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S. P. Mandali's

Ramnarain Ruia Autonomous College

Syllabus for MSc Program

Course: Microbiology (RPSMIC)

(Credit Based Semester and Grading System for the academic year 2019–2021)

Semester	Course code	TITLE	Credits
I	**RUSMIC101**	Microbial Genetics	**04**
	RUSMIC102	Microbial biochemistry I	**04**
	RUSMIC103	Medical Microbiology and Clinical Microbiology	**04**
	RUSMIC104	Emerging areas in Biology	**04**
II	**RUSMIC201**	Cell biology	**04**
	RUSMIC202	Microbial Biochemistry II	**04**
	RUSMIC203	Environmental Microbiology	**04**
	RUSMIC204	Research Methodology	**04**
III	**RUSMIC301**	Virology	**04**
	RUSMIC302	Immunology	**04**
	RUSMIC303	Food and Water Microbiology	**04**
	RUSMIC304	Techniques in Biology (Tools and Techniques)	**04**
IV	**RUSMIC401**	Pharmaceutical Microbiology	**04**
	RUSMIC402	Applied Microbiology	**04**
	RUSMIC403	Epidemiology and Clinical Research, therapeutics and Biosecurity	**04**
	RUSMIC404	Internship	**04**

MSc Microbiology Semester I 2019-2020

COURSE CODE	UNIT	TITLE	Credits	Lec / Week
RPSMIC 101	MICROBIAL GENETICS		04	04
	I	Gene expression and regulation	01	
	II	Cytoplasmic Inheritance & Chromosomal Rearrangements	01	
	III	Transposable elements and Population genetics	01	
	IV	Model organisms and Genetic basis of cancer	01	
RPSMIC 102	MICROBIAL BIOCHEMISTRY		04	04
	I	Biochemical Calculations and Thermodynamics	01	
	II	Biomolecules	01	
	III	One and two Carbon metabolism	01	
	IV	Transport of Biomolecules	01	
RPSMIC 103	MEDICAL AND CLINICAL MICROBIOLOGY		04	04
	I	Study of Infections – I	01	
	II	Study of Infections- II	01	
	III	Role of Biofilms in diseases	01	
	IV	Clinical Microbiology	01	
RPSMIC 104	EMERGING AREAS IN BIOLOGY		04	04
	I	Bioinformatics and computational biology	01	
	II	Synthetic and systems biology	01	
	III	Nanobiotechnology	01	
	IV	Contemporary tools in Molecular Biotechnology	01	
RPSMIC 1P1, 1P2, 1P3, 1P4	Practicals based on above four courses		8	16

Course Code: RPSMIC 101

Course Title: Microbial Genetics

Academic year 2019-20

Learning Objectives:

This paper begins with an account of transcription and translation processes and also post transcriptional modifications and post translational mechanisms, in both prokaryotic and eukaryotic systems. The next section discusses the levels of regulation of gene expression. It also aims at understanding the proteins involved in gene regulation and significance of antisense RNA molecules in therapeutic regulation. The paper also focuses on transposable genetic elements, genetic basis of cancer and model organisms.

As the UG syllabus does not discuss extra-chromosomal DNA in eukaryotes in details, Mt-DNA and Ct-DNA- its structure, importance in different organisms and its role in evolutionary studies has been included here. Topics on chromosomal rearrangements and its effect on gene expression and application of population genetics in gene expression too are included here to equip the learner with a sound background of genetics and its application

The next section stresses on the significance and role of transposons in genome organization and mutation of transposons, in bacteria, eukaryotes, Drosophila and Retroviruses. As oncogenes are currently very significant in the understanding of genetic pathways of cancer, the curriculum highlights the role of oncogenes and retroviruses in cancer and the role of cellular homologs of viral oncogenes and tumor suppressor genes

Learning Outcomes:

A complete understanding of basic genetic mechanisms like transcription and translation mechanisms, including post translational modifications will create a firm base of gene functioning and will help students distinguish between prokaryotic and eukaryotic transcription. The learner will also be able to assimilate the different levels of gene expression regulation and the different mechanisms by which it is regulated. Further, a detailed study and significance of Mt and Cp DNA and chromosomal rearrangements will equip the learner with a strong foundation for applying these principles for any biological system and comprehend their importance in evolution.

The section on transposons will make the learner capable of stating the medical significance and evolutionary significance of transposons, explaining the role of Ac, Ds elements of Maize and P element of Drosophila as transposable elements.

Awareness on the genetic basis of cancer and the role of cellular homologs of viral oncogenes and tumor suppressor genes will enhance the learners understanding of oncogenes and cancer and help the learner use this knowledge in further applications in research

Detailed syllabus

RPSMIC101: Microbial genetics

Unit	Title	Lectures
I	**Gene expression and its regulation**	**15**
	1.1 Gene expression Revision of prokaryote transcription and translation A. Transcription process in eukaryotes B. RNA molecules and processing i. Post transcriptional processing structure of mRNA a) pre-mRNA processing b) addition of 5'cap c) addition of Poly(A)tail d) RNA splicing e) RNA editing. ii. Small RNA molecules a) RNA interference b) Types c) Processing d) function of micro RNAs C. mRNA surveillance and Post translational modification of Proteins	**06**
	1.2. Regulation of gene expression A. Control of gene expression in prokaryotes i. Genes & regulatory element ii. Levels of gene regulation iii. DNA binding proteins iv. Antisense RNA molecules v. Riboswitches B. Control of gene expression in eukaryotes i. Regulation through modification of gene structure a) DNase I hypersensitivity b) histone modifications c) chromatin remodelling d) DNA methylation. ii. Regulation through regulatory molecules a) transcriptional activators b) Co-activators c) repressors d) enhancers e) insulators iii. Regulation through RNA processing & degradation iv. Regulation through RNA interference	**06**
	1.3 Chromosomal Rearrangements and effects on gene expression i. Amplification and deletion of genes ii. Inversions that alter gene expression iii. Phase variation in Salmonella	**03**

II	**Cytoplasmic Inheritance (Organellar Genetics)** **2.1) mitochondrial DNA (mt-DNA)** i. Mitochondrial genome structure ii. Ancestral and derived mitochondrial genome iii. Mitochondrial DNA of Human, yeast and flowering plants iv. Endosymbiotic theory v. Mitochondrial DNA replication, transcription & translation vi. Codon usage in Mitochondria vii. Damage to Mitochondrial DNA and aging. viii. Evolution of mitochondrial DNA ix. mt DNA analysis for study of evolutionary relationships **2.2) Chloroplast DNA (cp DNA)** i. Gene structure and organization ii. General features of replication, transcription and translation of cp DNA iii. Comparison of nuclear, eukaryotic, eubacterial mitochondrial and chloroplast DNA iv. Add maps v. Chloroplast Transformation **2.3) Examples of extranuclear inheritance-** i. Leaf Variegation, ii. Poky mutant of Neurospora, iii. Yeast petite mutant, iv. Human genetic diseases v.	**15** **05** **05** **05**
III	**Transposable genetic elements and population genetics** **3.1) Transposable genetic elements** **Revision of prokaryotic transposable elements** i. Transposable Elements in Eukaryotes Ac and Ds Elements in Maize ii. P Elements and Hybrid Dysgenesis in Drosophila Mariner, an Ancient and Widespread Transposon iii. Retro transposons Retrovirus like Elements Retroposons iv. The Genetic and Evolutionary Significance of Transposable Elements v. Transposons and Genome Organization Transposons and Mutation vi. Rearrangement of Immunoglobulin Genes vii. Evolutionary Issues Concerning Transposable Elements viii. Transpositions that alter gene Expression a) antigenic variation in Trypansomes b) Mating type switching in yeast c) Applications of Yeast Genetics: Cell cycle genetics and cancer **3.2) Population genetics** A) Population and gene pool i. Genotypic and Allelic frequencies ii. Calculation of Genotypic frequencies and Allelic frequencies for autosomal and X linked loci	**15** **08** **07**

	iii. Problems –calculation of allelic and genotypic frequencies iv. Hardy-Weinberg Law, genotypic frequencies at HWE, v. Implications of the H-W Law vi. H-W proportions for multiple alleles, vii. X-linked alleles viii. Testing for H-W proportions and problems ix. Genetic ill effects of in-breeding B) Changes in the genetic structure of populations: i. Mutation ii. Migration and gene flow iii. Genetic drift iv. Natural selection and Simple problems based on the natural forces	
IV	**Model organisms and Genetic basis of cancer** **4.1 Model organisms** a. Characteristics of an ideal model organism b. Elaborating each model organism i. *E. coli* ii. Yeast iii. *C. elegans* iv. *A. thaliana* v. *Mus musculus* **4.2 Genetic basis of cancer** i. Introduction: Cancer- a genetic disease, forms of Cancer, cancer and the Cell Cycle ii. Genetics Basis for Cancer iii. Oncogenes iv. Tumor-Inducing Retroviruses and Viral Oncogenes v. Cellular Homologs of Viral Oncogenes: The Proto-Oncogenes Mutant Cellular Oncogenes and Cancer vi. Chromosome Rearrangement and Cancer vii. Tumor Suppressor Genes viii. Inherited Cancers and Knudson's Two-Hit Hypothesis Cellular Roles of Tumor Suppressor Proteins Genetic Pathways to Cancer	**15** **07** **08**

References:

1. Watson, Baker, Bell, Gann, Levine, Losick, “Molecular Biology of the Gene”, Fifth Edition, Pearson Education (LPE)
2. Russell, P.J., “iGenetics- A Molecular Approach”, Third Edition, Pearson International Edition
3. Snustad & Simmons, “Principals of Genetics”, Third Edition, John Wiley & Sons Inc
4. Watson, Gilman, Witkowski, Zoller, “Recombinant DNA”, Second Edition, Scientific American Books
5. Pierce, B.A, “Genetics- A Conceptual Approach”, Second Edition, W.H. Freeman &Co

PRACTICALS: RPSMIC1P1 (60 Contact Hrs)

1. Problems on population genetics
2. B galactosidase assay
3. Isolation of genomic DNA from yeast
4. Transformation of yeast
5. Tetrad analysis of yeast
6. Isolation of mitochondria DNA & chloroplast DNA
7. Literature Review

Course Code: RPSMIC 102

Course Title: Microbial Biochemistry

Academic year 2019-20

Learning Objectives:

Biochemical studies are based on analytical techniques that require high precision and thorough understanding of behavior of biomolecules under different physical and chemical conditions. This course integrates theory and practice to familiarize and increase proficiency of the learner towards calculations related to reagent and chemical preparations with respect to normality, molarity, molality, density and specific gravity and the concept of pH and buffering action of buffers. The next section covers in detail the structural complexity of all biomolecules, viz; proteins, glycoproteins and lipids, and their role in molecular interactions, communication and signaling such that the learner gets a thorough and complete overview of significance of biomolecules in the cell.

Learning Outcomes:

The section on 'Aqueous solutions and acid base chemistry' in this course promotes problem solving such that the learner will be able to solve calculations in preparation of solutions and manipulation of behavior of biomolecules for analytical techniques and apply these techniques to the advancement of knowledge in microbial Biochemistry.

The second section reinforces the fundamentals of structure and function of biomolecules, knowledge of which will help the learner analyze and evaluate several biological processes related to complex processes like signaling and communication. The course also introduces biological pathways for metabolism of 1C and 2C compounds and transport mechanism across membrane like drug export mechanism giving rise to antibiotic resistance to emphasize some key biochemical processes not covered in the UG level.

Detailed syllabus

RPSMIC102: Microbial biochemistry

Unit	Topic	Lectures
I	**Biochemical Calculations and Thermodynamics**	**15**
	1.1. Biochemical Calculations	**09**
	1. SI Units Relevant to Biochemistry, Prefixes for Multiples and Fractions of Units, Relative molecular mass (M_r), Stoichiometry 2. Various units of expressing and inter-converting concentration of solutions: molarity, moles, normality, osmolarity, molality, mole fraction, density, specific gravity 3. Bronsted Concept of conjugate acid–conjugate base pairs, ionization of solutions, pH, titration curves, buffers: preparation, action and their use in Biology 4. Henderson-Hasselbalch equation, buffer capacity, polyproteic acids, amphoteric salts, ionic strengths **(problem solving under all heads)**	
	1.2. Thermodynamics	**06**
	1. Energy Transformations 2. First and second law of thermodynamics a) Statement and Introduction b) Enthalpy, examples from biochemistry and energy conservation in living organisms c) Entropy of universe, Protein denaturation 3. Gibbs Free Energy-Applications a) Introduction b) Photosynthesis, glycolysis, and the citric acid cycle c) Oxidative phosphorylation and ATP hydrolysis d) Enzyme–substrate interaction e) Protein solubility f) Protein stability	
II	**Biomolecules**	**15**
	2.1. Amino acids and Proteins	**04**
	1. Amino Acids and Peptides (Revision) a) Properties of α-Amino Acids b) Acidic and Basic Side Chains c) The Peptide Unit d) Polypeptides 2. The Architecture of Folded Proteins a) Conformations of Polypeptide Chains b) The Extended Chain β Structures c) Helices d) Turns and Bends, Domains, Subunits, and Interfaces e) Packing of Side Chains 3. Dynamic Properties of Proteins a) Packing of Side Cha Motion of Backbone and Side Chains	

	b) Conformational Changes c) Denaturation and Refolding d) Effects of pH and Solvent e) Irreversible Damage to Proteins **2.2. Sugars, Polysaccharides and glycoproteins** 1. Structures and Properties of Simple Sugars 2. Glycosides, Oligosaccharides, Glycosylamines, and Glycation 3. Polysaccharides (Glycans) 4. Glycoproteins and Proteoglycans **2.3. Lipids** 1. Lipid Structures a) Fatty Acids, Fatty Alcohols, and Hydrocarbons b) Acylglycerols, Ether Lipids, and Waxes c) Phospholipids d) Glycolipids e) Sphingolipids f) Sterols and Other Isoprenoid Lipids 2. Membranes-The Structure of Membranes **2.4. Evolution of Metabolic pathway** 1. The primordial metabolism 2. The role of duplication and fusion of DNA sequences in the evolution of metabolic pathways in the early cells 3. Hypotheses on the origin and evolution of metabolic pathways 4. The reconstruction of the origin and evolution of metabolic pathways	**03** **03** **05**
III	**One and two Carbon metabolism** **3.1: Metabolism of one carbon compounds:** a) Methylotrophs: Oxidation of methane, methanol, methylamines and carbon assimilation in methylotrophic bacteria and yeasts Methanogens: Methanogenesis form H_2, CO2, CH_3OH, HCOOH, methylamines, energy coupling and biosynthesis in methanogenic bacteria b) Acetogens: autotrophic pathway of acetate synthesis and CO_2 fixation, c) Carboxidotrophs: Biochemistry of chemolithoautotrophic metabolism d) Cyanogens and cynotrophs: cynogenesis and cyanide degradation **3.2: Metabolism of two- carbon compounds** a) Acetate-TCA and Glyoxylate cycle, modified citric acid cycle, carbon monoxide dehydrogenase pathway and disproportionation to methane b) Ethanol- acetic acid bacteria	**15** **07** **08**

	c) Glyoxylate and glycollate- dicarboxylic acid cycle, glycerate pathway, beta hydroxyaspartate pathway d) Oxalate- as carbon and energy source	
IV	**Transport of Biomolecules** **4.1: Transport of sugars** a) Transport of D-Glucose and D-Fructose into *E. coli* cell. b) Glucose transporters of erythrocytes, various glucose transporters present in humans (GLUT1-GLUT12) **4.2: Transport of amino acids** - Amino acid transporter families for various amino acids **4.3: Fatty acid transport** a) Mobilization of triacylglycerols stored in adipose tissue b) Fatty acid entry into mitochondria via the acyl-carnitine/carnitine transporter. **4.4: Transport of proteins** a) Protein transport: extracellular protein secretion, drug export system b) Folding of periplasmic proteins, translocation of folded proteins	**15** **03** **03** **03** **06**

References:

1. Biochemical calculations, Segel.R. 3rd edition John Wiley and Sons,1995
2. Biochemistry 3rd edition, Mathew, Van Holde and Ahern, Pearson Education
3. Principles of Biochemistry, 4thedition, Zubay, G., Wm.C. BrownPublishers,1998
4. Principles of Biochemistry,4thEdition Lehninger A.L., Cox and Nelson, CBS publishers and Distributors Pvt. Ltd. 1994
5. Microbial Biochemistry by G N Cohen-2011 2ndEdition, Springer
6. Biological Thermodynamics by Donald Haynie – 2nd Edition 2008 Cambridge University Press
7. Biochemistry: The Chemical reactions of living cell by David E. Metzler-2nd Edition Vol. 1&2 Elsevier Academic Press
8. The Physiology and Biochemistry of Prokaryotes by David White -3rd Edition 2007 Oxford University Press

PRACTICALS: RPSMIC1P2 (60 Contact Hrs)

1. Preparation of buffers
2. Determination of pK and PI value for an amino acid
3. Extraction of total lipids
4. Identification of fatty acids and other lipids by TLC
5. Determination of degree of unsaturation of fats and oils
6. Estimation of total sugars by phenol-sulphuric acid method
7. Determination of molar absorption coefficient(ε)of l-tyrosine
8. Determination of the isoelectric point of the given protein
9. Estimation of polyphenols /tannins by Folin-Denis method
10. Enrichment, isolation and identification of *Methylobacterium*
11. Diffusion studies of molecules across sheep RBCs

Course Code: RPSMIC 103

Course Title: Medical and Clinical Microbiology

Academic year 2019-20

Learning Objectives:

This course on Medical Microbiology introduces the students to mechanisms of pathogenesis, control and treatment of some representative and recent emerging diseases. The course also aims at introducing and elaborating on the recent growing interest in the study of the human microbiome, specially the gut microbiome.

The elucidation of mechanisms used by pathogens to evade host defense and regulate expression of pathogenicity has become easier with new techniques in molecular biology. The curriculum aims at opening doors to this aspect of medical microbiology for the students along with mechanisms employed by bacteria to overcome the onslaught of antibiotic treatments employed.

The growing threat of antibiotic resistance also emphasizes the need for equipping students with techniques used to study antibiotic sensitivity and determining effectiveness of therapies.

Learning Outcomes:

Students will be able to:

- Elaborate on pathogenesis mechanisms, and mode of transmission, epidemiology and therefore modes of prophylaxis of some current and emerging diseases
- Understand nature of regulation of expression of pathogenicity, evasion of host defense.
- Understand the nature and methods of eradication of biofilms, especially those on implants and medical devices
- contribute to the tackling of the threat of antibiotic resistance
- Perform and analyze all kinds of clinical microbiological tests associated with antibiotic susceptibility testing.

Detailed syllabus

RPSMIC103: Medical Microbiology and Clinical Microbiology

Unit	Topics	Lectures
I	**Study of Infections – I** Detailed Study of following infections including Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab. diagnosis, Prophylaxis, and Treatment: MOTT (mycobacteria other than TB), MDR and XDR TB, Legionellosis, Chikungunya, Emerging infections like-Rickettsial infections and C.*auris* Conditions caused by *Helicobacter pylori*, VRE (Vancomycin Resistant enterococci), Listeriosis, Leptospirosis	**15**
II	**Study of Infections- II and introduction to microbiome** **2.1: Detailed Study of following infections** including Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab. diagnosis, Prophylaxis, and Treatment Dengue, Hepatitis non-A, Swine flu **2.2: Microbiome studies** a. Stomach, small and large intestinal microbiome b. Function of the Human Gut Microbiota b. Gut Microbiota in health and disease	**15** **08** **07**
III	**Virulence regulation and strategies to evade defense** 3.1: Revision of Virulence mechanisms in pathogens 3.2: Mechanisms of virulence regulation a. Types of regulation b. Quorum Sensing 3.3: Measuring Virulence 3.4: Bacterial strategies for evading or surviving host defense systems a. Biofilms- Structure, development, biofilms on implants and prosthetic devices, Biofilm eradication b. Colonization of host surfaces c. Evading host responses	**15** **2** **4** **3** **6**
IV	**Clinical Microbiology- Antibiotic resistance and Antibiotic susceptibility testing** **4.1: Antibiotic resistance in microbes** a. Mechanisms of antibiotic resistance b. Transfer of antibiotic resistance c. Maintaining antibiotic resistance through Selective Pressure	**15** **7**

	4.2: Antibiotic susceptibility testing a. Tests that predict the effectiveness of therapy i. Antibiotic Susceptibility Testing Methods- Indications, standardization, QC, Procedures and interpretation ii. Detection of resistance- Beta lactamase and ESBL iii. Antibiograms b. Tests that monitor the effectiveness of therapy i. Molecular detection ii. MBC iii. Serum killing curves iv. Testing antibiotic combinations v. Time kill curves vi. Test of therapeutic efficacy and avoidance of toxicity	**8**

References:

1. Textbook of Microbiology 8th edition 2009-Ananthnarayan & Paniker-University press
2. Mim's Medical Microbiology, Richard Goering, Hazel Dockerell et al, 5th ed, 2013, Saunders, Elsevier
3. Medical Microbiology: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and Control, David Greenwood *et al*, 17th Edition, 2012, Churchill Livingstone/Elsevier
4. The Human Microbiota and Microbiome, Advances in Molecular and Cellular Microbiology 25, Edited by Julian R. Marchesi, 2014, CABI press
5. Bacterial Pathogenesis- A molecular approach, Brenda Wilson, Abigail Salyers et al, 3rd ed, 2011 ASM press
6. Medical Biofilms. Detection Prevention and Control, Ed Jana Jass, Sussane Surma et al, 2003, Wiley
7. Antibiofilm agents-From Diagnosis to treatment and Prevention, Springer Series on Biofilms Vol 8, Ed Kendra Rumbaugh, Iqbal Ahmed, 2014, Springer
8. Basic laboratory procedures in clinical bacteriology. J. Vandepitte, J. Verhaegen et al, 2nd ed, 2003, WHO, Geneva.

9. Koneman's Color Atlas and Textbook of Diagnostic Microbiology, Gary Procop, Elmer Koneman *et al.* 7th Edition, 2017, Wolters Kluwer.
10. Virulence Mechanisms of Bacterial Pathogens, by Indira Kudva, Nancy Cornick et al, Fifth ed, ASM Press, 2016
11. A brief guide to emerging infectious diseases and zoonoses. WHO.
12. Nett JE (2019) Candida auris: An emerging pathogen "incognito"? PLoS Pathog 15(4): e1007638. https://doi.org/10.1371/journal. Published: April 8, 2019
13. Spivak ES, Hanson KE. 2018. Candida auris: an emerging fungal pathogen. J Clin Microbiol 56:e01588-17. https://doi.org/10.1128/JCM.01588-17.
14. Abdad MY, Abou Abdallah R, Fournier P-E, Stenos J, Vasoo S. 2018. A concise review of the epidemiology and diagnostics of rickettsioses: Rickettsia and Orientia spp. J Clin Microbiol 56: e01728-17. https://doi.org/10.1128/JCM.01728-17.
15. Rickettsial Infections: Indian Perspective NARENDRA RATHI AND AKANKSHA RATHI, INDIAN PEDIATRICS VOLUME 47__FEBRUARY 17, 2010

PRACTICALS: RPSMIC1P3 (60 Contact Hrs)

1. Diagnosis for HIV - Trispot/ ELISA for AIDS (Demonstration)
2. Mono - Spot Test for diagnosis of Chikungunya (Demonstration expt.)
3. Diagnosis of leptospirosis – Kit method (Demonstration)
4. Diagnosis for *Helicobacter pylori* HPSA (Helicobacter pylori) (Demonstration expt.) (kit method)
5. Study of Quorum Sensing in *C.violaecium*
6. Study of Quorum sensing inhibitors
7. Detection of Biofilm formation on different surfaces
8. Determination of Minimum Biofilm Inhibition Concentration of an antibiotic
9. Study of biofilms in flow systems
10. Antibiotic Susceptibility Test – microdilution methods according to CLSI guidelines
11. Checkerboard assay
12. E-test

Course Code: RPSMIC 104

Course Title: Emerging areas in Biology

Academic year 2019-20

Learning Objectives:

Biology is becoming an increasingly data-intensive and interdisciplinary science. This new paper will introduce students to contemporary topics relevant in academia and industry today.

The first unit will introduce key computational methods that are common in the fields of bioinformatics and computational biology. From the most fundamental topics such as introduction to databases, sequence alignment and pattern finding, primer design, the pace builds up to more advanced but important topics like phylogenetic tree constructions, evolutionary analysis and, finally, introductory coding in a scripting language such as Python or R with theory and practical sessions on each sub-topic.

The second unit highlights the quantitative nature of biology and focuses on a bottom-up approach with Synthetic Biology complemented by a top-down approach with Systems Biology. Synthetic biology is a relatively new discipline where biology and engineering principles come together to develop new biological devices. With the advances in biology, genetics and genome sequencing coupled to the vast increase in the speed and storage capacity of computers and the internet, researchers today understand living organisms in much more detail, both in terms of the individual molecules and at the system level. A brief introduction to Systems biology will showcase the challenges that big-data biology faces and acquaint students with methods used to tackle these issues.

The third unit on Nanobiotechnology focuses on an upcoming field which is a highly interdisciplinary subject bringing together physics, chemistry, biology and engineering streams. Students will be introduced to terminology in nanobiotechnology along with principle and methods of synthesis of nanomaterials and their applications.

The fourth unit focuses on tools used in genetic engineering with core topics on Chemical synthesis of DNA, Sanger sequencing and Directed mutagenesis. Students will also learn in-depth about the key variations used in each of these approaches to motivate innovative thinking. Introduction of select eukaryotic models such as *Pichia* and their importance extends the students' knowledge base beyond the prokaryotic systems that are typically in focus in any Microbiology course.

This unit also includes a brief introduction to cutting-edge topics such as Optogenetics and Metabolic engineering. Although it is a tool popular in neuroscience, students will be familiarized with optogenetics to understand how light responsive proteins have been utilized to control cellular processes such as transcriptional regulation, cellular localization in non-neuronal contexts. Metabolic Engineering describes the field of study concerned with applying genetic engineering tools to alter flux through native or newly introduced metabolic pathways in biological systems. The course aims to introduce basic concepts in metabolic engineering and explores modern approaches in metabolic and strain engineering.

Learning Outcomes:

Students undertaking this course will participate in multiple hands-on practical sessions and be able to perform common applications as mentioned above including introductory computational analyses and interpretations as well as an understanding of considerations undertaken for the analysis of high throughput data sets from various databases.

The course will help student understand fundamental engineering concepts applicable to biological engineering, recognize key research work from academia & industry towards practical applications, receive hands on training with computational and experimental synthetic biology.

Students will be introduced to the emerging field of nanobiotechnology. They will understand the synthesis of nanomaterials and their applications in the field of biology and medicines. Students will appreciate the technological advances in the field of nanobiotechnology.

They will be able to understand methods for chemical synthesis and sequencing of DNA, the process of genetic manipulation in eukaryotic models and methods of directed mutagenesis.

Detail Syllabus

UNIT	TITLE	Lectures (60)
I	**Bioinformatics and computational biology** 1.1 Introduction 1.2 Genome sequencing projects: technologies and impact 1.3 Annotation, Databases and Protein Structures 1.4 Pairwise Alignment, Multiple Alignment, and BLAST 1.5 Primer Design 1.6 Phylogenetic Analysis 1.7 Coding 101 and algorithms	**15**
II	**Synthetic and systems biology** **2.1 Synthetic Biology:** a. Basic concepts in Engineering Biology b. Parts, Devices and Systems c. Logic gates d. Synthetic Gene Circuits and examples like Oscillators, Toggle Switches **2.2 Overview of Systems biology:** a. Approaches and methodologies, b. Analysis of biological Networks, c. Network Dynamics d. Network Motifs and Functional Modules, e. Dynamical Models f. Artificial Intelligence in Systems Biology	**15** **10** **05**
III	**Nanobiotechnology** 3.1 Nanoscale systems, nanoparticles, nanowires, thin films and multilayers; Properties of nanomaterials. 3.2 Synthesis of nanostructures - physical, chemical and biological, microbiological methods a. Biomolecules as nanostructures b. Nanoparticular carrier systems c. Micro and Nanofluidics d. Applications: Nano-biosensors, drug and gene delivery systems, chip technologies, Nano imaging, Nanomedicine and Cancer diagnostics and treatment.	**15** **03** **05** **07**
IV	**Contemporary tools in Molecular Biotechnology** **4.1 Chemical synthesis and sequencing of DNA:** a. Phosphoramidite method b. Uses of synthesized oligonucleotides c. Dideoxynucleoside method for sequencing of DNA	**15** **04**

	d. Automated DNA sequencing **4.2 Heterologous protein production in eukaryotic cells:** a. *Saccharomyces cerevisiae* b. *Pichia pastoris* c. Baculovirus- Insect cell d. Mammalian cell **4.3 Directed Mutagenesis:** a. Oligonucleotide directed mutagenesis with plasmid DNA b. PCR amplified oligonucleotide directed mutagenesis c. Random mutagenesis with degenerate oligonucleotide primer d. Random mutagenesis with nucleotide analogues, Error-prone PCR e. DNA shuffling f. Mutant proteins with unusual amino acids **4.4 Optogenetics:** Channel Rhodopsin's, Caged Proteins, Dimerizing Systems **4.5 Metabolic engineering:** Concepts and case studies	**03** **04** **02** **02**

REFERENCES

1. Molecular Biotechnology: Principles and Applications of Recombinant DNA. Bernard R. Glick, Jack J. Pasternak, ASM Press (2010)
2. Introduction to Bioinformatics in Microbiology. Henrik Christensen, Springer International Publishing (2018)
3. Introduction to Bioinformatics. Arthur Lesk, Oxford University Press (2013)
4. Synthetic Biology- A Primer. Geoff Baldwin et al. Imperial College Press (2015)
5. Synthetic Biology, 2 volume set. Robert Meyer, Wiley-Blackwell (2015)
6. Systems biology primer: the basic methods and approaches. Iman Tavassoly, Joseph Goldfarb, Ravi Iyengar. Essays in Biochemistry Oct 2018, 62 (4) 487-500
7. An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology edited by Michael Wink, Wiley VCH (2006)
8. At Light Speed: Advances in Optogenetic Systems for Regulating Cell Signalling and Behaviour, Repina, Nicole A et al. Annual review of chemical and biomolecular engineering vol. 8 (2017): 13-39.
9. Metabolic Engineering: Past and Future. Benjamin M. Woolston, Steven Edgar, Gregory Stephanopoulos. Annual Review of Chemical and Biomolecular Engineering 2013 4:1, 259-288

PRACTICALS: RPSMIC 1P4 (60 Contact Hrs)

1. Exploration of DNA and protein databases
2. Pair-wise and multiple alignment of DNA and Amino acid sequences
3. Primer design and conceptual PCR troubleshooting
4. Learning how to read/ write scripts (eg with Python)
5. Designing of Synthetic Gene Circuits
6. Bacterial photography: application of synthetic biology
7. Preparation of Nano silver particles by Wet reduction Method (Chemical)using Neem Extract (plants) & fungi (Microbiological)
8. Preliminary characterization of Nano silver by UV spectrometry
9. Antimicrobial effect of Ionic silver and Nano silver prepared by above methods
10. Study of Nano silver coated Gauze/textiles for antimicrobial effect on different bacteria

MSc Microbiology Semester II 2019-2020

COURSE CODE	UNIT	TITLE	Credits	Lec / Week
RPSMIC 201		CELL BIOLOGY	04	04
	I	Cell Structure & Cytoskeleton	01	
	II	Membrane Transport and Compartmentalization	01	
	III	Cell cycle & Cell communication	01	
	IV	Developmental Biology	01	
RPSMIC 202		MICROBIAL BIOCHEMISTRY II	04	04
	I	Analytical Biochemistry	01	
	II	Enzymology	01	
	III	Cell Signaling in Prokaryotes	01	
	IV	Biodegradation of Xenobiotics	01	
RPSMIC 203		ENVIRONMENTAL MICROBIOLOGY	04	04
	I	Microbial Ecology	01	
	II	Techniques in Microbial Ecology	01	
	III	Soil, Marine & Agricultural Microbiology	01	
	IV	Environmental & natural resources management and safety standards	01	
RPSMIC 204		RESEARCH METHODOLOGY	04	04
	I	Research Fundamentals and Terminology	01	
	II	Defining Research problem and data Collection	01	
	III	Sampling and sampling distributions	01	
	IV	Data analysis and report writing	01	
RPSMIC 2P1, 2P2, 2P3, 2P4		Practicals based on above four courses	8	16

Course Code: RPSMIC 201

Course Title: Cell Biology

Academic year 2019-20

Learning Objectives:

The section on cell membrane and its function revises and further elaborates topics covered at UG level. Structure of cell membrane and transport mechanisms are topics that are added primarily for reiteration whereas the topics on protein sorting in endoplasmic reticulum and Golgi apparatus and solute transport across cell organelles and nucleus are for further elaboration. Since the UG curriculum only touches upon the role of mitochondrion and chloroplast, detailed explanations on the role of membrane in transporting electrons across an energy gradient and photophosphorylation and its regulation is included here. Likewise, functions of the cytoskeletal framework of the cell in motility and cell division are elaborated here to emphasize cell organization and functioning as a whole, while recent microscopic techniques to image cell, the structure of cell and also live imaging of cellular processes would help the student understand methodologies used to study cells.

The third unit aims to create an understanding of the mechanism and roles of phases of cell division, to understand the role of intracellular and extracellular control of cell cycle events and apoptosis in programmed cell death. It further stresses on the roles of adherence junctions, desmosomes, gap junctions, cell-cell adhesion and cadherins in cell adhesion. The curriculum introduces the learner to understand and the stages in the development of multicellular organisms like *Caenorhabditis elegans* and Drosophila and also to sex determination in mammals and sperm fertilization. The section on cell communication aims at elaborating on the role of signal molecules and signaling mechanisms in cells

Learning Outcomes:

A detailed account of components of the cell membrane and also their significance in several functions of the cell including electron transport and solute transport and cell signaling would make the student capable of investigating further on transport of specific components. They will also able to distinguish between different types of transporters, channels and pumps functioning in influx and efflux of solute. Understanding mechanisms of protein sorting, the mechanism of transportation of proteins into different cell organelles and nucleus would enable the student extrapolate to various branches of biology like, enzymology, immunology etc.

Understanding the structure and mechanism by which mitochondria produces ATP, and chloroplasts perform photosynthesis will help student gather overall information on cell energetics and also know how light reactions are integral part of energy generation in photosynthetic systems and therefore apply it to specific systems, while the section on cytoskeletal functioning will help the students appreciate how the cytoskeletal framework supports the cell structure and cell behavior in different environments

A thorough understanding of the mechanism of cell cycle, relationship of cell cycle and programmed cell death via intracellular and extracellular control mechanisms, the importance of cell junctions and cell adhesion, the role of signaling genes and regulatory proteins in the development of multicellular organisms, sex determination and cell communication will help in completing a strong base of cell biology for the learners such that it will ease their progression to research in biological sciences

Detailed syllabus

RPSMIC201: Cell Biology

UNIT	TITLE	Lectures
I	**Cell Structure & Cytoskeleton** 1.1 Techniques to study cell and cellular structure. 1.2 Cell membrane structure: Lipid bilayer, membrane proteins, Spectrins, Glycophorin, Multi pass membrane proteins Bacteriorhodopsin. 1.3 Cytoskeleton: Cytoskeletal filaments, Microtubules, Actin regulation, molecular motors, cell behaviour. 1.4 Cell Junctions and cell adhesion: Anchoring, adherence junctions, Desmosomes, Gap junctions, cell-cell adhesion, Cadherins	15
II	**Membrane Transport and Compartmentalization** 2.1 Membrane Transport (Revision): Principles of membrane transport, ion channels and electrical properties of membranes. a) Passive Diffusion, and Facilitated Diffusion, b) Ion channels – Ligand gated and voltage gated channels, c) Active transport – ion pumps (eg: Na^+-K^+ pump) 2.2 Intracellular Compartments and protein sorting: Compartmentalization of cells, transport of molecules between the nucleus and cytosol, peroxisomes, Endoplasmic reticulum, transport of proteins into mitochondria and chloroplasts 2.3 Intracellular vesicular traffic: Endocytosis, exocytosis, transport from the ER through the Golgi apparatus	15
III	**Cell cycle & Cell communication** 3.1 Mechanism of cell division: M-phase& Cytokinesis.	15

	3.2 Cell cycle and Programmed cell death: Control system, intracellular control of cell cycle events, Apoptosis, extracellular control of cell growth and apoptosis 3.3 Cell communication: Extracellular signal molecules, nitric oxide gas signal, classes of cell-surface receptor proteins 3.4 Signaling through enzyme linked cell surface receptors: Docking sites, Ras, MAP kinase, Pl-3kinase, TGF 3.5 Signaling in plants: Serine/ Threonine kinases, role of ethylene, Phytochromes	
IV	**Developmental Biology** i. Evo-Devo: The Study of Evolution and Development ii. The Process of Development in Animals iii. Meiosis- Oogenesis, spermatogenesis and fertilization iv. The Embryonic Cleavage Divisions and Blastula Formation v. Gastrulation and Morphogenesis vi. Genetic Analysis of Development in Model Organisms vii. Genetic Analysis of Development Pathways viii. Molecular Analysis of Genes Involved in Development ix. Maternal Gene Activity in Development x. Maternal-Effect Genes xi. Determination of the Dorsal-Ventral and Anterior-Posterior Axes in Drosophila Embryos xii. Zygotic Gene Activity in Development xiii. Specification of Cell Types xiv. Drosophila signalling genes, gradient of nuclear gene regulatory protein, Dpp and Sog setup, Neural development	**15**

References:

1. Molecular Biology of The Cell–Albert, Johnson, Lewis, Raff, Roberts and Walter.
2. Molecular Cell Biology. Lodish, Birk, and Zipursky. Freeman

3. The Structure and Dynamics of Cell Membrane. Lipowsky and Sackmann. Elsevier.
4. Cell Movements: from Molecules to Motility- Bray Garland Pub. NY.
5. Snustad &Simmons, “Principals of Genetics”, Third Edition, John Wiley & Sons Inc

PRACTICALS: RPSMIC2P1 (60 Contact Hrs).

1. Study of cell cytology using Phase contrast Microscopy-Demonstration
2. Study of Cell structure using Confocal Microscopy- Demonstration
3. Study of Cell structure using Fluorescence Microscopy- Demonstration
4. Isolation of Chloroplasts.
5. Isolation of Mitochondria from the cell.
6. Cultivation of macrophage cell lines and study of cell viability
7. Study of Mitosis.
8. Study of Meiosis
9. Estimation of NO (Nitric Oxide) produced by Macrophages.
10. Study of Cell membrane integrity using up take of neutral red.

Course Code: RPSMIC 202

Course Title: Microbial Biochemistry II

Academic year 2019-20

Learning Objectives:

This paper deals with Analytical biochemistry, Enzymology, signaling and stress and microbial degradation.

A microbiologist with research aptitude or one with good technical skills in QA/QC labs needs to have a thorough and sound background of basic principles of analytical chemistry. The objectives of this paper are to imbibe an understanding of basic analytical chemistry techniques for study and purification bioorganic molecules using techniques like chromatography. Further methods of analysis of proteins, carbohydrates, lipids and other organic compounds is included to acquaint the learner with principles of analytical techniques for estimation of biomolecules.

Enzymology is an integral part of biochemical studies. Hence, the curriculum in this section ensures that after a revision of concepts in basic enzymology like, enzyme terminologies and kinetics of enzyme catalyzed reactions, the learner studies enzyme inhibition with specific examples along with enzyme regulation with the help of examples of allosteric enzymes, multienzyme complexes and multifunctional enzymes. Further, to understand mechanisms of enzyme catalysis specific examples like serine proteases, ribonucleases, triose phosphate isomerase, lysozyme, lactate and alcohol dehydrogenases and catalytic antibodies are dealt within details.

Understanding signaling and sensing systems in bacteria is an upcoming area especially due to the developments in the field of Systems Biology. Responses of bacteria to stress or to changes in the environment of their niche have far reaching effects on the inhabited system. This section aims at introducing the learner to the two component signaling systems functioning in bacteria and bacterial responses to stress using specific examples. The paper also aims at briefing the learner about bacterial development and quorum sensing and its effect on virulence expression.

In today's world with increasing pollution bioremediation and biodegradation are gaining extensive attention as methods that would save the environment. With this view the last section of the paper deals with microbial degradation. The objectives of this section are to understand the biochemistry of degradation of aromatic compounds that are the most difficult for breakdown. Biotransformation of polyaromatic hydrocarbons and pesticide detoxification are dealt with in details with the aim of not only projecting the complexity of the reactions but also to imbibe on the minds of the students the importance of reducing their use.

Learning outcomes:

The students will be able to calculate molecular weight, purity, length and volume of organic compounds. On learning the principles of methods of enzyme extraction and purification students will be able to apply these methods for extraction of enzymes practically. They will also be aware of the principles and applications of GC-MS, X-ray diffraction and confocal microscopy for mass determination, structure determination and location of protein and of the methods of analysis of biomolecules.

With a sound background of Enzymology, students will able to explain the enzyme terminologies basic concepts of enzyme catalysis, allosteric enzymes and its regulation, regulation by covalent modification, multienzyme complexes and multifunctional enzymes. The students will also be able to differentiate between different methods of enzyme regulation by the understanding developed with the help of this learning.

Understanding mechanisms of bacterial stress responses, mechanisms of quorum sensing using different examples will enhance the analytical ability of the learners and also applicability of these responses to other stress conditions or survival mechanisms.

Students will be able to discuss the organisms, enzymes, and genes involved in microbial degradation of aromatic compounds. This will enhance their understanding about bioremediation strategies. They will also be able to explain the mechanism of biotransformation of aromatic compounds like Naphthalene, phenanthrene, anthracene, alicyclic and higher aliphatic hydrocarbons and biochemical mechanisms of pesticide detoxification. Overall this section will also make the students more conscious towards environmental problems and also trigger them to find viable solutions.

Detailed syllabus

RPSMIC202: Microbial Biochemistry II

Unit	Topic	Lectures
I	**Analytical Biochemistry** 1. Determination of molecular weights, purity, length and volume of organic compounds 2. Extraction, purification, application and analysis of proteins, carbohydrates and lipids. 3. General methods of extraction: salting out, use of organic solvents 4. Purification: chromatographic techniques 5. Mass determination: ultracentrifuge, GC-MS 6. Structure determination: X-ray diffraction 7. Location: Confocal spectroscopy 8. Methods of analysis: a) Proteins, b) carbohydrates c) lipids d) other organic compounds	**15**
II	**Enzymology** 2.1: Discovery of enzymes, enzyme terminology, basic aspects of chemical kinetics, kinetics of enzyme catalysed reactions, enzyme inhibition (reversible and irreversible), specific examples – effect of pH on enzyme activity (Fumarase), Enzyme action by X-ray crystallography, nerve gas and its significance, HIV enzyme inhibitors and drug design 2.2: Enzyme regulation: Phosphofructokinase as allosteric enzyme, general properties of allosteric enzymes, two themes of allosteric regulations, regulation by covalent modification, regulation by multienzyme complexes and multifunctional enzymes, specific example- the blood coagulation cascade (problem solving) 2.3: Mechanisms of enzyme catalysis: five themes that occur in discussing enzymatic reactions, detailed mechanisms of enzyme catalysis for example- serine proteases, ribonucleases, triose phosphate isomerase, lysozyme, lactate and alcohol dehydrogenases, catalytic antibodies	**15** **06** **05** **04**
III	**Cell Signaling in Prokaryotes** 3.1: Introduction to two-component signaling systems: a) Response by facultative anaerobes to anaerobiosis, nitrate and nitrite, nitrogen supply, inorganic phosphate supply	**06**

	b) Effect of oxygen and light on the expression of photosynthetic genes in purple photosynthetic bacteria, response to osmotic pressure and temperature, response to potassium ion and external osmolarity, response to carbon sources c) Bacterial response to environmental stress-heat-shock response, repairing damaged DNA, the SOS response, oxidative stress 3.2: Synthesis of virulence factors in response to temperature, pH, nutrient, osmolarity and quorum sensors, chemotaxis, photo responses, aero taxis 3.3: Bacterial development and quorum sensing: Myxobacteria, Caulobacter, bioluminescence, systems similar to Lux R/Lux I in non-luminescent bacteria, biofilms.	**04** **05**
IV	**Biodegradation of Xenobiotics** 1. Microbial Degradation of Polychlorophenols 2. Degradation of Chloro-organic Pollutants by White Rot Fungi 3. Bacterial Decolorization and Degradation of Azo Dyes 4. Bacterial Degradation of High Molecular Weight Polynuclear Aromatic Hydrocarbons 5. Microbial Degradation of PAHs: Organisms and Environmental Compartments 6. Biodegradation of Aromatic Pollutants by Ligninolytic Fungal Strains 7. Bacterial Degradation of Petroleum Hydrocarbons 8. Microbial Degradation of Plastics and Water-Soluble Polymers 9. Microbial Degradation of Alkanes	**15**

References:

1. Biochemistry 3rdedition, Mathew, Van Holde and Ahern, Pearson Education Principles of Biochemistry,
2. 4thedition, Zubay, Principles of Biochemistry
3. Principles of Biochemistry, Horton and Moran, Scrimgeour Pears Rawn
4. Principles of Biochemistry, 4th Edition Lehninger A.L., Cox and Nelson, CBS publishers and Distributors Pvt. Ltd. 1994
5. Biochemistry by Conn and Stumpf
6. The physiology and biochemistry of prokaryotes, White D., Oxford University Press, 2000
7. Biotechnology H.J. Rehmand G. Reed(ed.), Volume 6 a. Biotransformation's, Verlag and Chemie, 1984
8. Introduction to bacterial metabolism Doelle H.W., Academic Press, 1975
9. Microbial ecology, Atlas R M and Bartha, Addison Wesley Longman Inc. 1998
10. Microbial Degradation of Xenobiotics by Shree Nath Singh 2012 Springer.

PRACTICALS: RPSMIC2P2 (60 Contact Hrs)

1) Purification strategy
2) Aqueous two-phase partitioning
3) Isolation of Amylase from *Aspergillus spp.*
4) Purification of an extracellular enzyme (βamylase) by salting out and dialysis
5) Enzyme kinetics effect of enzyme concentration, substrate concentration, pH, temperature and inhibitors on enzyme activity,
6) Demonstration of proteolytic activity
7) Determination of glucose isomerase present intracellularly in *Bacillus sp.*
8) Adaptation of *E. coli* to anaerobiosis
9) Chemotaxis of *Pseudomonas*
10) Effect of temperature and water activity on swarming of *Proteus*
11) Different bacteriolytic response associated with addition of lysozyme and salt.
12) Microbial degradation of polycyclic aromatic hydrocarbons (PAHs)enrichment, isolation and screening of bacteria
13) Extraction of protein by precipitation with Acetone

Course Code: RPSMIC 203

Course Title: Environmental Microbiology

Academic year 2019-20

Learning Objectives:

Environment is the surrounding in which we live. It is very important to understand the components of environment along with the factors that affects the environmental system. One of the important factors that influences environment are microorganisms. Microorganisms due to their metabolism bring about interconversion of many elements in nature into different forms by changing their oxidation state. In this course students will get introduced to basic concepts of microbial ecology. They will get introduced to microbial diversity. Organisms that can grow under extreme conditions of environment like temperature, pressure, pH, radiations etc. are called as extremophiles. Proteins obtained from extremophiles have potential biotechnological applications. Thus, students should learn about different kinds of extremophiles and their applications. Study of microorganisms in environment involves various steps like sample collection, cultural and non-cultural methods. Students will be introduced to modern methods of studying environmental microorganisms like genomics, proteomics, immunological and nucleic acid-based methods. In order to understand microbes in environment, it is important to understand various habitats in the environment with respect to their composition and properties. Studying soil, marine and agricultural ecosystems will give the students an insight into the microcosmos. Role of microorganisms in maintaining a balance in nature is undisputed. Understanding these roles in interconversion of elements into various compounds through biogeochemical cycles is essential for a microbiologist. Microbiological analysis of food and water involves various processes like sampling, sample processing and methods of analysis. There are methods of analysis and standards established by various regulatory authorities for the microorganisms which students should know

Learning Outcomes:

Through this course, students will understand basic concepts of microbial ecology. They will realize and appreciate microbial diversity in environment and also know characteristics of various extremophiles. They will know the potential biotechnological applications of proteins from extremophiles. Students will understand techniques in microbial ecology with respect to sampling, sample processing and cultural methods. They will also know physiological methods of analysis of ecological samples. Students will realize the use of modern approaches of studying microbial ecology like genomics, proteomics, immunological and nucleic acid -based methods. Students will understand soil and marine ecosystems with respect to their structures and properties. Students will know agricultural microbiology and interactions between microorganisms and plant structures. Students will get an in depth understanding of role of microbes in biogeochemical cycles for various elements.

Detailed syllabus

RPSMIC203: Environmental Microbiology

UNIT	TITLE	Lectures
I	**Techniques in Microbial Ecology** 1.1 Revision of basic concepts: Microbial ecology: concepts, niche, habitat, ecosystem, Microbial diversity, interactions between microorganisms, ecological Succession Environmental sample collection and processing: Soils and Sediment, Water, Air 1.2: Techniques for microbial analysis: a) Cultural Methods, b) Physiological Methods: Measuring microbial activity in pure culture; Carbon respiration, Stable isotope probing, use of radioisotopes as tracers Adenylate energy charge, Enzyme assays c) Functional genomics, Metagenomics & proteomics-based approach d) Immunological methods e) Nucleic acid-based methods of analysis f) Recombinant DNA Techniques, RFLP, Denaturing /Temperature gradient, Plasmid analysis, Reporter genes. Rep PCR fingerprinting and microbial diversity 1.3: Molecular Techniques to Assess Microbial Community Structure, Function, and Dynamics in the Environment: culturable and unculturable bacteria.	15
II	**Study of Extremophiles & Marine Ecosystem:** 2.1 Marine microbiology: Marine and estuarine habitats. Characterization and stratification of the oceans Vertical and horizontal zones of marine habitats Marine microbes' characteristics, distribution, composition & activity. Marine pathogens 2.2 Extremophiles: Habitat, effect of extreme conditions on cellular components- membrane structure, nucleic acids and proteins, adaptation mechanism in microorganisms in diverse environments 2.3 Study of Thermophiles, Psychrophiles, halophiles, Piezophiles,	15

	Acidophiles, Alkaliphiles, Xerophiles, Radiation resistant organisms, Methanogens & their industrial applications 2.4 Biotechnological Applications of extreme proteins from the above groups 2.5 Mechanisms of metal resistance, Metal transformations, Microbial metal remediation 2.6-Geomicrobiology, Biofouling, biocorrosion, bioleaching.	
III	**Soil & Agricultural Microbiology** 3.1 Soil Microbiology: Litho ecosphere: Soil formation, Properties (physical and chemical) Soil communities. Link to microbial interactions. 3.2 Agricultural microbiology: Factors affecting microbial load of soils. Relationship between plants and microbe's rhizosphere, phyllosphere. Beneficial uses of microorganisms for plant growth and development, Interactions with aerial plant structures 3.3 Biofilms in plant-associated habitats: In the Phyllosphere (impact on survival and bacterial interactions, interaction of plants with epiphytic biofilms,), In the Rhizosphere (ubiquity and importance for rhizosphere bacteria, impact of rhizosphere biofilms on plant biology) 3.4 Biogeochemical cycles for Carbon Nitrogen and Oxygen. Degradation of complex polymers e.g. cellulose, lignin, lignocellulose.	**15**
IV	**Environmental & natural resources management and safety standards** 4.1 Environmental Impact Assessment and Sustainable Development. 4.2 Sewage & Sludge treatment and disposal methods. 4.3 Microbial contribution to green house gases, Combating Greenhouse effect using microbes. Concept of carbon credits 4.4 Solid waste management: Biodegradable waste from kitchen, abattoirs and agricultural fields and their recycling by aerobic composting or bio methanation. Non-biodegradable waste like plastics, glass metal scrap and building materials and plastic recycling, metal recycling. 4.5 Hazardous waste management: Hazardous waste from paint, pesticides and chemical industries and their composition, Probable means to reduce waste through Common Effluent Treatment Plants. 4.6 Biohazards: Introduction, levels of biohazards, Risk	**15**

	assessment, proper cleaning procedures Biomedical waste management. 4.7 Biosafety guidelines for GMOs and LMOs. Role of Institutional biosafety committee. RCGM, GEAC, etc. for GMO applications in food and agriculture. Environmental release of GMOs. Overview of national regulations and relevant international agreements. Ecolabelling, IS 22000, Generally Recognized as Safe (GRAS)	

References:

1. Brock Biology of microorganisms12th ed Madigan, Martinko, Dunlap, Clara, Pearson Intl Ed

2. R. M. Atlas and R. Bartha - 1998 - Microbial Ecology - Fundamentals and Applications. Addison Wesley Longman, Inc.

3. Microbial Diversity- Current Perspective and Potential Application--Johri and Satyanarayana

4. Methods in Microbiology Vol 35- Extremophiles (2006) Edited by Fred Rainey, Aharon Oren (Academic press)

5.R.M Maier, I. L. Pepper and C. P. Gerba 2010, Environmental Microbiology Academic Press

6.Rastogi &Sani, Microbes and Microbial Technology, 2011, pp 29-57, Molecular Techniques to Assess Microbial Community Structure, Function, and Dynamics in the Environment

7.A K Bej and M H Mahbubani, Applications of the polymerase chain reaction in environmental. Microbiology. Genome Res. 1992 1: 151-159

8. The Metagenomicsof soil byRolfDaniel,470/June2005/vol3, www.nature.com/reviews

9.Metagenomics: DNA sequencing of environmental samples, Susannah Green Tringe and Edward M. Rubin,806/November2005/Volume6

10.Marine Microbiology: Ecology and Applications. Colin Munn. Garland publishing. ISBN: 0815365179

11.Environmental Microbiology. Alan H. Varnam. Manson Publishing. 2000.

12.Agricultural Microbiology. G. Rangaswami, D. J. Bagyaraj, D.G. Bagyaraj. PHI Learning Pvt. Ltd., 2004

13.Microbes and Microbial Technology: Agricultural and Environmental Applications. Iqbal Ahmad, Farah Ahmad, John Pichtel. Springer, 2011.

14. Water and Wastewater analysis Volume 1. Handbook of methods in environmental studies. S. K. Maiti. ABD Publishers 2004

15. Soil analysis Volume 2. Handbook of methods in environmental studies. S.K. Maiti. ABD Publishers 2004

16. Environmental chemistry B. K. Sharma

17. Resource ecology. S. K. Agarwal

18. Environmental management. H. V. Jadhav, Vipul Prakashan, 2002
19. Environmental management. R.K. Jain and others
20. Modern trends in ecology and environment. R. S. Ambasht
21. Industrial hygiene and safety. M. H. Fulekar

PRACTICALS: RPSMIC2P3 (60 Contact Hrs)

1. Enrichment & isolation of thermophiles from hot springs/compost heaps & extraction of thermophilic enzymes & determination of its specific activity.
2. Soil analysis -Physical
    i. Particle size analysis
    ii. Water retention capacity
    iii. Bulk density and tap density
3. Soil analysis- Chemical
    i. Nitrogen
    ii. Phosphorus
    iii. Chloride
    iv. organic matter
    v. calcium carbonate content
4. Soil analysis-Microbial
    i. Microbial load
    ii. presence of cellulose, lignin & xylan degraders
    iii. Detection of inorganic metabolism
    iv. Detection of siderophore producing bactera
    v. Isolation of iron bacteria
    vi. Isolation of Plant Growth Promoting bacteria from Rhizosphere
    vii. Dehydrogenase Activity of Soils
    viii. Determination of nitrogen mineralization and nitrification in soils and the influence of chemicals on these processes
5. Visit to CETP

Course Code: RPSMIC 204

Course Title: Research Methodology

Academic year 2019-20

Learning Objectives:

Research is an integral part of basic sciences and this course prepares the learner to all the concepts associated with 'Research Methodology', viz; Research hypothesis and its formulation, methods of data collection, process of sampling, sampling designs, statistical significance of the selected design, processing the collected data, use of different software for data processing and interpreting the results. Representing the research in an effective way is a must. The course therefore further discusses the types of research report and the guidelines for writing the same. The overall objective of this course is to prepare the student for a dissertation project that will be presented as a poster and submitted as a research thesis.

Learning Outcomes:

The learner will be able to formulate a hypothesis, differentiate between laws, theory and postulates, design a research project, execute the experiments including appropriate calibrations and controls, with a carefully written record of the outcomes; use different methods of data collection and process the collected data by conventional and modern methods. They will understand the significance of studying different variables in a research study and its effects on the results obtained and the importance of the statistical analysis of the results. At the end the students will also be aware of different methodologies by which research can be effectively communicated.

Detailed syllabus

RPSMIC204: Research Methodology

UNIT	TITLE	Lectures
	Tools and Techniques: Research Methodology	**60**
I	**Research Fundamentals and Terminology**	
	1.1 Philosophy of natural science	**01**
	1.2. Meaning and Objective of research, features of a good research study, scientific method	**04**
	1.3. Research methodology: Strategies planning and analysis	**02**
	1.4: Study designs and variations (only definitions): basic, applied, historical, exploratory, experimental, ex-post-facto, case study, diagnostic research, crossover design, case control design, cohort study design, multifactorial design	**08**
II	**Defining Research problem and data Collection**	
	2.1 Literature search and personal reference database	**01**
	2.2 Hypothesis, theory and scientific law: development, structure, conditions, sources, formulation, explanation of hypothesis; structure, identification, elements, classification, functions of theory; scientific laws and principles	**05**
	2.3 Methods and techniques of data collection: types of data, methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case/ pilot study, methods), methods of secondary data collection (internal/external), schedule method	**09**
III	**Sampling and sampling distributions**	
	3.1 Sampling frame, importance of probability sampling, simple random sampling, systematic sampling, stratified random sampling, cluster sampling, problems due to unintended sampling, ecological and statistical population in the laboratory	**08**
	3.2 Variables: nominal, ordinal, discontinuous, continuous, derived	**02**
	3.3 Statistical Issues-Effect measure, hypothesis testing and confidence interval, Comparing two proportions, Measures of association in 2 x 2 tables, Normal distribution, Comparison of means, Non-parametric methods, Regression analysis	**05**

IV	**Data analysis and report writing** 4.1 Experimental data collection and data processing: Processing operations, problems in processing, elements of analysis in data processing, software for data processing. 4.2 Report writing and presentation: types of research reports, guidelines for writing a report, report format, appendices, Miscellaneous information, poster and oral presentations 4.3 Scientific Communication 4.4 Guide to grant application	**03** **08** **02** **02**

References:

1. Kothari, C.R,1985, Research Methodology- Methods and Techniques, New Delhi, Wiley Eastern Limited.
2. Das, S.K, 1986, An Introduction to Research, Kolkata, Mukherjee and Company Pvt. Ltd.
3. Misra R.P., 1989, Research Methodology: A Handbook, New Delhi, Concept Publishing Company
4. Kumar, R., 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd.ed.), Singapore, Pearson Education.
5. Bhattacharya, D.K., 2006, Research Methodology (2nd.ed.), New Delhi, Excel Books.
6. Panneerselvam R.,2012, Research Methodology, New Delhi, PHI Learning Pvt. Ltd.
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8. Rosner B.A., 2011, Fundamentals of Biostatistics, Cengage Learning
9. Katz J.M., 2009, From Research to Manuscript: A guide to scientific writing, USA, Springer Science
10. Saravanavel, P. 1990. Research methodology. Allahabad, Kitab Mahal
11. Petter Laake, Haakon Breien Benestad and Bjørn Reino Olsen 2007 Research methodology in the medical and biological sciences. Academic Press

Practicals (Semester II)

1. Research Project Proposal

AC/II(18-19).2.RPS9

S.P. Mandali's

Ramnarain Ruia Autonomous College

Syllabus for MSc Part II

Program: MSc

Course: Microbiology (RPSMIC)

(Credit Based Semester and Grading System proposed for the academic year 2019–2020)

SEMESTER III

Course Code	Unit	TITLE	Credits	L / Week
		Immunology and Clinical Research	04	04
RPSMIC 301	I	Immune System and Health : Part I	01	
	II	Recent advances in Immunology :Immunobiology	01	
	III	Recent advances in immune tolerance	01	
	IV	Clinical Research and Clinical Microbiology	01	
		Food Microbiology	04	04
RPSMIC 302	I	Microbes In Food	01	
	II	Uses Of Microbes In Food	01	
	III	Control Of Microbes In Food	01	
	IV	Microbial Detection And Food Safety	01	
		Advances In Biotechnology	04	04
RPSMIC 303	I	Plant And Agricultural Biotechnology	01	
	II	Animal Biotechnology	01	
	III	Nano Biotechnology	01	
	IV	Medical Biotechnology	01	
		Applied and Environmental Microbiology	04	04
RPSMIC 304	I	Microbial Diversity	01	
	II	Techniques In Microbial Ecology	01	
	III	Soil, Marine & Agricultural Microbiology	01	
	IV	Advanced Food & Water Microbiology	01	
RPSMIC 3P1, 3P2, 3P3, 3P4	Practicals based on above four courses		8	16

SEMESTER IV

Course Code	Unit	TITLE	Credits	L / Week
		Medical Microbiology and Epidemiology	04	04
RPSMIC 401	I	Study of Infections – I	01	
	II	Study of Infections- II	01	
	III	Role of Biofilms in diseases	01	
	IV	Epidemiology and Microbiome studies	01	
		Pharmaceutical Microbiology	04	04
RPSMIC 402	I	Principles And Applications Of GMP In Pharmaceuticals And Cosmetics	01	
	II	Quality Management And Regulatory Aspects	01	
	III	Analytical Aspects of Cosmetic Products	01	
	IV	Drug Discovery	01	
		Advances in Biotechnology	04	04
RPSMIC 403	I	Pharmaceutical Biotechnology	01	
	II	IPR and ethics in Biotechnology	01	
	III	Environmental & natural resources management and safety standards	01	
	IV	Advances in Molecular Biotechnology	01	
RPSMIC 404		INTERNSHIP	04	04
RPSMIC 4P1, 4P2, 4P3, 4P4		Practicals based on above four courses	10	16

Course Code: RPSMIC 301

Course Title: Immunology and Clinical Research

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 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. Immune responses to viral, bacterial diseases. 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 mechanisms of immune tolerance. Also cancer immunology will allow students to gain insights into interaction between immune system and cancer.

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
- Understand immune response developed against viral and bacterial infections.
- Understand molecular basis of generating immunoglobulin diversity
- Discuss various types of immune tolerances
- Understanding mechanisms to generate immune tolerance
- Understand various aspects of clinical research

Detail Syllabus

Course Code	Unit	Topics	Credits	Lectures
RPSMIC 301		**Immunology and Clinical Research**	**04**	**60**
	I	Immune system and health part I; Immune response to infectious diseases:-- a) Immune response to Prions, b) Immune response to viral infections- HIV/AIDS-HIV and the immune system-Influenza-Avian H5N1. c) Immune response to Bacterial diseases- Difference in the Immune response to extracellular andintracellular bacteria : Diphtheria, Tuberculosis d) Microbial ways of evading immune system.	01	**15**
	II	Recent advances in immunology: Immuno biology 2.1Recent advances in Innate immunity including receptors involved and signaling system. Physiological & immunological barriers. 2.2 the cellular players :Phagocytic cells, Lymphocytic cells, DCs. 2.3 The innate immune response: Inflammation, Acute Phase Reaction 2.4 Molecular basis of diversity of immunoglobulin molecules. 2.5 Multigene organization of Ig genes. 2.6 Variable-Region Gene Rearrangements. 2.7 Mechanism of Variable-Region DNA Rearrangements. 2.8 Generation of antibody diversity. 2.9 Manipulations of the immune response	01	**15**
	III	3.1 Recent advances in immune tolerance a) -Central Tolerance b) -Peripheral Tolerance c) -Tolerance Induction d) -T-cell Tolerance e) -B-cell Tolerance f) -Incomplete Tolerance g) -Duration of Tolerance 3.2 Recent advances in autoimmunity a) -Interplaying Factors b) -Triggering Factors c) -Mechanisms of Damage d) -Organ Specific Autoimmune Diseases e) -Systemic Autoimmune Diseases f) -Animal Models for Autoimmune Diseases g) -Proposed Mechanisms for Induction of Autoimmunity h) -Treatment of Autoimmune Diseases 3.3 Cancer immunology. a) -Cancer:Origin & Terminology b) -Malignant Transformation of Cells c) -Oncogenes & Cancer Induction d) -Tumors of the Immune System 37 e) -Tumor Antigens f) -Tumor Evasion of the Immune System g) -Cancer Immunotherapy	01	**15**

	IV	Clinical Research and Clinical Microbiology 4.1 Introduction to Clinical Research. a. Good Clinical practice Guidelines b. Ethical aspects of Clinical Research c. Regulatory Requirements in clinical research d. Clinical Research Methodologies and Management e. Clinical Data Management and Statistics in Clinical Research 4.2 a. Revision of Antimicrobial Susceptibility Testing b. Test for determination of bactericidal activity c. Testing of antibiotic combinations d. Test of therapeutic efficacy and avoidance of toxicity	01	**08** **07**

References:

RPSMIC 301

1. Clinics in laboratory medicine, Emerging Infections and their causative agents. September 2004 vol. 24 no. 3
2. Immunology – Essential and Fundamental, Sulabha Pathak and Urmi Palan. 3rd edition Capital publishing company.
3. Immunology- Kuby 6th edition W. H. Freeman and company- New York.
4. The Elements of immunology- Fahim Halim Khan- Pearson Education.
5. Immunology an introduction- 4th edition- Ian R. Tizard-Thomson.
6. Immunobiology –the immune system in health and disease 6th ed.- Janeway.Travers.GS
7. Color Atlas and Textbook of Diagnostic Microbiology By Konaman *et al* 5th Edition Volume 2 Lipincott

Course Code: RPSMIC 302

Course Title: Food Microbiology

Academic year 2019-20

Learning Objectives:

This course will give the learners a thorough background on food microbiology. The microbes associated with our food tend to have a bad name – food poisoning is often in the news. Yet while some make us ill and others can be a nuisance by spoiling our food, without the activities of microbes there would no bread, cheese, beer or chocolate. The course begins with the importance and sources of microorganism in food.It then moves on to give an overview of different factors that influence the growth of different organisms in food. Fermented foods are an integral part of diet in all civilizations. Understanding the roles of different microorganisms in cheese, meat, vegetables, cereal fermented foods is therefore essential for a microbiologist. Since food is a highly nutritious medium for the growth of microorganisms, excessive growth of microorganisms will lead to spoiling of food. Students will be then given a thorough insight into different physical, chemical methods for preservation as well newer techniques of food preservation. Food borne infections and food poisoning are an inseparable from Food Microbiology. Different quantitative,qualitative, microbiological and rapid methods for detecting the organisms in foods and also quality control and good lab manufacturing practice and HACCP to ensure food safety at different levels of processing and production of foods.is included in this course to equip the learner with skills required by the industry and make them job ready.

Learning outcomes:

Students will realise the importance of microorganisms in foods and how the microbiological quality of food is of great significance.Students will appreciate the roles of good microorganism in giving them fermented foods with the desirable texture, taste and appearance. Students can also try making those foods at home keeping in mind all the conditions required for a well-directed fermentation, e.gwine ,cheese , idli. Exposure to preservation techniques will help to understand the ways to increase the shelf life of the food while still maintaining its quality. It will also make them aware how the foods are wasted or can become toxic for us if not stored properly at a desirable condition.Students will be able to enumerate and detect different pathogenic microorganism by applying the different method which they have studied. Students will learn different ways to ensure the safety of food by keeping the good manufacturing practices in mind. HAACP will help them understand the different points of contamination during production and processing of foods and the measures to be taken to avoid it. A systematic and in depth study of this course will make the learners entry into food industry much easier and will also make it easier for them to adopt to working condition in food microbiological laboratory.

Detail Syllabus

Course Code	Unit	Topics	Credits	Lectures
RPSMIC 302		**Food Microbiology**	**04**	**60**
RPSMIC 302	I	**Microbes in foods** 1.1 Importance of microbes in food 1.2 Sources of microbes in food 1.3 Normal microbiological quality of food 1.4 Factors influencing microbial growth in food	01	**02** **03** **04** **06**
	II	**Uses of microbes in food** 2.1 Microbial stress response in food 2.2 Starter cultures 2.3 Microbiology of fermented foods General method of production 2.3.a Cheese – Swiss and Blue cheese 2.3.b.Fermented meat product – Sausage 2.3.c Fermented vegetable products – Pickles, soy product Sauerkraut 2.3.d Fermented cereal product - Bread and Idli	01	**04** **02** **09**
	III	**Control of microbes in food** 3.1 Control of access: Control by physical removal, heat, low temperature, reduced aw, low pH and organic acids, modified atmosphere, antimicrobial preservatives, irradiation 3.2 Novel emerging techniques of food preservation 3.3 Control by combination of methods (Hurdle concept)	01	**05** **04** **06**
	IV	**Microbial Detection and Food Safety** 4.1.a. Conventional Methods. Methods used, Sampling for microbial analysis 4.1.b.Quantitative microbial enumeration in food 4.1.c.Qualitative methods of microbial detection 4.1.d.Bacterial Toxins 4.1.e.Rapid methods 4.1.f.Biosensors 4.2 Controlling the Microbiological Quality of food. 4.2.a Quality and Criteria 4.2.b.Sampling Schemes 4.2.c.QC using microbiological control	01	**06** **09**

		4.2.d.Control at source 4.2.e.Codes of GMP 4.2.f. HACCP 4.2.g. Laboratory Accreditation		

References:

RPSMIC 302

1. Bibek Ray and Arun Bhunia(2008) Fundamental Food Microbiology 4th Ed. CRC Press.

2. Srilakshami B (2010) Food Science. 5th Ed. New Age International Publishers.

3. James Jay , M Loessner and D Golden (2005) Modern Food Microbiology 7th Ed.

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5. J Maud Kordylas(1991) Processing and Preservation of tropical and subtropical foods. ELBS Macmillan

6.Gerald Reed (2004) Prescott and Dunn's Industrial Microbiology 4th Ed. CBS Publishers.

7.N Shakuntala Manay and Shadaksharaswamy M (1985) Foods Facts and Principles. New Age International

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9.Aylward F (2001) Food Technology Processing and Laboratory Control. Agrobios (India)

Course Code: RPSMIC 303

Course Title: Advances in Biotechnology

Academic year 2019-20

Learning Objectives:

Biotechnological advancement is important for making use of principles of biology for human benefit. Biotechnology involves cultivation and manipulation of plant and animal cell under in vitro conditions. Plants are cultivated under laboratory conditions for the purpose of conservation, to get virus free plants, to be used for production of certain biopharmaceuticals on large scale. Studying the principles and practices of plant tissue culture will enable students to understand all these aspects. Animal cells are also cultivated in vitro for various purposes like cultivation of virus for research studies and vaccine preparation, evaluation of drugs on cells, production of pharmaceutical products like monoclonal antibodies. Hence in this course, basics of animal cell culture which includes terminology, media used for cell culture, types of cell cultures has been included. Since the learner needs to widen his knowledge base in techniques used in biotechnology, development of transgenic animals is discussed in details here. Nanotechnology is an emerging field in science and truly an interdisciplinary field bringing together physics, chemistry, biology and engineering fields. Students will be introduced to terminology in nanobiotechnology alongwith principle and methods of synthesis of nanomaterials and their applications. Medical biotechnology is again an allied field of biotechnology which deals with techniques involving clinical significance. Diagnosis of various genetic disorders, concept, methods and applications of gene therapy is introduced to equip the learner in this allied field. In this course students will get introduced to modern pharmaceutical concepts like pharmacogenomics, pharmacokinetics. Topics of social interest like sex determination, human cloning are also introduced.

Learning Objectives:

Students will understand basics of plant tissue culture with respect to terminologies and techniques involved. Students will know production of secondary metabolites using plant tissue culture. Students will understand genetic engineering involved in plant biotechnology. Students will realise use of plant cells for production of secondary metabolites. Students will understand concepts associated with animal tissue culture. Students will understand the techniques involved in development of transgenic animals. Students will be introduced to the emerging field of nanobiotechnology. They will understand the synthesis of nanomaterials and their applications in the field of biology and medicines. Students will appreciate the technological advances in the field of nanobiotechnology. Students will know genetic disorders and should understand their diagnosis at pre-implantation and pre-natal stage. Students will be sensitized to the importance of genetic counselling in the process of diagnosis and treatment of genetic disorders. Students will understand the concept of gene therapy. They will also learn the meaning, applications and significance in the modern scenario of terms like pharmacogenetics, toxicogenomics, tissue engineering and biomolecular engineering.

Detail Syllabus

Course Code	Unit	Topics	Credits	Lectures
RPSMIC 303		**Advances in Biotechnology**	**04**	**60**
	I	**Plant and Agricultural Biotechnology** 1.1 Plant Tissue Culture for crop improvement--Initiation and maintenance of Callus and Suspension culture, Direct and Indirect Organogenesis, Micropropagation, Artificial seeds, Anther culture and dihaploids, Protoplast isolation culture and fusion, Production of haploids, Somaclonal variations, Germplasm conservation, Somatic hybrids, Cybrids. 1.2 Production of secondary metabolites from plant cell cultures, Technology of plant cell culture for production of chemicals, Bioreactor systems and models for mass cultivation of plant cells. 1.3 Plant Transformation Technology – Agrobacterium mediated gene transfer, Agrobacterium based vectors, viral vectors, Direct gene transfer methods, chemical methods, electroporation, microinjection, particle bombardment, Molecular breeding, plant selectable markers, Reporter genes, Positive selection, Selectable marker elimination, Transgene silencing, Strategies to avoid transgene silencing. 1.4 Plant Genetic Engineering for Productivity and Performance— Biotic Stress Tolerance- Herbicide resistance, Glyphosate, Insect Resistance, Bt toxin, Disease Resistance, Virus resistance Abiotic Stress Tolerance-- Drought, Flooding, Salt and temperature. By manipulation of—Photosynthesis, Nitrogen fixation, Nutrient uptake efficiency For Quality Improvement-Protein, Lipids, carbohydrates, vitamins and minerals. Biosafety concerns of transgenic plants 1.5 Plants as bioreactors	01	**05** **04** **02** **03** **01**

	II	**Animal Biotechnology** 2.1Animal Tissue Culture: Primary culture, Organ culture, Embryo Culture, Established Cell lines 2.2 Scale up, Cryopreservation, Culture Collections 2.3 Risks and Safety, Bioethics. 2.4 Stem Cell Technology, Cloning techniques Applications. 2.5 Transgenics and knockouts: Transgenic cattle, Transgenic birds, Transgenic fish 2.6 Applications: Transgenic mice: i) Retroviral method ii) DNA microinjection method iii) Engineered Embryonic Stem cell method	01	**03** **02** **01** **02** **04** **03**
	III	**Nanobiotechnology** 3.1 Nanoscale systems, nanoparticles, nanowires,thin films and multilayers; Properties of nanomaterials. 3.2 Synthesis of nanostuctures - physical, chemical and biological,microbiological methods a. Biomolecules as nanostructures. b.Nanoparticular carrier systems, Micro and Nanofluidics. c. Applications: Biosensors, drug and gene delivery systems, chip technologies, nano imaging, Nanomedicine and Cancer diagnostics and treatment.	01	**07** **08**
	IV	**Medical Biotechnology** 4.1 Genetic Testing of diseases and disorders, Cancer genetics., Immunogenetics; prenatal diagnosis-chorionic villus sampling, amniocentesis, Pre-implantation diagnosis., Genetic counselling. 4.2 Gene therapy-concept, vectors, gene targeting and tissue-specific expression, Anti- sense Technology 4.3 Introduction to pharmacogenomics, Pharmacogenetics and toxicogenomics	01	**04** **05** **02**

		4.4Social- genetic discrimination: insurance and employment, human cloning, foeticide, Sex determination 4.5 Tissue Engineering, Methods of Synthesis, Biomolecular Engineering		**02** **02**

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2.Introduction to Plant Biotechnology(3rd Edtn), H.S. Chawla

3.Roberta Smith, Plant Tissue Culture: Techniques and Experiments,2nd Edtn,Academic Press,2000

4.H.K.Das(ed),Textbook of Biotechnology,Wiley India,2004

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6.B.B.Buchanan, W.Gruissen and R.L.Jones(eds), Biochemistry and Molecular Biology of Plants,American Society of Plant Biology,Rockville,USA,2000.

7. Plant Biotechnology and Agriculture:Prospects for the 21st Century, Arie altman ,Paul Michael Hasegawa,

8.Plant Biotechnology and Genetics:Principles, Techniques & Applications, Stewart, C.Neal,June 2008,John Wiley &Son

9.Animal Cell Culture by IanFreshney

10.Basic Cell Culture. Ed.J.M.Davis 2nd.Ed 2007. Oxford press

11.Animal Cell Culture Sudha Gangal

12.Principles of biotechnology and applications-Glick and Pasternack

13.Nanobiotechnology by David Goodsell. John Wiley

14.Handbook of Nanostructured biomaterials and their applications in nanobiotechnology by Nalwa HS 2005. American scientific publishers

15.Nanobiotechnology by Niemeyer CM & Mirkin CA 2005 .Wiley Interscience

16. Jogdand S. N., Medical Biotechnology, Himalaya Publishing House, Mumbai, (2008)

17.Judit Pongracz, Mary Keen, Medical Biotechnology, Churchill Livingstone, Elsevier (2009)

18. Pratibha Nallari & V. Venugopal Rao, Medical Biotechnology, Oxford University Press, India (2010)

Course Code: RPSMIC 304

Course Title: APPLIED AND ENVIRONMENTAL MICROBIOLOGY

Academic year 2019-20

Learning Objectives:

Environment is the surrounding in which we live. It is very important to understand the components of environment along with the factors that affects the environmental system. One of the important factors that influences environment are microorganisms. Microorganisms due to their metabolism bring about interconversion of many elements in nature into different forms by changing their oxidation state. In this course students will get introduced to basic concepts of microbial ecology. They will get introduced to microbial diversity. Organisms that can grow under extreme conditions of environment like temperature, pressure, pH, radiations etc. are called as extremophiles. Proteins obtained from extremophiles have potential biotechnological applications. Thus students should learn about different kinds of extremophiles and their applications. Study of microorganisms in environment involves various steps like sample collection, cultural and non cultural methods. Students will be introduced to modern methods of studying environmental microorganisms like genomics, proteomics, immunological and nucleic acid based methods. In order to understand microbes in environment, it is important to understand various habitats in the environment with respect to their composition and properties. Studying soil, marine and agricultural ecosystems will give the students an insight into the microcosmos. Role of microorganisms in maintaining a balance in nature is undisputed. Understanding these roles in interconversion of elements into various compounds through biogeochemical cycles is essential for a microbiologist. Microbiological analysis of food and water involves various processes like sampling, sample processing and methods of analysis. There are methods of analysis and standards established by various regulatory authorities for the microorganisms which students should know. Students should know use of biosensors for rapid toxicological and microbiological analysis of food. A very new branch in which microbiologists can play a significant role is the branch of nutraceuticals. The learner is also introduced to this branch in this course.

Learning outcomes:

Through this course, students will understand basic concepts of microbial ecology. They will realise and appreciate microbial diversity in environment and also know characteristics of various extremophiles. They will know the potential biotechnological applications of proteins from extremophiles. Students will understand techniques in microbial ecology with respect to sampling, sample processing and cultural methods. They will also know physiological methods of analysis of ecological samples. Students will realise the use of modern approaches of studying microbial ecology like genomics, proteomics, immunological and nucleic acid -based methods. Students will understand soil and marine ecosystems with respect to their structures and properties. Students will know agricultural microbiology and interactions between microorganisms and plant structures. Students will get an in depth understanding of role of microbes in biogeochemical cycles for various elements. The background knowledge of the learner about

sampling and sample processing approaches for food and water samples, standards used for analysis of food and water laid by regulatory authorities will strengthen his/her knowledge base. Exposure to modern methods of food analysis like use of biosensors, and to nutraceuticals as a class of compounds used for nutritional and pharmaceutical purposes, will trigger the innovative minds; while knowledge on microbiological analysis methods and regulations for drinking water will strengthen skills of the job seekers

Detail Syllabus

Course Code	Unit	Topics	Credits	Lectures
RPSMIC 304		**APPLIED AND ENVIRONMENTAL MICROBIOLOGY**		
	I	**Microbial Diversity** 1.1 Microbial ecology: concepts, niche, habitat, ecosystem. 1.2 Introduction to microbial diversity: Types of microorganisms- bacteria, Archaebacteria, Eucarya interactions between microorganisms , ecological Succession 1.3 Extremophiles: Habitat, effect of extreme conditions on cellular components- membrane structure, nucleic acids and proteins, adaptation mechanism in microorganisms in diverse environments 1.4 Study of Thermophiles, Psychrophiles, halophiles, Piezophiles, Acidophiles, Alkaliphiles, Xerophiles, Radiation resistant organisms, Methanogens. 1.5 Biotechnological Applications of extreme proteins from the above groups Geomicrobiology: Biofouling, biocorrosion, bioleaching.	01	**02** **04** **04** **03** **02**
	II	**Techniques in Microbial Ecology** 2.1: Environmental sample collection and processing.: Soils and Sediment, Water, Air, Detection of Micro organisms on fomites 2.2: Cultural Methods:Cultural methods for isolation & enumeration of Bacteria 2.3: Physiological Methods:Measuring microbial activity in pure culture; Carbon respiration, Stable isotope probing, Use of radioisotopes as tracers Adenylate energy charge, Enzyme assays, 2.4 Functional genomics &proteomics based approach	01	**02** **02** **03** **01**

		2.5:Immunological methods: Immunoassays. 2.6 Nucleic acid based methods of analysis:Obtaining Nucleic acids from Environment, Use of Gene probes, PCR, 2.7 Recombinant DNA Techniques, RFLP, Denaturing /Temperature gradient, Plasmid analysis, Reporter genes. Rep PCR fingerprinting and microbial diversity 2.8 Molecular Techniques to Assess Microbial Community Structure, Function, and Dynamics in the Environment: culturable and unculturable bacteria		**01** **02** **02** **02**
	III	**Soil, Marine & Agricultural Microbiology** 3.1 Soil Microbiology: The litho ecosphere: Soil formation, Properties (physical and chemical) Soil communities. Link to microbial interactions. Soil sampling for surface, subsurface soils .Processing and storage of samples. 3.2 Marine microbiology: Marine and estuarine habitats. Characterization and stratification of the oceans Vertical and horizontal zones of marine habitats Marine microbes characteristics, distribution, composition & activity.		**04** **04**
		3.3 Agricultural microbiology: Factors affecting microbial load of soils. Relationship between plants and microbes rhizosphere, phyllosphere. Beneficial uses of microorganisms for plant growth and development, Interactions with aerial plant structures. 3.4 Microbial contribution to animal nutrition Special reference to Rumen flora 3.5: Biogeochemical cycles for Carbon Nitrogen and Oxygen. Degradation of recalcitrant polymers and xenobiotics eg cellulose, lignin .lignocellulose. Combating Greenhouse effect using microbes. Concept of carbon credits	01	**03** **02** **02**

	IV	**Advanced Food & Water Microbiology** 4.1 Use of enzymatic/ thermal techniques for food analysis 4.2 Food additives and ingredients :Food additives-definitions, classification and functions, (Preservatives, antioxidants, colors, emulsifiers, natural and microbial flavors) 4.3 Toxicological evaluation of food additives. 4.4 Applications of fibres from food sources, microbial fructooligosaccharides. 4.5 Nutraceuticals and health foods: Introduction to nutraceuticals: definitions, basis of claims for a compound as a nutraceutical, regulatory issues for nutraceuticals .Microbes and production of nutraceuticals like lycopene, isoflavonoids, prebiotics and probiotics, glucosamine, phytosterols.Formulation of functional foods containing nutraceuticals – stability and analytical issues, labelling issues. 4.6 Drinking water risk assessment & its safety: Bottled water–legislation: Types of bottled water.BIS Regulations regarding the production of bottled waters wrt final quality of the product. Potential chemical and microbiological hazards in the bottles depending on the type of water, the type of bottle and the bottling procedure. The application of HACCP in the bottling plants: Water Quality attained from point of use water purifier units , Types of water purifiers.: Microbiological specifications and methods used certify water purifiers International standards regulating quality of water purifiers .	01	**02** **03** **01** **01** **04** **04**

References:

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3. Microbial Diversity- Current Perspective and Potential Application--Johri and Satyanarayana

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19.Macleod AJ. 1973. Instrumental Methods of Food Analysis. ElekSci.Marcel Dekker

20.Nielsen S. (Eds.). 1994. Introduction to Chemical Analysis of Foods. Jones & Bartlett

21. Branen AL, Davidson PM & Salminen S. 2001. Food Additives. 2nd Ed. Marcel Dekker.

22. Gerorge AB. 2004. Fenaroli's Handbook of Flavor Ingredients. 5th Ed. CRC Press.

23. Madhavi DL, Deshpande SS & Salunkhe DK. 1996. Food Antioxidants: Technological, Toxicological and Health Perspective. Marcel Dekker.

24. Stephen AM. (Ed.). 2006. Food Polysaccharides and Their Applications. Marcel Dekker.Brigelius-Flohé, J & Joost HG. 2006. Nutritional Genomics: Impact on Health and Disease. Wiley VCH.

25. Gibson GR & William CM. 2000. Functional Foods - Concept to Product.

26. Losso JN. 2007. Angi-angiogenic Functional and Medicinal Foods. CRC Press.

27. Manson P.2001. Dietary Supplements. 2nd Ed. Pharmaceutical Press.

28. Shi J. (Ed.). 2006. Functional Food Ingredients and Nutraceuticals: Processing Technologies. CRC Press.

PRACTICALS: RPSMIC 3P1 (60 Contact Hrs)

1.Study of virulence factors-Phagocytosis & Phagocytic index

2. Collection of human blood & separation of mononuclear cells by ficoll hypaque density gradient centrifugation,

3. Counting of viable cells by trypan blue.

4. Checkerboard assay

5. Dissertation

PRACTICALS: RPSMIC 3P2 (60 Contact Hrs)

1. Microbiological study of fermented foods (Idli batter and sauerkraut)

2.Microbiological load in carrot and apple juice, salad, mayonnaise

3. Quality Assessment and Analysis of food

i) Milk (Raw and Packed)

ii) Ice cream

iii) Yoghurt

iv) Seafood

4. Dissertation

PRACTICALS: RPSMIC 3P3 (60 Contact Hrs)

1. Preparation of Nanosilver By Wet reduction Method(Chemical),using Neem Extract (plants) & fungi (Microbiological)

2. Characterization of Nanosilver by UV spectrometry and microscopic methods

3. Antimicrobial effect of Ionic silver and Nanosilver prepared by above methods.

4. Study of Nanosilver coated Gauze/textiles for antimicrobial effect on different bacteria

5. Dissertation

PRACTICALS: RPSMIC 3P4 (60 Contact Hrs)

1. Enrichment & isolation of thermophiles from hot springs/compost heaps & extraction of thermophilic enzymes & determination of its specific activity..

2. Assessment of point of use water purifiers (Zero B) for removal of bacteria.

3.Soil analysis-comparison of arid and fertile soil on the bases of

i) presence of cellulose, lignin & xylan degraders

ii) levels of organic matter

4. Dissertation

Course Code: RPSMIC 401

Course Title: Medical Microbiology and Epidemiology

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:

- 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
- Understand nature of biofilms and its association with human diseases
- Understand methods of eradication of biofilms
- Understand definitions associated with epidemiology
- Understand the concept of microbiome. Know the positive effects of microbiota on human health

Detail Syllabus

Course Code	Unit	Topics	Credits	Lectures
RPSMIC 401		**Medical Microbiology and Epidemiology**	**04**	**60**
RPSMIC 401	I	**Study of Infections – I** Detailed Study of following infections including Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab.diagnosis, Prophylaxis, and Treatment:-- AIDS, MOTT (mycobacteria other than TB) Legionellosis, Chikungunya, Cholera caused by *V. cholerae* 0139,Swine flu.	01	**15**
	II	**Study of Infections- II** Detailed Study of following infections including Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab.diagnosis, Prophylaxis, and Treatment:-- Conditions caused by *Helicobactor pylori,* Campylobacter, Dengue, SARS, Listeriosis, VRE (Vancomycin Resistant enterococci), Leptospirosis, Hepatitis non A, prions	01	**15**
	III	**Role of Biofilms in diseases** 3.1Structure and properties of biofilms: 3.2 Formation of biofilm , Regulation of Initial Attachment, Biofilm Formation Proceeds via Multiple Convergent Genetic Pathways, Early Attachment Events, Maturation of the Biofilm , Detachment and Return to the Planktonic Growth Mode 3.3 Biofilm erradication :Methods and commonly used biocides such as surfactants, enzymes, triclosan, chlorhexidine, quarternary ammonium compounds. 3.4 Use of other biofilm management methods such as probiotic organisms and prebiotics to restore disrupted beneficial biofilms to a “normal state”. Correction of environmental conditions for enhanced bioremediation of biofilms (eg dental plaque) Disadvantages of biofilm management strategies-development of resistant strains-cross resistance induction 3.5 Biofilms from different environments,Impact of environment on biofilm development and its composition and implications of each on biofilms in water bodies, biofouling associated microbial biofilms prosthetics associated biofilms,human associated biofilms eg. Gut	01	**15**
	IV	**Epidemiology and Microbiome studies**	01	

		A] Epidemiology of infectious diseases : 4.1 Historical aspects-definition 4.2 Descriptive Epidemiology-aims and uses 4.3 Host parasite interactions in the cause of diseases 4.4 Epidemiological principles in prevention and control of Diseases 4.5 Measures of risks: frequency measures, morbidity frequency measures, mortality frequency measures natality(birth) measures, measures of association, measures of public health impact. 4.6 Public health surveillance: purpose and characteristics, identifying health problems for surveillance, collecting data for surveillance, analyzing and interpreting data, disseminating data and interpretation, evaluating and improving surveillance. B] Microbiome studies a. Stomach, small and large intestinal microbiome b. Function of the Human Gut Microbiota b. Gut Microbiota in health and disease		**08** **07**

Reference Books

RPSMIC 401

1. Clinics in laboratory medicine, Emerging Infections and their causative agents. September 2004vol. 24 no. 3.

2. Textbook of Microbiology 8th edition 2009-Ananthnarayan & Paniker-University press

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7. Principles of epidemiology in public health practices 3rd edition (www.cdc.gov/training/products/ss1000)

8 . Basic lab methods in medical bacteriology, WHO Geniva.

9. Medical laboratory technology by Godkar.

10. Handbook of Epidemiology- W. Ahrens, I. Pigeot Springer- Verlag Berlin Herdelberg (2005).

11 Epidemiology for Public Health Practice- Robert H Friis & Thomas A. Sellers 3rd editionJones & Bartlett publishers.

12. Textbook of preventive and Community medicine- Park & Park.

13. Infectious disease surveillance by Nikuchia Nikanatha Blackwell Publishing 2005.

14. The Human Microbiota and Microbiome by Julian R. Marchesi
CABI

Course Code: RPSMIC 402

Course Title: Pharmaceutical Microbiology

Academic year 2019-20

Learning objectives:

Pharmaceutical industry encounters problems of microbial contamination in their plants as well as products. So they need to have quality control and assessment to prevent contamination. In this course students will learn basic concepts associated with regulatory factors in pharmaceutical industry like QC, A and GMP. They will also get introduced to design of premises of pharmaceutical industry with respect to structure, layout, cleaning. It is important to understand documentation in this industry. It is important to understand testing done for checking preservation efficacy of preservative used in pharmaceutical product. Nowadays, rational drug designing is evolving as an important branch in science which involves studying of 3 D structures of drug molecule and target molecule. Students will be introduced to techniques involved in drug discovery like proteomics, bioinformatics.

In this course students will get introduced to regulatory affairs of pharmaceuticals industry and some basics of drug discovery.

Learning outcomes: Students should be able to:

- Get introduced to terminology used in pharmaceutical microbiology.
- Understand regulatory aspects in pharmaceutical industry, QC, GCLP.
- Understand design of pharmaceutical industry.
- Understand principle behind microbial testing carried out in pharmaceutical industry.
- Understand concept of validation and apply it to pharmaceutical industry.
- Get introduced to modern methods of drug discovery.
- Understand methods used for proteomic and bioinformatics studies.
- Understand the process of lead identification.
- Get introduced to various softwares used for studying 3D structures of drug and target molecule.

Detail Syllabus

Course Code	Unit	Topics	Credits	Lectures
RPSMIC 402		**Pharmaceutical Microbiology**	**04**	**60**
RPSMIC 402	I	**Principles and applications of GMP in pharmaceuticals** 1.1 Principles – Applications and Definitions 1.2 The concept of Quality 1.3 The regulatory factors 1.4 QC, QA and GMP 1.5 Quality assurance beyond GMP 1.6 ISO	01	**02** **02** **02** **02** **02** **02**
	II	**Quality management,regulatory aspects and Analytical aspects for pharmaceutical products** 2.1 Premises and contamination control, location, design, structure, layout, services and cleaning. 2.2 Personnel management, training, Hygiene and health. 2.3Documentation 2.4 Quality control and GCLP 2.5 Sterile and other products.	01	**04** **02** **01** **02** **02** **04**
	III	**Analytical aspects of cosmetic Products** 3.1 Sanitary practices in cosmetic manufacturing 3.2 Global regulatory and toxicological aspects of cosmetic preservation 3.3 Cosmetics microbiology- testing methods and preservation 3.4 Antimicrobial preservation efficacy and microbial content testing 3.5 Validation method for cosmetics 3.6 Preservation strategy 3.7 Evaluation of antimicrobial mechanism	01	**02** **02** **02** **02** **02** **02** **02** **01**
	IV	**Drug Discovery** 4.1 Modern Methods of Drug Discovery 4.2 Proteomics 4.3 Bioinformatics 4.4 High throughput screening technology 4.5 Natural products for lead identification 4.6 The role of protein 3D structures in the drug discovery process	01	**02** **03** **02** **03** **02** **03**

References:

RPSMIC402

1. Sharp John (2000) Quality in the manufacture of medicines and other healthcare products. Pharmaceutical Press.

2.Iyer S. (2003) Guidelines on cGMP and quality of Pharmaceutical products. D K Publishers Mumbai.

3.Philip A , Taylor and Francis (2006) Cosmetic Microbiology a practical approach.2nd Ed.

4. Denyer S p, Hodges N A and Gorman S P (2005) Hugo and Russell's Pharmaceutical Microbiology. Blackwell Publishing.

5.Bhatia R and Ichhapujani R L (1995) Quality Assurance in Microbiology. CBS publishers and distributors.

6.Hillisch A and Hilgenfeld R (2009) Modern Methods of drug discovery. Springer International Edition.

7.Kadam s s, Mahadik K R and Bothara K G (2009). Principles of medicinal Chemistry. Vol II NiraliPrakashan Pune.

8.Lemke T L and Williams D A (2008) Foye's Principles of medicinal Chemistry. 6th Ed. Wolter Luwer, Lippincott Williams and Wilkins. N Delhi

Course Code: RPSMIC 403

Course Title: Advances in Biotechnology

Academic year 2019-20

Learning objectives:

Many of the pharmaceutical products are manufactured at commercial scale. It is important to understand upstream and downstream production of biopharmaceuticals. In this course students will get introduced to industrial scale production of biopharmaceuticals like cytokines, interferons, insulin etc. Drug discovery tools high throughput screening, chemiinformatics etc. will also be discussed in this course. Intellectual property right (IPR) is an important concept related to securing ownership on your creation. In this course students will be taught about basics of IPR. In biological sciences, ethical issues arise when there is use of animal models, genetically modified organisms (GMOs), humans for experiments. Students should have knowledge and they should be sensitized towards the issue of bioethics. Also they should be made aware of agencies dealing with the issue of bioethics and how to assess whether the given research work is ethical, these things are taught in this course. There is lot of diversity found in marine microorganisms. It is important to explore these organisms for useful products like antibiotics, enzymes, polymers etc. This course thus discusses microbial diversity in marine ecosystem and products that are obtained from them. Genetic engineering is used to manipulate the organism to produce protein of our interest. In this course students will be taught various techniques involved in protein production from not only prokaryotes but also from eukaryotic models. Chemical synthesis of DNA is discussed which is used for synthesis of oligonucleotides like pimers etc. Directed mutagenesis is a method of introducing mutation at specific site in the genome, techniques for which will be discussed in this course. It is important to introduce students to modern field like synthetic biology, which will be done in this course.

This course will essentially teach students various concepts in the field of biotechnology ranging from biopharmaceuticals to synthetic biology.

Learning outcomes: Students should be able to:

- Understand the process of production of various biopharmaceuticals.
- Know about new vaccines and vaccine designing approaches.
- Get introduced to various drug discovery tools and appreciate use of *in silico* methods in drug designing.
- Understand basic concepts of IPR, understand requirements of patentability.
- Know type and categories of biotechnological patent.
- Get sensitized towards ethics in biological sciences.
- Know about regulatory authorities for dealing with ethical issues.
- Understand methods for chemical synthesis and sequencing of DNA.
- Understand process of genetic manipulation in prokaryotic and eukaryotic models.
- Understand the method of directed mutagenesis.
- Understand various steps involved in protein engineering.
- Get introduced to field of synthetic biology and know its applications in industry.

Detail Syllabus

Course Code	Unit	Topics	Credits	Lectures
RPSMIC 403		**Biotechnology & Environmental Resource Management**	**04**	**60**
RPSMIC 403	I	**Pharmaceutical Biotechnology** 1.1 Biologics, Biopharmaceuticals, 1.2 Protein structure stability, folding, structure prediction, Post translation modifications, Protein Therapeutics – Upstream and Downstream processing, Cytokines, Interferon production, Interleukins production, Therapeutic hormones – Insulin, Human Growth Hormone, Recombinant blood products, Therapeutic Enzymes 1.3 Newer Vaccines, Vaccine Designing Approaches 1.4 Drug Discovery Tools, Combinatorial Chemistry, High Throughput Screening, Chemiinformatics, In silico Modelling, Molecular Modeling, Structure Prediction, Rational Drug Designing, Drug Development, Concept of Pharmacognosy, Pharmacokinetics and Pharmacodynamics	01	**02** **05** **03** **05**
	II	**IPR and Ethics in Biotechnology** 2.1 Biotechnology and Intellectual Property Rights 2.1a. Intellectual Property Rights (IPR) and Protection (IPP) 2.1 b. Biotechnology and IPR-Rationale of Patent in Research and Scientific Innovations , Biotechnological Patents 2.1c. Requirements for Patentability- Patentable subject matter, Novelty, Invention in Biotechnological Research, Industrial Applicability, Enablement Requirement. 2.1d. Patent Specifications and Basic Component of License Agreement, In IP System 2.1e. Categories of Biotechnological Patents- Patenting in New Era of Genomics, Proteomics and Microbiology, Examples of Patents granted by USPTO, Concerns over Biotechnology Patents. Biotechnology and Bioethics Bioethics and cross-cultural bioethics.- Autonomy, Rights, Beneficience, Do No Harm, Justice,Confidentiality, Animal Rights, Environmental ethics, Decision-Making Perceptions of Ethical Biotechnology.-'Moral' is not the same as Ethical, Mixed Perception of Benefit & Risk, Reasoning behind Acceptance or Rejection of Genetic Manipulation,Concerns about Consuming	01	**12**

		products of GMOs. Past and Present 'Bioethical Conflicts' in Biotechnology- Interference with Nature , Fear of Unknown, Regulatory Concerns, Human Misuse Future 'Bioethical Conflicts' in Biotechnology. - Changing perception of Nature, Human Genetic Engineering Bioethics vs Business: A Conflict?- IPP, Global Issues of Technology Transfer, Safety vs Costs, Is New Technology Better Resolution of Conflicts- Who can be trusted?, Public Education, Sufficient Regulations Ethical limits of Biotechnology.-Absolute or Relative, Timeless or Transient 2.2. Criteria to Assess whether Biotech Research is Ethical.		**03**
	III	**Environmental & natural resources management and safety standards** 3.1 Natural resources: Renewable/ non renewable. Land, water, forest, minerals, energy, food. Associated problems and management practices. Environmental Impact Assessment and Sustainable Development 3.2 Solid waste management: Biodegradable waste from kitchen, abattoirs and agricultural fields and their recycling by aerobic composting or biomethanation. Non biodegradable waste like plastics, glass metal scrap and building materials and plastic recycling, metal recycling. 3.3 Hazardous waste management: Hazardous waste from paint, pesticides and chemical industries and their composition, Sewage & Sludge treatment and disposal methods. Probable means to reduce these waste through Common Effluent Treatment Plants. 3.4 Biomedical and electronic waste management, recovery of precious metals from electronic waste resources. 3.5 Biohazards: Introduction, levels of biohazards, Risk assessment, proper cleaning procedures 3.6 Biosafety: Historical background and introduction, need of biosafety levels, biosafety guidelines for GMOs and LMOs. Role of Institutional biosafety committee. RCGM, GEAC, etc. for GMO	01	**06** **03** **04** **02**

		applications in food and agriculture. Environmental release of GMOs. Overview of national regulations and relevant international agreements. Ecolabelling, IS 22000, Generally Recognized as Safe (GRAS)		
	IV	**Advances in Molecular Biotechnology** 4.1 Chemical synthesis and sequencing of DNA: Phosphoramidite method, Uses of synthesized oligonucleotides, Dideoxynucleotide method for sequencing of DNA, Automated DNA sequencing, Using Phage M13 as a sequencing vector 4.2 Manipulation of Gene Expression in Procaryotes: Gene expression from strong and regulatable promoters, Fusion proteins, unidirectional tandem gene arrays, Increasing protein stability, protein folding, DNA integration into host chromosome, 4.3Heterologous protein production production in eukaryotic cells:Expression systems like Saccharomyces cerevisiae, Pichia pastoris, Baculovirus-Insect cell, mammalian cell 4.4 Directed Mutagenesis: Oligonucleotide directed mutagenesis with M13, Oligonucleotide directed mutagenesis with plasmid DNA, PCR amplified oligonucleotide directed mutagenesis, Random mutagenesis with degenerate oligonucleotide primer, Random mutagenesis with nucleotide analogues, Error-prone PCR, DNA shuffling, Mutant proteins with unusual amino acids 4.5Protein Engineering: Adding disulfide bonds, Changing aspargine to other amino acids, Reducing the number of free sulfhydryl residues, Increasing enzymatic activity, Modifying metal cofactor requirement, Decreasing protease sensitivity, Modifying protein specificity, Increasing enzyme stability and specificity, altering multiple properties 4.6 Synthetic Biology: Introduction, types, mechanisms, applications in industry	01	**03** **03** **03** **03** **02** **01**

References:

RPSMIC403

1. Gary Walsh, Pharmaceutical Biotechnology – Concepts and Applications (E-Book), John Wiley & Sons Ltd. (2007)

2.Jogdand S. N., Biopharmaceuticals, Himalaya Publishing House, Mumbai (2006)

3.K. Sambamurthi, Pharmaceutical Biotechnology, New Age International (2006)

4.Daan J. A. Crommelin, Robert D. Sindelar and Bernd Meibohm Pharmaceutical Biotechnology: Fundamentals and Applications, informa healthcare, (Oct 30, 2007)

5. Biodiversity,Biotechnology&Traditional Knowledge- Understanding Intellectual Property Rights , Aravind Kumar, Govind Das, Narosa

6. A textbook of Biotechnology, R.C.Dubey ,S.Chand

7. Biotechnology,Second Completely Revised Edition-Volume 12-Legal,Economic and Ethical Dimensions.Volume Editor-D.Brauer(A multi- Volume Comprehensive Treatise),H.J.Rehm and G.Reed, A.Puhler ,P Stadler

8. Ethics in Biotechnology-An Executive Guide ,Chris MacDonald &Rahul.K. Dhanda

9. www.BiotechEthics.ca

10. David H.Attway& Oskar R.Zabosky: Marine Biotechnology, Volume 1,2,3, plenum press (1993).

11. Molecular Biotechnology: Principles and Applications of Recombinant DNA Bernard R. Glick, Jack J. Pasternak, 4/e (2010), ASM Press

12. An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnologyedited by Michael Wink, (2006)Wiley VCH

13. Molecular biotechnology: principles and practices Channarayappa, (2006), Universities Press

Course Code: RPSMIC 404

Course Title: Internship

Academic year 2019-20

Explore • Experience • Excel

PRACTICALS: RPSMIC 4P1 (60 Contact Hrs)

13. Diagnosis for HIV - Trispot/ ELISA for AIDS (Demonstration)
14. Acid fast staining for MOTT
15. Mono - Spot Test for diagnosis of Chikungunya (Demonstration expt.)
16. Diagnosis for V.c.0139 5.Cholera red test, String test, Oxidase test, Biochemical tests, & isolation on TCBS medium for identification of Vibrio cholerae 0139.
17. Diagnosis for Helicobacter pylori HPSA (Helicobacter pylori) (Demonstration expt.) (kit method)

PRACTICALS: RPSMIC 4P2 (60 Contact Hrs)

1. Sterility testing and reporting (as per Pharmacopia)
2. Microbial load in cosmetic product
3. Efficacy testing of preservatives like parabens
4. Efficacy of preservation and shelf life study.
5. Preparation of cosmetic product and its preservation study

PRACTICALS: RPSMIC 4P3 (60 Contact Hrs)

1. Assignments on IPR-Case studies on different patents granted
2. Report on International Bioethics survey on specific concerned issues
3. Research Project experimental work

PRACTICALS: RPSMIC 4P4 (60 Contact Hrs)

1. Internship – Students will be sent for internship to research nstitute/industry for a period of four months

Modality of Assessment (Semester III) :

Theory

A) Internal Assessment - 40%

40 marks

Sr No	Evaluation type	Marks
1	Presentation & assignment	15
2	One class Test (multiple choice questions / objective)	20
3	Active participation in routine class instructional deliveries	05
4	Overall conduct as a responsible student, manners, skill in articulation, leadership qualities demonstrated through organizing co-curricular activities, etc.	

B) External examination- 60 %

Semester End Theory Assessment -60 marks

A. Duration - These examinations shall be of 2.5 hours duration

B. Theory question paper pattern:-

1. There shall be five questions each of 12marks on each unit. Fifth one will be based on all the four units.
2. All questions shall be compulsory with internal choice within the questions. Each question will be of 20 to 23 marks with options.
3. Questions may be subdivided into sub-questions a, b, c, d & e only &the allocation of marks depends on the weightage of the topic.

Questions	Options	Marks	Questions on
Q.1)	Any 2 out of 4	12	Unit I
Q.2)	Any 2 out of 4	12	Unit II
Q.3)	Any 2 out of 4	12	Unit III
Q.4)	Any 2 out of 4	12	Unit IV
Q.5) A	Any 4 out of 8	04	Unit I, II, III, IV
Q.5) B	Any 4 out of 8	04	
Q.5 C	Any 2 out of 4	04	

Practical Examination Pattern (Semester III) :

Particulars	Practical 1	Practical 2	Practical 3	Practical 4
Laboratory work	15	30	20	15
Quiz	-	-	10	-
Viva	05	-	-	05
Project Work presentation	30	20	20	30
Total	**50**	**50**	**50**	**50**

PRACTICAL BOOK/JOURNAL

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

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

Research project work: Candidates are required to present duly certified dissertation report based on the topic of research along with the laboratory notebook containing raw data and make the poster presentation of the research work for evaluation by the examiner.

Modality of Assessment (Semester IV) :

Theory

Paper I		Paper II		Paper III		Paper IV	
Theory	**Internal**	**Theory**	**Internal**	**Theory**	**Internal**	**Internship evaluation by mentor**	**Internship evaluation by internal faculty**
60 marks	40 marks	60 marks	40 marks	60 marks	40 marks	60 marks	40 marks

Semester End Theory Assessment -60 marks

B. Duration - These examinations shall be of 2.5 hours duration

C. Theory question paper pattern:-

4. There shall be five questions each of 12marks on each unit. Fifth one will be based on all the four units.
5. All questions shall be compulsory with internal choice within the questions. Each question will be of 20 to 23 marks with options.
6. Questions may be subdivided into sub-questions a, b, c, d & e only &the allocation of marks depends on the weightage of the topic.

Questions	Options	Marks	Questions on
Q.1)	Any 2 out of 4	12	Unit I
Q.2)	Any 2 out of 4	12	Unit II
Q.3)	Any 2 out of 4	12	Unit III
Q.4)	Any 2 out of 4	12	Unit IV
Q.5) A	Any 4 out of 8	04	Unit I, II, III, IV
Q.5) B	Any 4 out of 8	04	
Q.5 C	Any 2 out of 4	04	

Practical Examination Pattern (Semester IV)

Particulars	Practical 1	Practical 2	Practical 3	Practical 4
Practical	50	50	-	-
Internship presentation	-	-	50	-
Internship Report	-	-	-	50
Total	50	50	50	50

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 of the Department/ Co-ordinator of the department ; failing which the student will not be allowed to appear for the practical examination.

Overall Examination Pattern

Semester III

Course	RPSMIC 301			RPSMIC 302			RPSMIC 303			RPSMIC 304			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**400**
Practicals	-	**50**	**50**	**-**	**50**	**50**	**-**	**50**	**50**	**-**	**50**	**50**	**200**

Semester IV

Course	RPSMIC 401			RPSMIC 402			RPSMIC 403			RPSMIC 404			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internship evaluation	Internship evaluation	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**400**
Practicals	-	**50**	**50**	**-**	**50**	**50**	-	**50**	**50**	**-**	**50**	**50**	**200**
