment and carbon credits.
- Understand principle of working of important instruments used in biochemical, microbiological analysis.
- Get an overview of IPR and types of IP

Detailed Syllabus

Course Code	Title	Credits
RUSMIC504	**BIOPROCESS TECHNOLOGY**	**2.5 Credits(65 lectures)**
Unit I	**UPSTREAM PROCESSING**	**15 lectures**
	1.1: Strains and Strain Improvement of industrial microorganisms i. Isolation of industrially important microorganisms ii. Improvement of industrial microorganisms a. Selection of induced mutants for primary metabolite b. Isolation of induced mutants for secondary metabolites. **1.2: Sterilization** i. Introduction. Media sterilization (Concept of nabla factor) ii. Design and methods of batch sterilization iii. Design and methods of continuous sterilization	**10** **5**
Unit II	**FERMENTER EQUIPMENT AND CONTROL**	**15 lectures**
	2.1.Design of fermenter i. Inoculum development ii. Basic functions of fermenter- Aseptic operation & containment, Body construction, Aeration and agitation iii. Achievement & maintenance of aseptic condition, Valves / Steam traps - function in general & examples. iv. Types of fermenters: Acetator, Cavitator, Tower fermenter, Cylindro conical, Air lift – outer loop / inner loop, Deep jet, Cyclone column, Packed tower (generator), Rotating disc, Bubble cap **2.2: Control of variables** Introduction, Types of sensors, Sensing & Control of- pH, temp, Dissolved oxygen, Flow measurement &control, Pressure, Inlet / Exit gas analysis, Foam sensing, oxygen	**10** **5**
Unit III	**DOWNSTREAM PROCESSING**	**15 lectures**
	3.1. Downstream processing i.Recovery & Purification of fermentation products:	**10**

	Introduction, Precipitation, Filtration - theory, filter-aids, batch filters(Plate and frame filters), continuous filters(Rotary vacuum), Centrifugation: flocculating agent, range of centrifuges - Basket, tubular bowl. i. Cell disruption: Physico-chemical. ii. Liquid – Liquid extraction, Solvent recovery, iii. Chromatography –Ion exchange &Adsorption Membrane processes – Ultrafiltration, reverse osmosis, liquid membranes. Drying, Crystallization, Whole broth processing. **3.2. Environmental aspects** 3.2.1 Effluent treatment and regulations for fermentation industry 3.2.2. Modern methods of effluent treatment 3.2.3.Carbon Credits	**05**
Unit IV	**BIOINSTRUMENTATION AND IPR**	**15 lectures**
	4.1. Bioinstrumentation – Principles, working and applications of**:** i. Spectrophotometry (I. R) ii. Atomic absorption (AAS) & Atomic Emission spectroscopy (Flame photometry) iii. Mass Spectroscopy- MALDI ToF, ESI **4.2. Intellectual Property Rights:** i. Introduction to Intellectual Property ii. Genesis of IPR - GATT, WTO, TRIPS, World Intellectual Property Rights Organization (WIPO) iii. Types of Intellectual Property – Patents, Copyright,Trademark, Trade secret, Plant varieties protection act, Designs, Geographical Indications	**8** **7**

References:

1. Casida L. E., "Industrial Microbiology"(2009) Reprint, New Age International (P)Ltd,Publishers, New Delhi
2. Stanbury P. F., Whitaker A. &HaII--S. J., (1997), "Principles of Fermentation Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.
3. H. A. Modi, (2009). ''Fermentation Technology'' Vols 1 & 2, Pointer Publications, India
4. Okafor Nakuda (2007) ''Modern Industrial Microbiology and Biotechnology'', Science Publications Enfield, NH, USA.

5. G Y Shitole and Ram Sable (2012) Environmental Degradation Issues And Challenges (Research publication)
6. Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial Microbiology", 2nd Edition, Panima Publishing Corporation, New Delhi.

Practicals (Semester-V) RUSMICP501

[Practicals Based on 501,Credits -1.5Lectures- 60]

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.

[Practicals Based on 502,Credits -1.5,Lectures-60]

1. Assignment on sample collection, transport and processing of any one pathological sample
2. 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.
3. Identification of isolates obtained from following samples by morphological, cultural and biochemical properties
    . Nasal/ throat swabs(URT infection)
    a. Sputum (LRT infection)
    b. Skin swab/ pus (Skin infection)
    c. Identification of *Candida* species using the germ tube test and growth on Chrom agar
    d. Stool (GI tract infection)
    e. Urine (UTI infection).
4. Demonstration of malarial parasite in blood film

5. Selection and testing of antibiotics using the Kirby-Bauer method
6. Determination of MIC of an antibiotic by E-test
7. Synergistic action of two drugs
8. Determination of MBC of an antibiotic.
9. Detection of βlactamase in *S.aureus.*
10. Role of plasmids in antibiotic resistance through curing of the plasmid

Practicals (Semester-V) RUSMICP502

[Practicals Based on 503;Credits-1.5,Lectures- 60]

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 Heterofermentation in Lactic acid bacteria
7. Detection of enzyme phosphatase
8. Quantitative assay of Phosphatase

[Practicals Based on 504,Credits -1.5,Lectures- 60]

1. Strip Plate Technique
2. Streak Plate Technique
3. Gradient plate technique for isolation of mutants.
4. Production and detection of vitamin B12 by bioautography.
5. Anaerobic digestion of Industrial effluent- Generation and detection of methane
6. Demonstration of IR spectroscopy and analysis of IR spectrum of one compound
7. Demonstration of GC-MS/ LC-MS.

Course Code: RUSMIC601
Course Title: GENE MANIPULATION, BIOINFORMATICS, CELL BIOLOGY &VIROLOGY
Academic year 2019-20

Learning Objectives

This course introduces the learner to gene manipulation techniques which are an essential tool for modern day Genetic studies. This course also gives students theoretical and hands-oncompetence in major analytical techniques used inbioinformatics.

The section on Cell biology, although repeats some topics covered in FYBSc, is essentially to help the learner strengthen the basics of prokaryotic and eukaryotic cell structure. As the course on Biochemistry already deals with structure and function of cell membrane, the unit on Cell biology here does not repeat it.

Under the section of Virology, the course covers basic structure, life cycle of different types of viruses, genetics of lambda and cultivation of viruses. The course elaborates on different terminologies like cancer, prions, viriods and their mechanism.

Learning Outcomes: Students should be able to-

- Understand fundamentals of gene manipulation
- Use bioinformatics tools for genetic analysis and structure building
- Correlate structure and function of important cell components of prokaryotic and eukaryotic cells
- Understand the basic structure, classification, enumeration, cultivation and life cycle of viruses
- Understand the terms like cancer, prions, viriods and their mechanisms
- Understand regulation of lambda phage

Detailed Syllabus

Course Code	Title	Credits
RUSMIC601	**GENE MANIPULATION, BIOINFORMATICS, &VIROLOGY**	**2.5 Credits(65 lectures)**
Unit I	**GENE MANIPULATION AND BIOINFORMATICS**	**15 lectures**
	1.1 Basic Principles of Gene Manipulation: i. Cutting and joining DNA: Restriction endonucleases, Ligases, Linkers and Adapters ii. Cloning vectors: Characteristics of a good vector, Plasmid vectors, Bacteriophage λ, Expression vectors iii. Cloning strategies: Genomic libraries, cDNA libraries, PCR **1.2. Bioinformatics** **i. Introduction** a. Definition, aims, tasks and applications of Bioinformatics. b. Overview of prominent Databases, tools and their uses c. Importance, Types and classification of databases d. Nucleic acid sequence databases- EMBL, GenBank, Ensembl e. Protein sequence databases-PIR, SWISS-PROT, TrEMBL f. Protein structure databases: PDB, Cn3D. g. Pathway analysis: KEGG. **Applications:** a. Transcriptome, Metabolomics, Pharmacogenomics, b. Phylogenetic analysis, Phylogenetic tree, Annotation, SNPs c. Sequence alignment-- global v/s local alignment, FASTA file format, BLAST. **d. Genomics-** structural, functional and comparative genomics. **e. Proteomics**- structural and functional proteomics. **1.3: Emerging techniques in Genome sciences** i. Microarray technologies ii. Karyotyping CRISPR-based technologies and applications	**07** **06**

		02
Unit II	**CELL BIOLOGY**	**15 lectures**
	2.1 Structure and function of Prokaryotic cell **a.** Cell wall **b.** Capsule **c.** Flagella **d.** Endospore **2.2 Cytoskeleton and cell motility in eukaryotes** a. Cytosol, Ergastoplasm and cytoskeleton b. Structure and function: Microtubules, Microfilaments, Intermediate filaments c. Microtubular organelles – Cilia, Flagella and centrioles d. Microfilament structures and role of associated proteins e. Molecular motors: Myosins, Kinesins, Dyenin	**07** **08**
Unit III	**BASIC VIROLOGY**	**15 lectures**
	3.1. Viral architecture- 3.1.a. Capsid, viral genome and envelope 3.1.b. Structure of TMV, T4, Influenzavirus, HIV. **3.2. Viral classification** **3.3. The viral replication cycle**- attachment, penetration, uncoating, types of viral genome and their replication, assembly, maturation and release. **3.4. Cultivation of viruses**- cell culture techniques, embryonated egg, laboratory animals, Cell culture methods:Equipment required for animal cell culture,Isolation of animal tissue	**04** **02** **04** **05**
Unit IV	**ADVANCED VIROLOGY**	**15 lectures**
	4.1. Life cycle of T4 phage, TMV, Influenza Virus and HIV in detail **4.2. Visualization and enumeration of virus particles** 4.2.a. Measurement of infectious units i. Plaque assay ii. Fluorescent focus assay iii. Infectious centre assay iv. Transformation assay	05 03

	v. Endpoint dilution assay. 4.2.b. Measurement of virus particles and their components i. Electron microscopy ii. Atomic force microscopy iii. Haemagglutination iv. Measurement of viral enzyme activity.	02
	4.3. Regulation of lytic and lysogenic pathway of lambda phage	01
	4.4. Role of viruses in cancer: Imp Definitions, characteristics of cancer cell, cancer multi step process, Human DNA tumor viruses- EBV, Kaposis sarcoma virus, Hepatitis B and C virus, Papiloma Virus.	02
	4.5. Prions and viroids	**02**

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1. R. H. Tamarin, (2004), "Principles of genetics", Tata McGraw Hill.
2. M.Madigan, J.Martinko, J.Parkar, (2009), "Brock Biology of microorganisms", 12th ed., Pearson Education International.
3. Fairbanks and Anderson, (1999), "Genetics", Wadsworth Publishing Company.
4. Prescott, Harley and Klein, "Microbiology" 7th edition McGraw Hill international edition.
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6. Teri Shors,.(2009) , "Understanding viruses", Jones and Bartlett publishers.
7. S.Ignacimuthu, (2005), "Basic Bioinformatics", Narosa publishing house.
8. Robert Weaver, (2008), "Molecular biology", , 3rd edn. McGraw Hill international edition.
9. Primrose and Twyman, (2001), "Principles of gene manipulation and genomics", 6thed, Blackwell Publishing
10. Arthur Lesk, (2009), "Introduction to Bioinformatics", 3rd Edition, Oxford University Press
11. Snustad, Simmons, "Principles of genetics", 3rdedn. John Wiley & sons, Inc.
12. A textbook of biotechnology R.C.Dubey 4 thed.S.Chand.
13. P.S Verma & V.K.Agarwal, "Cell biology,genetics,molecular biology,evolution & ecology, 14th edn.
14. Lodish, Scott." Molecular cell biology,7th edn,Macmillan higher education,international edn.
15. Ramsden Jerry," Bioinformatics: An introduction, Springer international edition.
16. Flint, Enquist, Racanillo and Skalka, "Principles of virology", (2009)3rdedn. ASM press
17. T. K. Attwood & D. J. Parry-Smith, (2003), "Introduction to bioinformatics", Pearson education
18. Benjamin Lewin,(2014) 9th edition, "Genes IX", Jones and Bartlett publishers.
19. JD Watson, Baker (2004) 5thedn."Molecular biology of the gene", CSHL Press and Benjamin Cummings

Course Code: RUSMIC 602
Course Title: IMMUNOLOGY
Academic year 2019-20

Learning objectives:

The course will help students to build on the basic information regarding Innate Immunity and Host Defence mechanisms that they have gained in S.Y. B.Sc. Immunology is an integral part of Medical Microbiology and this course is designed to help students understand the ability of our immune system to defend against invading pathogens in a logical fashion. This includes our innate ability to defend against microorganisms (innate immunity); should this first line of defense fail, how we can fight infections (acquired immunity). The course elaborates on the mechanisms of acquired defense after an introduction on the molecular nature of antigens and antibodies along with the role of different cells and their surface molecules in acquired immunity. After a basic introduction to cells of immune mechanisms the other units include details of mechanisms of acquired immunity- Humoral and Cell mediated. The curriculum also deals with how immune systems can fight infections (acquired immunity); if we react excessively, what price we pay (hypersensitivity); and very importantly, can we protect ourselves from diseased state (vaccination).

Learning Outcomes:

Students should be able to**-**

- Conceptualize how the innate and adaptive immune responses coordinate to fight
- invading pathogens
- Discuss the role of antigen in initiating the immune response
- Correlate the structure & functions of immunoglobulin
- Understand the importance of all the other entities involved i.e. T cells, B cells, NK cells, APCs, Cytokines, MHC, TcR, BcR, Co-receptors, Signalling pathways etc.
- Understand the effector responses- Humoral Immunity & Cell Mediated Immunity and differentiate between them
- Acquire an understanding of the role of immune system in disease: Unregulated response resulting in Hypersensitivity
- Understand the mechanism of Antigen-Antibody interaction & it’s significance in diagnosis
- Apply the concept of immunity for protection from disease by development of vaccines

Detailed Syllabus

Course Code	Title	Credits
RUSMIC602	**IMMUNOLOGY**	**2.5 Credits(65 lectures)**
Unit I	**ANTIGENS, ANTIBODIES AND ANTIGEN PRESENTATION**	**15 lectures**
	1.1: Antigens 1.1.1: Immunogenicity versus antigenicity 1.1.2: Factors that influence immunogenicity – foreignness, molecular size, chemical composition, heterogenicity, ability to be processed and presented, contribution of the biological system to immunogenicity – genotype of the recipient, animal, immunogen dosage, route of administration and adjuvants 1.1.3: Epitopes / antigen determinants (only concepts) 1.1.4: Haptens and antigenicity 1.1.5: 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 **1.2: Immunoglobulins** 1.2.1: Immunoglobulins – basic and fine structure 1.2.2: Immunoglobulin classes and biological activities 1.2.3:Antigenic determinants on immunoglobulins – isotypes, allotypes, idiotypes 1.2.4: Immunoglobulin Superfamily 1.2.5: Monoclonal antibodies, Production (Diagrammatically) & applications **1.3: T Cells, B cells and NK Cells** **1.4: Antigen presenting cells** Antigen presentation- professional and nonprofessional cells and processing pathways, (Cytosolic and Endocytic pathway)	**05** **07** **01** **02**
Unit II	**ACTIVATION OF IMMUNE CELLS**	**15 lectures**

	2.1 Cytokines Properties and functions Cytokines secreted by Th1 and Th2 cells **2.2 MHC complex and MHC molecules** Structure of class I, and class II molecules; class III molecules Peptide – MHC interaction **2.3 T cells** Receptors, structure (alpha-beta, gamma-delta TcR) TcR-CD3 complex structure & functions. Accessory molecules. Subsets of T cells (Th1, Th2, T reg) T cell activation, Costimulatory molecules, T cell differentiation (memory & effector cell) **2.4 B cells** Receptors----structure & organization B cell activation and differentiation – i. Thymus dependent and independent antigens ii. B cell activating signals iii. Role of Th cells in Humoral response, formation of T – B conjugates, CD40 / CD40L interaction, Th cell cytokine signals.	**02** **03** **05** **05**
Unit III	**IMMUNE RESPONSES AND THEIR DETECTION**	**15 lectures**
	3.1.Humoral Response 3.1.1.Introduction of Humoral response, Primary and secondary responses 3.1.2.Germinalcentres and antigen induced B cell differentiation 3.1.3.Affinity maturation and somatic hyper mutation, Ig diversity, class switching 3.1.4.Generation of plasma cells and memory cells **3.2.Cell mediated effector response** 3.2.1. Generation and target destruction by Cytotoxic T cells. 3.2.2. Killing mechanism of NK cells. 3.2.3. Antibody dependent cell cytotoxicity (ADCC) **3.3. Antigen-Antibody reactions** Precipitation, agglutination, passive agglutination,	**05** **03** **06**

	agglutination inhibition, Radioimmunoassay (RIA), Enzyme immunoassays (EIA), Immunofluorescence, western blot technique **3.4.Immunodiagnostics** Modern immunology based diagnostic tests	**01**
Unit IV	**VACCINES, IMMUNOHEMATOLOGY AND HYPERSENSITIVITY**	**15 lectures**
	4.1: Vaccines 4.1.1 Active and passive immunization 4.1.2 Types of vaccines - Killed and attenuated vaccines, Whole organism vaccines, Purified macromolecules as vaccines, recombinant viral vector vaccines, DNA vaccines 4.1.3 Use of adjuvants in vaccine 4.1.4 New vaccine strategies,Ideal vaccine **4.2: Immunohematology** 4.2.1: Human blood group systems, ABO, secretors and non-secretors, Bombay Blood group. 4.2.2: Rhesus system and list of other blood group systems. 4.2.3: Haemolytic disease of new born, Coombs test. **4.3: Hypersensitivity** Coombs and Gell's classification Type I to Type IV hypersensitivity, Mechanism and manifestation.	**05** **05** **05**

References:

1. Kuby Immunology, 6th Edition, W H Freeman and Company
2. Pathak &Palan, Immunology: Essential & Fundamental, 1st& 3rd Edition, Capital Publishing Company
3. Fahim Khan, Elements of Immunology, Pearson Education
4. Kuby Immunology, 7th Edition, W H Freeman and Company
5. http://www.macmillanlearning.com/catalog/static/whf/kuby/

Course Code: RUSMIC603
Course Title: MICROBIAL BIOCHEMISTRY PART II
Academic year 2019-20

Learning objectives:

There are a large number of macromolecules such as lipids, carbohydrates, proteins andnucleic acids which are catabolised by the living cells. Cells also bring about biosynthesis ofthese macromolecules. Various enzymes play a major role in these biochemical reactions. After an elaborate discussion on carbohydrate metabolism in the Semester V, the learner is made aware of the mechanisms ofcatabolism, anabolism as well as the regulation of lipid and nitrogenous compounds in this section.

Regulation of enzymatic reactions is a very critical part of metabolism. Studying these at the genetic level, would help students to get an insight on key mechanisms of economizing in the cells. Pathways for photosynthesis, with emphasis on prokaryotes are also dealt with here. Prokaryotic cells are alsoinvolved in metabolism of inorganic compounds. The last section elaborates on these mechanisms.

Learning Outcomes: Students should be able to-

- Understand the reactions involved in metabolism of lipids and hydrocarbons.
- Describe and explain protein catabolism as well as anabolic processes in the cell.
- Explain nucleic acid metabolism and recycling of nucleotides.
- Discuss the mechanism of regulation with regards to allosteric proteins, gene expression as well as through other mechanisms like end product inhibition and covalent modification.
- Describe prokaryotic photosynthesis with respect to photosynthetic pigments, photochemical apparatus and light and dark reactions.
- Describe metabolism of inorganic compounds and Lithotrophy

Detailed Syllabus

Course Code	Title	Credits
RUSMIC 603	**MICROBIAL BIOCHEMISTRY PART II**	**2.5 Credits(65 lectures)**
Unit I	**PID METABOLISM & CATABOLISM OF HYDROCARBONS**	**15 lectures**
	1.1 General introduction to Lipids 1.1.1. Lipids and their functions 1.1.2. Action of lipases on triglycerides /tripalmitate 1.1.3. Phospholipids and their properties 1.1.4. Common phosphoglycerides in bacteria **2. Catabolism of Lipids** 1.2.1.Oxidation of saturated fatty acid- β oxidation pathway, Energetics of β oxidation of Palmitic acid 1.2.2. Oxidation of propionic acid. 1.2.3. Degradation of poly beta hydroxy butyrate **3. Anabolism of Lipids** 1. Biosynthesis of straight chain even carbon saturated fatty acid (palmitic acid) 2. Biosynthesis of phosphoglycerides in bacteria 3. Biosynthesis of PHB 4. **Catabolism of aliphatic hydrocarbons** 1. Oxidation of saturated aliphatic hydrocarbon (n-alkane) 2. Omega oxidation pathway- Pathway in ***Corynebacterium*** and yeast Pathway in ***Pseudomonas***	**02** **05** **06** **02**
Unit II	**METABOLISM OF PROTEINS AND NUCLEIC ACIDS**	**15 lectures**
	2.1 Protein catabolism 2.1.1. Enzymatic degradation of proteins 2.1.2. Metabolic fate of amino acids (schematic only) 2.1.3. Metabolism of single amino acids – i. Deamination reactions ii. Decarboxylation iii. Transamination 2.1.4. Fermentation of single amino acid -Glutamic acid by *Clostridium* 2.1.5. Fermentation of pair of amino acids -Stickland	**05**

	reaction **2. Amino acid synthesis** 2.1. Schematic representation of amino acid families Synthesis of amino acids of Aspartate family **3. Nucleic acid Catabolism** 1. Degradation of purine nucleotides up to uric acid formation 2. Recycling of purine and pyrimidine nucleotides by salvage pathway **4. Anabolism of Nucleic Acids** 4.1. Metabolic origin of atoms in purine and pyrimidine ring synthesis of pyrimidine nucleotides. synthesis of purine nucleotides. rmation of deoxyribonucleotides. .4.5. Synthesis of nucleotide diphosphates and triphosphates. le of nucleotides (high energy triphosphates)	**04** **03** **03**
Unit III	**METABOLIC REGULATION**	**15 lectures**
	3.1: Overview and major modes of regulation Examples of cellular control mechanism acting at various levels of metabolism (tabulation only) 2. **Allosteric proteins** 3.2.1. Definition 3.2.2. Allosteric enzymes - Role of allosteric enzymes using ATCase as example (no kinetic study) 3.2.3.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)** 3.3.1. Introduction to operon model 3.3.2. 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 3.3.3. Regulation of gene expression i. Multiple Sigma Factors	**01** **03** **06**

	ii. Riboswitches **3.4 Regulation of enzyme activity (Post translational regulation)** 3.4.1. End-Product Inhibition and Mechanism of End Product Inhibition in branched pathways with examples a. Isofunctional enzymes b. Concerted feedback inhibition c. Sequential feedback inhibition d. Cumulative Feedback inhibition e. Combined activation and inhibition 3.4.2 Covalent modifications of enzymes i. General examples without structure ii. Monocyclic cascade &inter-convertible enzyme definition **ii.** Glutamine synthetase system of **E.coli** 3.4.3. Regulation by proteolytic cleavage **3.5 Regulation of EMP and TCA** (Schematic and Role of Pyruvate dehydrogenase Complex)	**04** **01**
Unit IV	**PROKARYOTIC PHOTOSYNTHESIS & INORGANIC METABOLISM**	**15 lectures**
	1. Prokaryotic photosynthesis 4.1.1. Early studies on photosynthesis i. Light and dark reactions ii. Bacterial photosynthesis iii. Hill reaction 2. Phototrophic prokaryotes -Oxygenic, Anoxygenic phototrophs examples only 3. Photosynthetic pigments 4. Location of photochemical apparatus 5. Photophosphorylation 6. Light reactions in i. Purple photosynthetic bacteria ii. Green sulphur bacteria iii. Cyanobacteria (with details) 7. Dark reaction i. Calvin Benson cycle ii. Reductive TCA **2. Inorganic Metabolism** 4.2.1. Assimilatory pathways- i. Assimilation of nitrate, ii. Ammonia fixation – Glutamate dehydrogenase, Glutamine synthetase, GS-GOGAT, Carbamoyl phosphate synthetase	**09** **03**

	iii. Biological nitrogen fixation (Mechanism for N_2fixation and protection of nitrogenase) iv Assimilation of sulphate 2. Dissimilatory pathways- i. Nitrate as an electron acceptor (Denitrification in *Paracoccusdenitrificans*) ii. Sulphate as an electron acceptor 4.2.3: Lithotrophy– Enlist organisms and products formed during oxidation of Hydrogen, carbon monoxide, Ammonia, Nitrite, Sulphur, Iron. 4.2.3: Lithotrophy– Enlist organisms and products formed during oxidation of Hydrogen, carbon monoxide, Ammonia, Nitrite, Sulphur, Iron.	**02** **01**

References:

1. Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition, The Macmillan press Ltd
2. Conn, E.E., P. K. Stumpf, G. Bruening and R. Y. Doi. 1987**.** Outlines of Biochemistry, 5th edition, 1987. John Wiley & Sons. New York.
3. Gottschalk, G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag
4. White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rd edition, Oxford University Press
5. Nelson, D. L. and M.M. Cox (2005), Lehninger, Principles of biochemistry. 4th edition, W. H. Freeman and Company.
6. Salle, A.J. Fundamental Principles of Bacteriology, 7thedn McGraw Hill Book Co.
7. Cohen, G.N. (2011). Microbial Biochemistry. 2ndedn, Springer
8. Madigan, M.T. and J.M. Martinko 2006. Brock Biology of Microorganisms.Pearson Prentice Hall;
9. Biochemistry 3rd edition, Mathew, Van Holde and Ahern, Pearson Education
10. Zubay, G. L (1996), Biochemistry, 4th edition, Wm. C. Brown publishers
11. Principles of Biochemistry, Lehninger, 5thednW. H. Freeman and Company

Course Code: RUSMIC604
Course Title: INDUSTRIAL MICROBIOLOGY
Academic year 2019-20

Learning Objectives

The learner was introduced to fermentation technology in Semester V. This semester the learner is introduced to industrial fermentations for brewing, pharmaceutical and food industry.This section of the curriculum also includes traditional fermentation processes of alcoholic beverages and modern fermentations that acquaint the learner to exploit microbial technology to make greener fuels. The learner is provided with thedetails of productions of important products like antibiotics, vitamins, organic acid, food products and supplementsandenzymes.

Bioassays as analysis techniques used by quality control or R & D labs of industries for various products are also dealt with here.The learner is expected to learn the need of Quality management as theproducts need to fulfil these requirements. Thus, this paper readies the learner to understand andapply the knowledge of fermentation technology and related products.This course aims to enable graduates to enter industry with an appropriate level of understandingof the need for both the science and business aspects to be achievable to make a viable product and enhance their entrepreneurial skills.

Learning Outcomes: Students should be able to-

- Understand the actual process involved in fermentations of important beverages, pharmaceutical and food products.
- Learn the applications of enzymes in various fields.
- Understand the principle of bioassays as an analytical technique
- Learn the salient features of quality management.

Detailed Syllabus

Course Code	Title	Credits
RUSMIC 604	**INDUSTRIAL MICROBIOLOGY**	**2.5 Credits(65 lectures)**
Unit I	**INDUSTRIAL FERMENTATIONS:I**	**15 lectures**
	1.1. Types of alcoholic beverage. 1.2. Beer –Ale and Lager 1.3. Wine –Red and white & Champagne 1.4. Vinegar (acetator& Generator) 1.5. Bioethanol production- -From feedstock to fermentable sugars - *Zymomonas mobilis* as an alternate ethanol producer 1.6. Acetone Butanol Fermentation	**1** **3** **4** **2** **3** **2**
Unit II	**INDUSTRIAL FERMENTATIONS:II**	**15 lectures**
	2.1 Production of secondary metabolites-Antibiotics- Penicillin& Semisynthetic Penicillins 2.2 Production of primary metabolites- i. Vitamin B_{12} from *Propionibacterium& Pseudomonas* ii. Amino acids- Methods for manufacture, Glutamic Acid (direct) iii. Organic acids- Citric acid iv. Enzymes- Uses of enzymes in industry, Production of Fungal amylase by solid substrate fermentation, Stabilization of enzymes- Immobilization techniques v. Biotransformation of steroids	**04** **03** **01** **01** **05** **01**
Unit III	**INDUSTRIAL FERMENTATIONS: II**	**15 lectures**
	i. Mushroom cultivation i. SCP- Substrates used, Organisms and safety i. Fermented foods- Bread, fermented cassava, tea and coffee v. Mold modified foods- Types (list only), Production of Soya sauce v. Lactic acid starter cultures, prebiotics and probiotics	**03** **03** **03** **02** **04**

Unit IV	BIOASSAYS & QUALITY ASSURANCE	15 lectures
	4.1 Bioassays i. Comparison of Chemical and Biological assays i. Microbiological assays- Test organisms,types of assay methods and factors affecting. i. Modern methods for assay of fermentation products	**05**
	4.2 QA, QC, GMP: i. Definitions- Manufacture, Quality, Quality Control, In-Process Control, Quality Assurance, Good Manufacturing Practices. i. Chemicals & Pharmaceutical production: The five variables, In process Items, Finished Products, Labels and Labelling, Packaging materials, Documentation, Regulations. i. Control of Microbial contamination during manufacture: Premises and contamination control Manufacture of sterile products, Clean and Aseptic Area, Important publications related to QA	**07**
	4.3 Sterilization Control and Sterility Assurance: i. Bio-burden determinations i. Environmental monitoring i. Sterilization Monitors – Physical, Chemical and Biological indicators v. Sterility Testing	**03**

References:

1. Casida L. E., "Industrial Microbiology" 2009 Reprint, New Age International (P) Ltd, Publishers, New Delhi
2. Crueger W. and Crueger A. 2000 "Biotechnology -"A Textbook of Industrial Microbiology", 2nd Edition, Panima Publishing Corporation, New Delhi.
3. H. A. Modi, 2009. ‘’Fermentation Technology’’ Vol: 1 & 2, Pointer Publications, India
4. Prescott and Dunn's ‘’Industrial Microbiology’’(1982) 4th Edition, McMillan Publishers
5. Hugo & Rusell’s,”Pharmaceutical Microbiology” Blackwell Science, Seventh Edition
6. Peppler, H. J. and Perlman, D. (1979), "Microbial Technology’’. Vol 1 & 2, Academic Press.
7. Michael J. Waites, 2001 “Industrial Microbiology: An Introduction”, Blackwell Science Publications
8. Naduka Okafor, “Modern Industrial Microbiology”, Science Publications, 2007

Practicals (Semester-VI) RUSMICP602

[Practicals Based on 603;Credits -1.5,Lectures- 60]

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 of 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 cyanobacteria
10. Study of Lithotrophs – Nitrosification and Nitrification

[Practicals Based on 604;Credits:1.5, Lectures:60]

1. Alcohol tolerance for yeast.
2. Sugar tolerance for yeast.
3. Inoculum Development for alcohol fermentation
4. Alcohol fermentation.: -Efficiency of fermentation
5. Chemical estimation –Sugar by Cole's Ferricyanide method
6. Chemical estimation –Alcohol Estimation- Dichromate method
7. Demonstration of HPLC for alcohol estimation
8. Production of fungal amylase using solid substrate fermentation
9. Immobilization of yeast invertase
10. Mushroom cultivation
11. Production of *Spirulina* SCP
12. Isolation of Lactic acid bacteria from probiotics
13. Bioassay of an antibiotic (Ampicillin / Penicillin)
14. Bioassay of Cyanocobalamin.
15. Chemical estimation of Penicillin
16. Sterility testing of water for injection or DPT vaccine.

Modality of Assessment:

Theory Examination Pattern:

A. Internal Assessment - 40% 40 marks.

	Evaluation type	Marks
	One Assignment/Case study/Project	10
	One class Test (multiple choice questions / objective)	20
	Active participation in routine class instructional deliveries(case studies/ seminars//presentation)	05
	Overall conduct as a responsible student, manners, skill in articulation, leadership qualities demonstrated through organizing co-curricular activities, etc.	05

B) External examination - 60 %

Semester End Theory Assessment - 60% 60 marks

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern: -There shall be **four** questions each of **15** marks, one on each unit. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Questions	Options	Marks	Questions on
Q.1)A)	Any 2 out of 4	12	Unit I
Q.1)B)	Any 3 out of 5	03	
Q.2)A)	Any 2 out of 4	12	Unit II
Q.2)B)	Any 3 out of 5	03	
Q.3)A)	Any 2 out of 4	12	Unit III
Q.3)B)	Any 3 out of 5	03	
Q.4)A)	Any 2 out of 4	12	Unit IV
Q.4)B)	Any 3 out of 5	03	

Practical Examination Pattern:

(A)Internal Examination: -

	Paper I	Paper II	Paper III	Paper IV
Journal	05	05	05	05
Tests	10	10	10	10
Participation	05	05	05	05
Total	20	20	20	20

(B) External (Semester end practical examination):- 30 Marks Per Section

Sr. No.	Particulars	Marks	Total
1	Lab work	50+50=	100
2	Viva	10+10=	20

PRACTICAL BOOK/JOURNAL

Semester V and VI:

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 DistributionPattern

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

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
