



UNIVERSITY OF CALICUT

Abstract

General and Academic - Faculty of Science - Syllabus of MSc Microbiology Programme under CBCSS PG Regulations 2019 with effect from 2019 Admission onwards -Implemented- Orders Issued.

G & A - IV - J

U.O.No. 8861/2019/Admn

Dated, Calicut University.P.O, 05.07.2019

*Read:-*1. U.O.No. 4487/2019/Admn dated 26.03.2019

2. Minutes of the meeting of the Board of Studies in Microbiology held on 08.04.2019

3. Item No. I.10 in the minutes of the meeting of Faculty of Science held on 27.06.2019

ORDER

The Regulations for Choice Based Credit and Semester System for Post Graduate (PG) Curriculum-2019 (CBCSS PG Regulations 2019), for all PG Programmes under Affiliated Colleges and SDE/Private Registration with effect from 2019 Admission has been implemented in the University of Calicut vide paper read first above.

The meeting of the Board of Studies in Microbiology held on 08.04.2019 has approved the Syllabus of MSc Programme in tune with new CBCSS PG Regulations implemented with effect from 2019 Admission onwards, vide paper read second above.

The Faculty of Science at its meeting held on 27.06.2019 has approved the minutes of the meeting of the Board of Studies in Microbiology held on 08.04.2019, vide paper read third above.

Under these circumstances, considering the urgency, the Vice Chancellor has accorded sanction to implement the Scheme and Syllabus of MSc Microbiology Programme in accordance with the new CBCSS PG Regulations 2019, in the University of Calicut with effect from 2019 Admission onwards, subject to ratification by the Academic Council.

The Scheme and Syllabus of MSc Microbiology Programme in accordance with CBCSS PG Regulations 2019, is therefore implemented in the University with effect from 2019 Admission onwards.

Orders are issued accordingly. (Syllabus appended)

Biju George K

Assistant Registrar

To

The Principals of all Affiliated Colleges

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Section Officer



UNIVERSITY OF CALICUT

M.Sc. Microbiology (CBCSS) Syllabus

For affiliated colleges

2019 Admission onwards

Detailed Scheme for the M. Sc. Microbiology (CBCSS) course 2019

Course		Contact Hours/Week	Credit	Exam Duration	Weightage	
					Ext	Int
Semester I	1. MBGIC01. General Biochemistry and Microbial Metabolism	4	4	3 Hours	4	1
	2. MBGIC02. Biophysics and Instrumentation	3	3	3 Hours	4	1
	3. MBGIC03. Environmental and Sanitation Microbiology	3	3	3 Hours	4	1
	4. MBGIC04. Agricultural Microbiology and Plant Pathology	3	2	3 Hours	4	1
	5. MBGIL01. Practical I	6	4	1 day x 5 Hours	4	1
	6. MBGIL02. Practical II	6	4	2 days x 5 hours	4	1
Total		25	20			
Semester II	7. MBG2C05. Principles of Genetics	5	4	3 Hours	4	1
	8. MBG2C06. Food and Dairy Microbiology	5	4	3 Hours	4	1
	9. MBG2C07. Industrial Microbiology	4	4	3 Hours	4	1
	10. MBG2C08. Immunology	5	4	3 Hours	4	1
	11. MBG2L03. Practical III	6	4	2 days x 5 hours	4	1
	Total		25	20		
Semester III	12. MBG3C09. Medical Microbiology	5	4	3 Hours	4	1
	13. MBG3C10. Molecular biology	4	4	3 Hours	4	1
	14. MBG3E01. Diagnostic microbiology	4	4	3 Hours	4	1
	15. MBG3E02. Cell Biology					
	16. MBG3E03. Microbial Taxonomy					
	17. MBG3L04 Practical IV	6	4	2 days x 5 hours ¹	4	1
18. MBG3L05. Practical V	6	4	2 days x 5 hours ²	4	1	
Total		25	20			
Semester IV	19. MBG4C11. Biostatistics and Bioinformatics	4	4	3 Hours	4	1
	20. MBG4E04. Microbial Biotechnology	4	4	3 Hours	4	1
	21. MBG4E05. Genetic engineering					
	22. MBG4E06. Biosafety, Bioethics and IPR					
	23. MBG4L06. Practical VI	6	4	1 day x 5 Hours	4	1
	24. MBG4P. Dissertation	11	8	1 day x 5 Hours	4	1
Total		25	20			
Grand Total			80			
Audit Course I: Ability Enhancement Course (AEC)		No workload	4			
Audit Course II (PCC): Professional Competency Course (PCC)			4			

WEIGHTAGE DISTRIBUTION OF EXAMINATIONS AND PROJECT WORK

Theory examination (Internal)

	Percentage	Weightage
Test paper	40	2
Seminar/Presentation	20	1
Assignment	20	1
Attendance	20	1

Practical examination (Internal)

	Percentage	Weightage
Lab skill	40	4
Record/Viva	30	3
Practical Test	30	3

Practical examination (External)

		Percentage	Weightage
Experiment	Principle/Procedure	10	1
	Major Experiment	20	2
	Minor Experiment	30	3
	Spotters	10	1
Record		10	1
Viva		20	2

Dissertation

Sl . No	Criteria	% of weightage	Weightage External	Weightage Internal
1	Relevance of the topic and Statement of problem	60%	8	2
2	Methodology & Analysis		8	2
3	Quality of Report & Presentation		8	2
4	Viva-voce	-40%	16	4
	Total Weightage	100%	40	10

Question paper

	Number of questions	Weightage	Total
Short Answer	14 out of 14	1	14
Short essays	7 out of 10	2	14
Essays	2 out of 4	4	8
Total:			36

M.SC. MICROBIOLOGY (CBCSS)

SYLLABUS 2019

Semester I

1. MBG1C01. General Biochemistry and Microbial Metabolism
2. MBG1C02. Biophysics and Instrumentation
3. MBG1C03. Environmental and Sanitation Microbiology
4. MBG1C04. Agricultural Microbiology and Plant Pathology
5. MBG1L01. Practical I
6. MBG1L02. Practical II

Semester II

7. MBG2C05. Principles of Genetics
8. MBG2C06. Food and Dairy Microbiology
9. MBG2C07. Industrial Microbiology
10. MBG2C08. Immunology
11. MBG2L03. Practical III

Semester III

12. MBG3C09. Medical Microbiology
13. MBG3C10. Molecular biology
14. MBG3E01. Diagnostic microbiology
15. MBG3E02. Cell Biology
16. MBG3E03. Microbial Taxonomy
17. MBG3L04 Practical IV
18. MBG3L05. Practical V

Semester IV

19. MBG4C11. Biostatistics and Bioinformatics
20. MBG4E04. Microbial Biotechnology
21. MBG4E05. Genetic engineering
22. MBG4E06. Biosafety, Bioethics and IPR
23. MBG4L06. Practical VI
24. MBG4Pr. Dissertation

SEMESTER I

MBG1C01. General Biochemistry and Microbial Metabolism

Unit 1:-Structure and functions of Biomolecules: - Structure, classifications and functions of carbohydrates- Monosaccharides; Disaccharides and polysaccharides.. Heteropolysaccharides, Glycosaminoglycans and Glycoproteins. Structure and functions of amino acids and proteins: - Chemical structures and classifications of amino acids. Chemical properties of amino acids; Lipids –structure, properties and classification. Fatty acid classification- Saturated, unsaturated and poly- unsaturated fatty acids (PUFA); Short chain, medium chain and long chain fatty acids. Phospholipids and Sphingolipids; prostaglandins, prostacyclins and leukotriens. Hormones and vitamins -structure and functions.

Unit 2:-Carbohydrate metabolism: Respiration and fermentation. Respiration – aerobic and anaerobic respiration. Glycolysis- aerobic and anaerobic types; alcoholic fermentation; regulation of glycolysis. Pyruvate dehydrogenase complex; Krebs cycle; Glyoxylate cycle- significance, regulation; Phosphorylation – substrate level and oxidative phosphorylation. Electron transport chain- components and mechanism of ATP formation; Chemi-osmotic coupling hypothesis. Gluconeogenesis. Glycogenesis and glycogenolysis. Peptidoglycan biosynthesis.

Unit 3:-Amino acid metabolism- Transamination, deamination, transmethylation and decarboxylation. Glucogenic and ketogenic amino acids, Microbial metabolism of glycine, phenylalanine and lysine.

Unit 4:-Lipid metabolism-Fatty acid oxidation; alpha, beta, and omega oxidations; Fatty acid synthesis; synthesis of unsaturated and long chain fatty acids.

Unit 5 : Nucleic acid metabolism - Biosynthesis and degradation of purines and pyrimidines- de novo and salvage pathways.

Unit 6:-Enzymology- Enzyme–IUB-Nomenclature; Classification; Enzyme active sites; coenzymes and co-factors; Factors affecting enzyme activity, Enzyme kinetics - Michaelis-Menton equation Multi-subunit enzymes; isozymes; allosteric enzymes; enzyme regulation; Enzyme inhibition; Mechanism of Enzyme action; Enzyme purification techniques. Enzyme immobilization.

MBG 1C02: Biophysics And Instrumentation

Unit I : Structure of atoms, molecule, Physico-chemical forces- ions, ionic bonds, covalent bonds, Hydrogen bonds, vander Walls forces, hydrophobic interactions, polar and non-polar molecules. Laws of thermodynamics, the concept of enthalpy, entropy and free energy, thermodynamic equilibrium, redox potential, high energy molecules, examples of redox potential in biological system. DNA-Protein interaction-. Lambda repressor and cro binding to DNA. Interactions of transcription factors-HLH, bHLH, Leucine Zipper, Cys-His, Zinc fingers. Histone-DNA interaction, RNA protein interactions, DNA-drug Interaction.

Unit II: Structural implication of peptide bond, Ramachandran plot, protein families, alpha domains, beta-domains, alpha- beta domains, Protein-drug interaction. peptide mass finger printing using MALDI-TOF, MASCOT database.

Unit III: Principle, Instrument Design, methods and Applications of Microscopy: Light, Scanning and Transmission electron, phase contrast, polarization, confocal and interference microscopy, CCD camera, Introduction to Atomic force microscopy. Beer-Lamberts law, Principle, Instrument Design, methods and Applications of UV-Visible spectra, IR spectra, Raman Spectra, Fluorescence spectra, NMR and ESR spectra. Colorimetry, spectrophotometry, Flourimetry, Flame photometry and Spectroscopy. Xray diffraction technique-principle and application.

Unit IV : Principle, Instrument Design, methods and Applications of Chromatography, ion exchange, molecular sieve, affinity chromatography, paper, TLC, GC, HPLC, HPTLC, FPLC, GC-MS, LC-MS. Centrifugation and Ultracentrifugation, Centrifugation - Principle and application of various types of centrifugation. Electrophoresis- AGE, PAGE- SDS & Native PAGE, Capillary Electrophoresis, isoelectric focusing, 2D Electrophoresis.

Unit V: pH meter- principle, types and applications. Dialysis-principle and applications. Principle, methods and Applications of Ultra filtration, Sonication, Lyophilization. Refractometry, Cytometry and Flow cytometry, Introduction to Radioactive isotopes, autoradiography, radiation dosimetry- GM counter, Liquid scintillation counting, safety aspects. Biosensors.

MBG1C03. Environmental and Sanitation Microbiology

Unit 1 : Microbial Ecology: Microbial Communities. Basic concept of ecosystem, Ecological niches, Microbial succession- Primary and secondary succession. Microbial interactions- Neutralism, commensalism, symbiosis, synergism, competition, parasitism, antagonism and predation. Bio-geochemical cycles- C,N, S, P and Fe.

Unit 2 : Air microbiology: Air microflora- transient nature of air flora, droplet nuclei and aerosols. Methods of air sampling and types of air samplers – impaction on solids, impingement technique in liquid, sedimentation, centrifugation, precipitation and thermal precipitations. Air sanitation- methods and applications.

Unit 3 : Water Microbiology: Fresh water and marine microbial populations; potable water and indicator microorganisms, Bacteriological analysis of drinking water and other quantitation techniques; drinking water purification. Waste water- Sources, types, composition and characteristics (DO, BOD, COD) . Microbiology of waste water. Sewage treatment.

Unit 4: Pollution and Environment: Biosensors and environmental applications. Pollution- Soil, Air, Water and Marine pollution. Solid waste management – land filling and composting. Biogas production. Treatment of petroleum waste and xenobiotic. Biodegradation of recalcitrant. Bioleaching – General mechanism, Bioleaching of Copper, Uranium, and Gold.

MBG1C04. Agricultural Microbiology and Plant Pathology

Unit 1: Microbial interactions: Microbial flora of soil. Plant – Microbe interactions :- .Nitrogen fixation- Symbiotic and non-symbiotic, physiology and genetics of nitrogen fixation. Mycorrhizae, Rhizosphere and Phylloplane microorganisms. Animal-Microbe Interactions - Rumen microflora, Nematophagous fungi, Bioluminescent bacteria, Termite nutrition

Unit 2: Applications of microbes in agriculture: Biofertilizers. Symbiotic nitrogen fixation - (Rhizobium, Frankia). Symbiotic nutrient mobilizers - Endomycorrhizae and Ectomycorrhizae. Non symbiotic microbes – Azotobacter. Associative Symbiosis – Azospirillum. Cyanobacteria (Nostoc, Gloeocapsa), Azolla-Anabaena System. Mass

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production of biofertilizers. Bio pesticides- bacterial, fungal and viral. Advantages and disadvantages of bio pesticides over the chemical counter parts. GM crops and its significance.

Unit 3: Plant pathology: Components of disease (disease pyramid). Symptoms, epidemiology and control of common plant diseases. Fungal diseases- Late blight of potato, Downy mildew of grapes, Powdery mildew of cucurbits, Early blight of potato, Rice blast, Red rot of sugarcane, Sheath blight of rice, Rusts of wheat. Bacterial diseases – Crown gall disease and Ti plasmid, BLB of rice, Red stripe of sugarcane, Bacterial wilt of Banana (Moko disease), Soft rot of potato, Citrus canker, Ratoon stunting of sugarcane.

Unit 4: Mycoplasma – Coconut root wilt. Viral diseases – Tobacco mosaic, Yellow vein mosaic of Bhindi, Rice Tungro, Leaf curl of papaya, Bunchy top of banana, Potato spindle tuber, Coconut Cadang- Cadang. Nematode- Potato cyst nematode. Plant defense mechanisms- Structural, biochemical, SAR and ISR.

MBG1L01. Practical I

(General Biochemistry and Microbial Metabolism)

1. Preparation of solutions – Percentage, Molar, Normal and dilution of stock solutions
2. Preparation of buffers.
3. Estimation of Glucose by ortho toluidine method
4. Estimation of fructose by Roe – Pappadapoulose Method
5. Estimation of reducing sugars by DNS method
6. Qualitative identification of carbohydrates in mixture containing mono, di and polysaccharides.- starch, dextrin, sucrose, maltose, lactose, glucose, fructose, xylose and galactose.
7. Estimation of amino acid, methionine by nitroprusside method.
8. Protein Estimation using Lowry's method.
9. Protein estimation by Bradford's method.
10. Estimation of ascorbic acid in plant matter
11. Estimation of citric acid
12. Estimation of cholesterol by Zak's method

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13. Bacterial synthesis of PHB and its estimation
14. Demonstration of siderophore production by microbes
15. Spectrophotometric assay of enzyme activity.
16. Determination of K_m and V_{max} .
17. Effect of pH and temperature on enzyme activity - amylase SDS PAGE using protein Standards
18. Gel filtration chromatography
19. Dialysis of proteins
20. Paper chromatography
21. TLC
22. Column separation of plant pigments
23. Fractionation of egg protein and its identification

MBG1L02. Practical II

(Biophysics and Instrumentation, Environmental and sanitation microbiology & Agricultural Microbiology and plant pathology)

1. Study of air microflora by plate exposure and liquid entrapment
2. Cultivation of fungi - Slide culture technique.
3. Water potability testing by Most Probable Number technique
4. Determination of DO, BOD and COD
5. Efficiency testing of bacteria proof filters and autoclave.
6. Anaerobic culturing by liquid paraffin overlay and pyrogallol.
7. Anaerobic enrichment of cellulose digesters
8. Winogradsky column.
9. Demonstration of Microbial Bioluminescence.
10. Phage cultivation
11. Microbial flora from different soil types and habitats – bacterial and fungal
12. Isolation of actinomycetes from soil.

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13. Detection of R:S ratio by estimating rhizosphere population.
14. Assay of extracellular enzymes– cellulase, protease, lipase and phosphatase
15. Isolation of nitrogen fixing bacteria, *Rhizobium*.
16. Isolation of non symbiotic nitrogen fixing bacteria.
17. Isolation of *Azospirillum*
18. Isolation of phosphate solubilizing organisms.
19. Cultivation of *Azolla*
20. Isolation of biocontrol agents, *Pseudomonas fluorescense* and *Trichoderma*
21. Microflora of termite gut- isolation of cellulose degrading bacteria and direct microscopic examination of protozoa
22. Demonstration of microbial antagonism
23. Bioassay of Bti and Bt
24. Comparison of microflora in Bt-treated and chemical pesticide-treated soils
25. Microbial degradation of phenols
26. Phosphate, nitrogen and metal removal by microbes

SEMESTER II

MBG2C05. Principles of Genetics

Unit I: Introduction to Classical genetics: Pre- Mendelian genetic concepts: Preformation, Epigenesis, Inheritance of acquired characters and Mutation theory. Heredity and Environment: Concepts of Phenotype, Genotype, Heredity, variation, Pure lines and Inbred lines. Biography of Mendel and his experiments on pea plants. Law of Segregation: Monohybrid cross, Back cross and Test cross, Problems related. Law of Independent Assortment: Dihybrid cross in pea plant, Back cross and Test cross, Problems related. Multiple Alleles: Definition, ABO blood groups and Rh factor in Human, Genetic Problems related. Gene Interactions. Deviations from Mendelism: Incomplete inheritance and Codominance. Inter allelic: Complementary gene interaction (9:7) Ex: *Lathyrus odoratus* Supplementary gene interaction (9:3:4) Ex: Grain color in Maize. Epistasis - Dominant Ex.: Fruit color in *Cucurbita pepo*, Recessive - Ex.: Coat color in Mice. Non- Epistasis - Ex.: Comb pattern in Poultry.

Unit II: Sex linkage in Genetics: Meiotic behavior of chromosome and non - disjunction. Theory of non-disjunction. Sex linked inheritance in man (Colour-blindness, Haemophilia). Attached X-chromosome. Chromosome theory of Sex determination: XX- XY, XX-XO, ZZ-ZW

Environment and sex determination. Hormonal control of Sex determination. Gynandromorphs Dosage compensation in *Drosophila* and Man (Lyon's hypothesis). Inheritance of Mitochondrial DNA and Chloroplast DNA

Unit III: Linkage and Crossing over: Linkage: Definition of Linkage, Coupling and Repulsion hypothesis. Types of linkage-complete linkage and incomplete linkage. Factors affecting linkage- distance between genes, age, temperature, radiation, sex, chemicals and nutrition. Crossing over: Crossing over- definition and types of crossing over: Germinal and Somatic crossing over. Cytological basis of crossing over: Stern's experiments in *Drosophila*. Mechanism of crossing over: Chiasma type theory, Breakage first theory, Contact first theory, Strain or torsion theory. Molecular mechanism of crossing over - Holiday model, Crossing over in *Drosophila*. Interference and coincidence, Steps in Construction of genetic map.

M.Sc. Microbiology Syllabus (CBCSS) for affiliated colleges

Unit IV: Chromosomal aberrations: Numerical: Euploidy (Monoploidy, Haploidy and Polyploidy) Polyploidy- Autopolyploidy and Allopolyploidy. Aneuploidy- Monosomy, Nullisomy and Trisomy. Structural - Deletions (Terminal, Interstitial), Duplication (Tandem, Reverse tandem and Displaced), Translocation (Simple, Isochrome, Reciprocal, Displaced) and Inversions (Pericentric and Paracentric). Significance of chromosomal aberrations.

Unit V: Pedigree: Symbols used in pedigree studies, Pedigree analysis and construction, Pedigree analysis for the inheritance pattern of genetic diseases, Genetic Counselling.

Unit VI: Bacterial genetics: Bacterial Genetics: Transformation, Transduction-Generalized and specialized; Conjugation: F factor mediated, Hfr and Sexduction. Transposable elements: Bacteria, Yeast, Maize and Drosophila.

MBG2C06. Food and Dairy Microbiology

Unit 1: Food as a substrate for microorganisms. Common microorganisms in food. Factors influencing microbial growth in food – intrinsic, extrinsic and implicit.

Unit 2 : Fermented food products: Food fermentations- Principles and classification. Starter, non-starter cultures in food fermentation. Fermentation of wine and beer. Fermented vegetables- sauerkraut, pickle, olives. Fermented cereals- bread, idli, dosa, koji. Fermented meat– sausage. Fermented fish products. Other fermented foods- Vinegar, soy sauce. Whey fermentation. SCP fermentation

Unit 3: Dairy microbiology: Physical and chemical properties of milk. Microbiological analysis of milk- DMC, SPC, MBRT, Resazurin test, Alkaline phosphatase test. Fermented Dairy products- Yoghurt, kefir, Acidophilus milk, buttermilk and cheese. Probiotics (*Lactobacillus*, *Bifidobacterium*) and prebiotics.

Unit 4: Food spoilage and preservation: General principles underlying food spoilage. Spoilage of meat, fish, egg, milk, vegetables, fruits and stored grains. Spoilage at low temperature. Spoilage of canned food. Principles of food preservation. Food preservation by physical methods- high and low temperature, drying, freezing, irradiation and high pressure. Food preservation by chemical methods- characteristics of food preservatives. Class I and class II preservatives. Modern food preservation techniques- high electronic field pulses, oscillating magnetic fields pulses, intense light pulses and ultra high hydrostatic pressure.

M.Sc. Microbiology Syllabus (CBCSS) for affiliated colleges

Unit 5: Food poisoning: Food borne infections – Bacterial, Fungal and viral infections. Bacterial- *Salmonella, Staphylococcus, Listeria, Brucella, Bacillus, Clostridium, Escherichia*. Fungal – Aflatoxins and ergotism. Viral- Hepatitis, Bovine Spongiform encephalopathy.

Unit 6: Food hygiene, regulation and standards: Food sanitation. Food control agencies and their regulations. Codes for GMP. HACCP and FSO Systems for food safety.

MBG2C07. Industrial Microbiology

Unit 1: Isolation and screening of industrially important microbes. Strain selection and improvement. Bioprocesses- concepts and design. Continuous and batch fermentations. Types of bioreactors. Bioreactor design and control.

Unit 2: Kinetics of fermentation process. Transport phenomena in bioprocess such as mass transport coefficients for gases and liquids and oxygen transfer coefficients, heat transfer.

Unit 3: Principles of bioprocess media formulations. Sterilization systems. Concepts of inoculum development. Monitoring and control of variables such as temperature, agitation, pressure and pH.

Unit 4: Down stream processing – filtration, centrifugation, precipitation, salting out, crystallization and biphasic separation. Bioassays, Standardization, formulations and packaging. Shelf life consideration.

Unit 5: Manufacture of the following: penicillin, streptomycin, tetracycline, Vit. B -12. Citric acid by surface and submerged process. Ethanol fermentation from molasses. Industrial fermentation of wine and beer. Acetone - butanol fermentation. Bakers yeast. Lactic acid from whey, amylases by fungi, mono - sodium glutamate. Importance of fermentations in ayurvedic medicines. Importance and production of Single cell protein (SCP).

Unit 6: Industrial microbiological products as primary and secondary metabolites, regulation of overproduction of primary and secondary metabolites, bypassing of regulatory mechanisms for the over-production of primary and secondary metabolites.

MBG2C08. Immunology

Unit 1: Defense System: Immunity- Types and Detailed Mechanisms of Innate and Acquired Immunity. Vaccines. Antigens. Immunoglobulins- Structure, Classification and Biological Functions. Genetic Basis of Immunological Diversity. Monoclonal Antibodies and Hybridoma Technology

Unit 2: Lymphoid System: Lymphoid Cells. Hematopoiesis. Structure, Function, Maturation, Development and Classification of T and B Lymphocytes. Lymphocyte Traffic. Toll Like Receptors (TLR), Lymphoid Organs – Primary and Secondary. Cytokines- Types and Biological functions.

Unit 3: Immune Response: Humoral and Cell Mediated Immune Response. Primary and Secondary Immune Response. Processing and Presentation of Intracellular and Extracellular antigens. Immunological Tolerance and Theories of Immune Response. Major Histocompatibility Complex

Unit 4: Antigen-Antibody Reactions and their applications in immunodiagnosis. Complement System- Activation and Biological Functions. Structure of Membrane Attack Complex, Complement Fixation Test. Hypersensitivity- Types and Mechanisms.

Unit 5: Autoimmune Diseases-Causes, pathogenesis, diagnosis and treatment of common autoimmune diseases. Immunodeficiency Diseases, Transplantation Immunology-Types of Grafts, Grafts Acceptance & Mechanism of Graft Rejections. Host Versus Graft (HVG) and Graft Versus Host (GVH) Reactions, Prevention of Graft Rejections. Immunohematology- ABO and Rh Blood Group Systems, Blood Transfusion, Hemolytic Diseases, Rh Incompatibility. Tumor Immunology.

MB2L03. Practical III

(Food and Dairy microbiology & Industrial microbiology)

1. Milk microbiology - direct microscopic count and standard plate count, presumptive test for coliforms
2. Testing the quality of milk - Methylene blue reductase test, Resazurin test and alkaline phosphatase test.
3. Isolation of microbes from yoghurt, idli batter – bacterial and fungal
4. Brine storage of foods.
5. Whey fermentation to alcohol
6. Microbial spoilage of refrigerated food
7. Microbial analysis of food products – detection of indicator organisms ,faecal streptococci and *E.coli* by Most Probable Number method and direct plating.
8. Microbial analysis of food products – detection of pathogenic microorganisms, *S. aureus*, *Salmonella* and *Vibrio*.
9. Microbial analysis of food products – detection of anaerobic spore forming *Clostridia*
10. Microbial analysis of food products – detection of yeast and mould
11. Growth curve of bacteria using breeds count, CFU, turbidimetry and PCV
12. Demonstration of mutation in bacteria
13. Isolation of amylase producers.
14. Isolation of cellulase producers
15. Scale up of inoculum.
16. Cell disruption techniques
17. Downstream processing - Salting out
18. Immobilization of cell or enzyme
19. Bioassay of antibiotic.
20. Citric acid production by submerged fermentation.
21. Solid state fermentation
22. Production of wine.
23. Cultivation of mushroom.
24. Demonstration of IAA production

SEMESTER III

MBG3C09. Medical Microbiology

Unit 1 : Bacteriology: Morphological characteristics, pathogenicity, epidemiology, laboratory diagnosis and treatment of following pathogenic bacteria. Morphological characteristics, pathogenicity, epidemiology, laboratory diagnosis and treatment of following pathogenic bacteria. Aerobic cocci- Staphylococcus, Streptococcus, Pneumococcus and Nesseria. Aerobic Gram positive bacilli- *Corynebacterium diphtheriae* and *Bacillus anthracis*. Anaerobic Gram positive bacilli – *Clostridium botulinum*. Gram negative bacilli – Enterobacteriaceae- *Escherichia coli*, *Proteus*, *Klebsiella*, *Shigella* and *Salmonella*. *Vibrio cholerae*. Spirochetes – *Treponema* and *Leptospira*. *Mycoplasma*. *Mycobacteria* – *M. tuberculosis* and *M. leprae* Miscellaneous bacteria- *Listeria*, *Campylobacter* and *Helicobacter*

Unit 2: Virology: Quantification and classification of viruses. Pathogenesis, laboratory diagnosis and prophylaxis of following viral infections –Polio, Influenza, Mumps, Measles, Rabies, Japanese encephalitis, Viral haemorrhagic fever, Rubella, Hepatitis, HIV, Slow virus diseases, Emerging viral diseases- bird flu, swine flu and Nippah.

Unit 3: Mycology and parasitology: Fungi – General characteristics, classification based on morphology and reproduction. Fungal diseases – Superficial (*Piedra* and *Pityriasis*), Cutaneous (*Dermatophytoses*), Subcutaneous (*Mycetoma*), Deep (*Histoplasmosis*) and Opportunistic fungal infection (*Candidiasis*). Protozoa – general features and classification. Morphology, lifecycle, pathogenesis and epidemiology of protozoan parasites – *Entamoeba histolytica*, *Giardia lamblia*, *Trypanosoma*, *Leishmania* and *Plasmodium*. Helminths – *Schistosoma haematobium*, *Ancylostoma duodenale* and *Wuchereria bancrofti*.

Unit 4: Antibiotics- Classification of antibiotics based on the mode of action with one representative drug in each class- sulfonamides, quinolones, penicillins, cephalosporins, tetracyclines, aminoglycosides, macrolides. Brief outline of antifungal and antiviral drugs. Determination of MIC.

MBG3C10- Molecular Biology

Unit-1: DNA structure: Chemistry of DNA, Forces stabilizing DNA structure, Forms of DNA, Watson –Crick and Hoogsteen base pairing, Physical properties of ds DNA. Mechanisms of supercoiling in cells, Mechanism of action of Topoisomerase I and II, effect of supercoiling on structure of DNA and the role of supercoiling in gene expression. Organization of DNA into chromosomes: Eukaryotic chromosome organization and its molecular mechanism.

Unit- 2: DNA replication- Prokaryotic and eukaryotic DNA replication, mechanism of replication. Enzymes and necessary proteins in DNA replication. Telomeres, telomerase and end replication. Role of telomerase in aging and cancer. DNA Repair- Mismatch, Base-excision, Nucleotide-excision and direct repair DNA recombination- Homologous, site-specific and DNA transposition

Unit-3: Transcription- Prokaryotic and eukaryotic Transcription- RNA polymerases general and specific transcription factors- regulatory elements- mechanism of transcription regulation- Transcription termination. Post transcriptional modification- 5' cap formation-3' end processing and polyadenylation- splicing editing- nuclear export of mRNA- mRNA stability.

Unit-4: Translation: Structure and role of t-RNA in protein synthesis, ribosome structure, basic features of genetic code and its deciphering, wobble hypothesis, translation (initiation, elongation and termination in detail in prokaryotes as well as eukaryotes) Post translation modification by cleavage, self-assembly, assisted self-assembly chaperones, acylation, phosphorylation, acetylation and glycosylation, Histone acetylation and deacetylases, chromosome remodelling complex. Intein splicing. Protein targeting, co-translational import, post translational import, Lysosome targeting.

Unit 5: Molecular mechanism of gene regulation in prokaryotes-Transcriptional regulation in prokaryotes; Inducible & repressible system, positive and negative regulation; Operon concept, structure of operon, Lac, Trp, Ara operon, Catabolic repression, Attenuation. Role of Hormones in gene regulation. Antisense RNA, SiRNA, MicroRNA, Riboswitches & their applications.

Unit 6: Oncogenes & tumour suppressor genes, viral & cellular oncogenes, tumour suppressor genes from humans, pRb & p53 tumour suppressor protein.

MBG3E01. Diagnostic microbiology

Unit 1. Automated Blood Cultures. Rapid Antigen Tests.- Advanced Antibody Detection.- Phenotypic Testing of Bacterial Antimicrobial Susceptibility.- Biochemical Profile-Based Microbial Identification Systems.

Unit 2. Probe-Based Microbial Detection and Identification.- Pulsed Field Gel Electrophoresis.- In Vitro Nucleic Acid Amplification: An Introduction.- PCR and It's Variations.- Non-Polymerase Chain Reaction Mediated Target Amplification Techniques.- Recent Advances in Probe Amplification Technologies.- Signal Amplification Techniques: bDNA, hybrid capture.

Unit 3. Detection and Characterization of Molecular Amplification Products: Agarose Gel Electrophoresis, Southern Blot Hybridization, Restriction Enzyme Digest Analysis and Enzyme-Linked Immunoassay.- Direct Nucleotide Sequencing for Amplification Product Identification.- Microarray-Based Microbial Identification and Characterization.- Diagnostic Microbiology Using Real-time PCR Based on FRET Technology.

Unit 4. Bacterial Identification Based on 16S Ribosomal RNA Gene Sequence Analysis. Advance in the Diagnosis of Mycobacterium tuberculosis and Detection of Drug Resistance. Molecular Strain Typing Using Repetitive Sequence –Based PCR.

MBG3E02. Cell Biology

Unit 1- Introduction, Discovery of cell and Cell Theory. An overview of Cells – Composition of Cells Molecules of cell, cell membranes and cell Proteins. The Nucleus Nuclear Envelope- structure of nuclear pore complex, nuclear lamina, Transport across Nuclear Envelope, Chromatin: molecular organization, Nucleolus.

Unit 2- Mitochondria, Chloroplasts and Peroxisomes Structural organization, Function, Marker enzymes, Mitochondrial biogenesis, Protein import in mitochondria, Semiautonomous nature of mitochondria and chloroplast, chloroplast DNA, Peroxisomes' assembly

Unit 3- Cytoskeleton and Cell Movement Structure and organization of actin filaments; actin, myosin and cell movement; intermediate filaments; microtubules. Protein Sorting and

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Transport - The Endoplasmic reticulum, The Golgi Apparatus, Mechanism of Vesicular Transport, Lysosomes.

Unit 4. Signal transduction: electrical impulses and their transmission: Structure and electrical properties of neurons, resting potential, action potential, propagation of action potential, voltage gated and ligand gated channels, synaptic transmission, chemical signals and receptors, second messengers: cAMP, Ca ions, Ras pathway, glycogen breakdown by epinephrine. Nucleus, structure of chromosomes, chromosome banding, mitosis and meiosis, chromosomal organization Cell cycle: G1, S, G2, M phases, model organisms, MPF, cyclins, checkpoints, Role of Rb & p53. Cell cycle inhibitors

Unit 5. Cell death and cancer: Apoptosis and necrosis, apoptotic pathways, theories on apoptosis, types of tumor, induction of cancer, properties of cancer cells, oncogenes and onco genes, tumor suppressors, Molecular pathways- PIP3 Akt, MAP kinase.

MBG3E03. Microbial Taxonomy

Unit 1. Contributions of Pioneers in the field-Von Nageli, Chatton, Whittaker and Woese. Phylogenetic relationships. Brief outline of 5 kingdom classification. Three domain system-characteristics of the Domains: Bacteria, Archaea, Eukarya. Approaches in classification-Natural, Phenetic and Phylogenetic classification. Molecular or genetic approaches in classification. Numerical taxonomy.

Unit 2. Criteria used in classification-Morphological, cultural, biochemical, nutritional, ecological, serological characteristics. Principles and procedures of important tests (based on the characteristics) used in classification. Agglutination, Precipitation, ELISA, Western blotting, Phage typing, Fatty acid profile, Flow cytometry.

Unit 3. Molecular techniques: DNA base composition, DNA finger printing, Amino acid sequencing, PCR, Nucleic acid hybridisation, Southern blotting, DNA chips, Nucleic acid sequencing, Ribotyping and rRNA sequencing. Fluorescent In Situ Hybridisation (FISH).

Unit 4. Bergey's Manual of Systematic Bacteriology: Brief outline. Distinguishing features of Prokaryotes-Archaea and Bacteria. Characteristic features of the important groups under-Archaea: Crenarchaeota (Hyperthermophile) and Euarchaeota (Methanobacteriales and Halobacteriales). Bacteria: Proteobacteria (Alpha, Beta, Gamma, Delta and Epsilon),

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Nonproteobacteria (Deinococcus, Photosynthetic bacteria, Planctomycetes, Chlamydiae, Spirochetes and bacteroidetes), Gram positives -Low G+C gram positive bacteria (Firmicutes- Mycoplasma, Clostridia and Bacilli) and High G+C gram positive bacteria (Actinomycetes-Corynebacterium, Mycobacterium, Streptomyces).

MBG3L04 Practical IV

(Immunology and Medical Microbiology)

1. Acid fast staining
2. Preparation and microscopic examination of pathogenic microbes using permanent slides
3. Preparation of antibiotic discs
4. Determination of MIC
5. Demonstration of antifungal activity
6. Antibigrams of common bacterial pathogens by Kirby Bauer method
7. Detection of betalactamase production
8. Study of normal microbial flora of human beings
9. Identification of common bacterial pathogens from clinical specimen using morphological, cultural and biochemical characteristics.
10. Identification of common fungal pathogens from clinical specimen using morphological, cultural and biochemical characteristics.
11. Routes of viral inoculation in embryonated eggs
12. Blood group determination
13. Ouchterlony Double diffusion Test
14. Widal test: Slide and Tube tests
15. VDRL test
16. ELISA

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17. Immunoelectrophoresis
18. Blood cell count - TC and DC
19. ESR determination
20. Complement fixation test

MBG3L05. Practical V

(Principles of Genetics & Molecular Biology)

1. Study of mitotic stages using onion root tip
2. Meiosis
3. Agarose Gel Electrophoresis
4. DNA isolation, purification and visualization
5. Estimation of DNA
6. RNA isolation, purification and visualization
7. Estimation of RNA
8. Hyperchromic shift on DNA melting
9. Bacterial conjugation
10. Bacterial transformation
11. Isolation of plasmids
12. Induction of Beta galactosidase gene in E. coli
13. Cloning in E.coli
14. Restriction Enzyme digestion of DNA

SEMESTER 4

MBG4C11. Biostatistics and Bioinformatics

Unit 1. Biostatistics – Principles and practice of statistical methods in Biological Research; Basic statistics; Averages; statistics of Dispersion; Coefficient of variations; Standard error; Probability; Distributions; Tests of statistical significance; Students T-test; Basics of correlation and regression. Analysis of variance.

Unit -2 Introduction to Bioinformatics and Biological Databases: Biological databases - nucleic acid, genome, protein sequence -Uniprot-KB: SWISS-PROT, TrEMBL, gene expression databases. Mode of data storage - File formats - FASTA, Genbank and Uniprot. Various file formats for biomolecular sequences: GenBank, FASTA. Data submission & retrieval from NCBI, EMBL, DDBJ, Uniprot, PDB.

Unit 3- Sequence Alignments, Phylogeny and Phylogenetic trees :Local and Global Sequence alignment, pairwise and multiple sequence alignment. Scoring an alignment, scoring matrices, PAM & BLOSUM series of matrices. Types of phylogenetic trees, Different approaches of phylogenetic tree construction-UPGMA, Neighbour joining, Maximum Parsimony, Maximum likelihood.

Unit 4:- Molecular docking-types of docking-types of interaction-search algorithm, scoring function-key stages of docking-autodock -application-Drug designing. Structure prediction and protein modelling.

MBG4E04. Microbial Biotechnology

Unit 1. Production of microbial biofertilizers – cyanobacteria, *Rhizobium*, *Azotobacter*, *Azospirillum*, *Phosphobacteria* and VAM. Extremophiles and their possible uses - Thermophilic organisms. Yeasts and its uses - Brewer's and Baker's yeast - Food and fodder yeasts - yeast products and their uses. Microbes as a health food - Spirulina and its production methods.

Unit 2. Petroleum microbiology - Sedimental microbes in petroleum formation - Coal bioprocess to eliminate sulphur. Microbial enhanced oil recovery, oil spills degradation by

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microorganisms. Microbial production of fuels- H₂ and ethanol. Microbial leaching of ores - oil extraction - metal leaching and biomining. Microbes and bioremediation - role of microbes in herbicides, pesticides and other xenobiotics degradation. Degradation of toxic chemicals by *Pseudomonas*. Biotransformation - useful products obtained in biotransformation. Microbial production of products like Biopolymers and biosurfactants.

Unit 3. Immobilization of cells and enzymes. Advantages and disadvantages of immobilized systems. Enzyme based electrodes. ATPase based cell quantitation and Lumac system. Hybridoma technology for monoclonal antibodies, recombinant vaccines, Animal cell culture. Novel bioreactor designs for animal cell culture – hollow fiber, microcarrier and spin bioreactors. Probiotics - use of *Lactobacilli* and *Bifidobacterium* - therapeutic and nutritional value.

Unit 4. Microbial Insecticides, Commercial Products by Recombinant Microbes, Plant and animal Transgenesis, Cloning, Gene Therapy. Vaccine farming. Environmental impact of genetic engineering – problems of GM foods and crops, Bti. Toxin resistance of insects - cotton bollworm, tobacco budworm, use of multiple alleles of Bti toxin genes. Environmental release and monitoring of genetically modified/engineered organisms. Milk flavor manipulation through rumen microflora, mitigating greenhouse gas emission from dairying using biotechnology.

MBG4E05. Genetic engineering

Unit 1. Restriction digestion of DNA, separation by isopycnic & agarose gel methods. Cloning vectors-plasmids, BACs, PACs & YACs, cutting & joining DNA molecules, linkers, adaptors & homopolymer tailing, DNA libraries- construction of DNA libraries, genomic & cDNA libraries,

Unit 2. PCR-different types like RT-PCR, long PCR, inverse PCR, quantitative PCR, differential display PCR, nested PCR, RACE etc., probes- radiolabel led DNA/RNA probes, synthetic oligonucleotide probes, cloning strategies-cloning in E.coli, yeast & gram +ve bacteria.

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Unit 3. Expression strategies for heterologous genes, vector engineering & codon optimization, screening strategies, screening by hybridization, colony hybridization, plaque lift assay, Northern, southern & western blotting, FISH, reporter assays. (25 Marks)

Unit 4. DNA sequencing, nucleic acid microarrays, site directed mutagenesis & protein engineering, DNA introduction methods like calcium chloride facilitated uptake, microinjection, electroporation, particle bombardment, use of Ti plasmid in generating transgenic plants. Molecular markers in genome analysis: RFLP, RAPD, AFLP analysis. RNA interference. (15 Marks)

MBG4E06. Biosafety, Bioethics & IPR

Unit 1. Impacts of biotechnology – legal, socioeconomic, public elucidation of process of biotechnology in generating new forms of life. Biosafety in general, Food and feed products containing GMOs, Risk assessment/analysis, Risk management, Ethical aspects of GMOs, policy on the storage of GMOs, Gene technology act, Precautionary principle, Potential environmental risks & benefits, Potential socio-economical risks & benefits.

Unit 2. Bioethics: The Nature of Bioethics, Genetic modification/research on plants and animals, therapeutic cloning, human cloning, stem cell research. Federal Laws and the roles of: The Food and Drug Administration, The Centers for Disease Control and Prevention, The United States Department of Agriculture, The Environmental Protection Agency, State and Local Agencies

Unit 3. Patenting research tools and the law: Patents as a Strategy for Protection of Intellectual Property, Benefits and Costs of Patents, Requirements for Patent Protection, patentable subjects and protection in biotechnology, international convention for the protection of new varieties – Strasbourg convention, UPOV convention. Experimental Use Exemption. The patentability of microorganisms, legal protection for plants and other higher organisms, new plant varieties by rights, tissue culture protocols, transfer of technology. Patentability of vectors.

Unit 4. Patents on Research Tools. Access to data and intellectual property: scientific exchange in genome research. Patented research tools - Recombinant DNA, PCR, Taq Polymerase, Protein and DNA Sequencing Instruments, Research Tools in Drug Discovery.

MBG4L06. Practical VI

(Biostatistics and Bioinformatics)

1. Biological Databanks- Sequence Databases, Structure Databases, Specialized Databases
2. Introduction to National Center for Biotechnology Information (NCBI)
3. Data retrieval: Entrez, SRS and DBGet.
4. Analysis of gene sequence from nucleotide database.
5. Analysis of protein sequence from protein database.
6. Introduction to PDB and analysis of PDB file.
7. Molecular visualization
8. Gene structure and function prediction (using GenScan, GeneMark)
9. Sequence similarity searching using BLAST and interpretation of the results.
10. Multiple sequence alignment using Clustal and interpretation of the results.
11. Protein sequence analysis using ExpASy proteomics tools
12. Phylogenetic analysis using web tools
13. Phylogenetic analysis using PHYLIP
14. Sequence analysis using EMBOSS
15. Homology Modeling and structure refinement Swiss model
16. Model validation using What Check and Pro Check
17. Docking using HEX
18. Biostatistics problems
19. Statistical Analysis using EXCEL: graphical presentation
20. Regression Analysis using spreadsheet application

MBG4P. Dissertation

A dissertation should be submitted by each student as a part of the curriculum, based on a topic related to the subject area at the end of the fourth semester.

REFERENCES

1. A hand book of water and waste water microbiology – Mara & Nigel Horan
2. A text book of Medical Mycology-J. Chander
3. Advanced Techniques in Diagnostic Microbiology -Tang, Yi-Wei; Stratton, Charles W. (Eds.)2006.
4. Agricultural Microbiology – Rangaswami
5. Agricultural Microbiology – Subha rao
6. Bailey and Scott’s Diagnostic microbiology – Baron *et al*
7. Basic food microbiology – Banwart GJ
8. Biochemistry – DM Vasudevan and S Sreekumari
9. Biochemistry – Strayer
10. Biochemistry – Voet and Voet
11. Biochemistry – West and Todd
12. Bioethics: An Introduction for the Biosciences - Ben Mepham,
13. Bioinformatics - sequence and genome analysis – Mount
14. Bioinformatics computing – Bergeron
15. Biological fundamentals – Biotechnology – Ed. H.J. Rehm and G. Reid
16. Biopesticides, use and delivery – Hall and Menn
17. Biostatistical analysis - Zar
18. Biotechnology – B.D. Singh
19. Biotechnology of Integrated pest management – Persley
20. Cell & Molecular Biology-Gerald Karp.
21. Comprehensive biotechnology – Murray and Moo Yung
22. Dairy Microbiology – Robinson RK
23. Diagnostic methods in Clinical Virology : N.R. Grist
24. Environmental Biotechnology – Principles and applications –Burce E *et al.*,
25. Environmental biotechnology and cleaner bioprocess
26. Essential Clinical immunology – Helen Chappell and Mansei Haemy
27. Essentials of Diagnostic Virology: G. Storch
28. Food microbiology – Adams MR and Moss MO
29. Food Microbiology – Frazier WC and Westhoff
30. Food Microbiology -Doyle *et al.*

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31. Fundamental immunology – Paul W. E *et al*
32. Fundamental principles of bacteriology – A.J. Salle
33. Fundamentals of biotechnology – Ed. Paul Prave *et al.*,
34. Fundamentals of Immunology – Kuby
35. Fundamentals of microbiology – Frobisher
36. Fundamentals of Molecular Virology By Nicholas H. Acheson
37. Fundamentals of the Fungi- Moore
38. Fungal infections: Diagnosis and Management- Richardson and Warnock.
39. General Microbiology – Stanier
40. Genes VIII – Benjamin Lewin
41. Immunobiology – Janeway Travers
42. Immunology – Coleman *et al*
43. Immunology – Roitt
44. Industrial microbiology – Prescott and Dunns
45. Introduction to Bioinformatics – Arthur M Lesk
46. Introduction to immunology – John W Kimbal *et al.*,
47. Lehninger's Principles of Biochemistry – Nelson and Cox
48. Manuel of Industrial microbiology and biotechnology – Demain & Davies
49. Medical Microbiology - Macie and Mc. Cartney
50. Medical Microbiology : David Greenwood, Slack, Peutherer
51. Medical Mycology- Rippon
52. Medical Virology : Fenner and White
53. Microbial Ecology - Ronald M Atlas
54. Microbial genetics - Maloy, S.R., J.E., Cronana and D. Friedfelder. 1994.
55. Microbiology – Pelzar M.J, Chan *et al.*,
56. Microbiology – Prescott
57. Microbiological Applications – Alfred E Brown
58. Molecular Biology – Friefelder
59. Molecular biology of the cell – Bruce Alberts *et al.*,
60. Molecular Biology of the Gene – Watson
61. Molecular Biotechnology- Glick & Pasternac
62. Molecular Cell Biology – Lodish
63. Notes on Medical Virology By Morag. C. Timbury

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64. Plant breeding – B.D. Singh
65. Plants, genes and crop biotechnology – Chrispels & Sadava
66. Principles and Practice of Infectious diseases – Madell, Bennett, Dolin Vol-1 & 2
67. Principles of Biochemistry – White Handler and Smith
68. Principles of Fermentation technology – Stanburry PF, Whitekar
69. Principles of Gene Manipulation – Primrose
70. Principles of Microbiology – Ronald M Atlas
71. Recombinant DNA technology -Watson
72. Text book of Biotechnology – Cruger and Cruger
73. Text book of Medical Parasitology-CKJ Panicker.
74. Text book of Microbiology – Jayaram Paniker and Ananthanarayanan

M.Sc. Microbiology (CBCSS)
Ability Enhancement Course (AEC)

4 Credits

Recommended courses – Publications/ Book review/Seminar presentation

Theoretical knowledge required

Academic writing in science - Types of research papers, structure of research paper, reading a research paper and basics of writing a research paper

Language aspects of research paper, revising the paper, responding to peer reviews etc.

Ethical aspects of research writing, plagiarism.

Evaluation method

Theoretical knowledge assessed through written test
Paper published in UGC approved peer reviewed journals/Book reviews submitted by the student in the concerned subject area/seminar paper/poster presentation in state level/national/international seminars based on original works.

Professional Competency Course (PCC)

4 credits

Practical knowledge required

Application of different softwares such as SPSS/Design expert/ or any statistical software.

Data analysis and graph preparation.

Application of bibliography management softwares such as mendley and zotero.

Systematically searching the literature for systematic reviews, Evidence Based Case Reports etc.

Preparing effective presentations, power point/impress etc.

Evaluation method

Practical knowledge assessed performance test