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S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

Syllabus for MSc Program

Program: MSc (Microbiology)

Course code: RPSMIC

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

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 andbuffering 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 overviewof 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**	**15**
	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)	**03** **03**
	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.	**03**
	4.4 : Transport of proteins a) Protein transport: extracellular protein secretion, drug export system b) Folding of periplasmic proteins, translocation of folded proteins	**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	**15** **7**

	c. Maintaining antibiotic resistance through Selective Pressure **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	**15** **04**

	c. Dideoxynucleoside method for sequencing of DNA 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 adherencejunctions, 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 aimsat 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. 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, PI-3kinase, TGF 3.5 Signaling in plants: Serine/ Threonine kinases, role of ethylene, Phytochromes	**15**
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 withspecific 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 thereactions 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 differentmethods 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.	**03**
	4.2 Report writing and presentation: types of research reports, guidelines for writing a report, report format, appendices, Miscellaneous information, poster and oral presentations	**08**
	4.3 Scientific Communication	**02**
	4.4 Guide to grant application	**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.
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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