UNIVERSITY OF KALYANI

REVISED SYLLABUS

FOR THREE YEARS B.Sc. DEGREE COURSE

(HONOURS)

IN

MICROBIOLOGY

According to the New Examination Pattern
Part – I, Part- II & Part- III

WITH EFFECT FROM THE SESSION
2009 – 2010

07/08/2009
Secretary, Faculty Councils (U.G.)
University of Kalyani
Kalyani, Nadia

UNIVERSITY OF KALYANI
KALYANI NADIA
COUNCIL FOR UNDER GRADUATE STUDIES
PROCEEDINGS OF THE 21ST MEETING OF THE (PREVIOUS) COUNCIL FOR UG STUDIES HELD ON 13/09/2005

Revised Structure and Distribution of Marks for Practical Based Subjects at UG Level w.e.f. Academic Session 2005-2006

BACHELOR OF SCIENCE (GENERAL)	PART-I	PART-II	PART-III
Compulsory English : One half paper : 50 Marks Modern Indian Language : One half paper : 50 Marks	50 Marks 50 Marks	– –	– –
Environmental Studies : One full paper* : 100 Marks*	100 Marks*	–	–
Elective Subjects : **Three** : Four full papers : 3x4x100 each =1200 Marks	3x1x100 =300 Marks	3x2x100 =600 Marks { Th: 3x1x100 = 300 Marks; Pr: 3x1x100 = 300 Marks }	3x1x100 =300 Marks { Th : 3x1x 60 = 180 Marks; Pr : 3x1x40 = 120 Marks }
AGGREGATE MARKS : 1400	**500 Marks**	**600 Marks**	**300 Marks**

BACHELOR OF SCIENCE (HONOURS)	PART-I	PART-II	PART-III
Compulsory English : One half paper : 50 Marks Modern Indian Language : One half paper : 50 Marks	50 Marks 50 Marks	- -	- -
Environmental Studies : One full paper* : 100 Marks*	100 Marks*	-	-
Elective subjects : **Two** : Three full papers : 2x3x100 each = 600 Marks	2x1x100 Marks =200 Marks	2x2x100 =400 Marks { Th: 2x1x100 =200 Marks; Pr: 2x1x100 =200 Marks }	- -
One Honours Subject = 800 Marks			
Theory: Seven Papers = 540 Marks Practical: Four Papers = 260 Marks	200 Marks (Th: 2 x 75 Marks) (Pr : 1 x 50 Marks)	200 Marks (Th: 2 x 75 Marks) (Pr : 1 x 50 Marks)	400 Marks (Th: 3 x 80 Marks) (Pr : 2 x 80 Marks)
For Computer Science Honours	For Computer Science Honours		
Theory : Seven Papers = 440 Marks Practical : Four Papers = 280 Marks Project : One Paper = 80 Marks	200 Marks (Th: 2 x 50 Marks) (Pr: 1 x 100 Marks)	200 Marks (Th: 2 x 50 Marks) (Pr: 1 x 100 Marks)	400 Marks (Th: 3 x 80 Marks) (Pr : 1 x 80 Marks) (Project : 1 x 80 Marks)
AGGREGATE MARKS : 1600	**600 Marks**	**600 Marks**	**400 Marks**

* ***With effect from the session 2009-2010.***

07/08/2009
Secretary, Faculty Councils (U.G.)
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University of Kalyani

Revised Syllabus of Microbiology (Honours Course)

(w.e.f. the session 2009-2010)

Contents

07/08/2009
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Distribution of Marks

PART I (1st year)

	LECTURES/ CLASS PERIOD	MARKS
PAPER I		**75**
Group A		
Overview of Microbiology and Diversity of Microbes	50	50
Group B		
Microbial cell & cell components	25	25
PAPER II		**75**
Group A		
Bio-molecules and Enzymology	40	40
Group B		
Biophysico-chemical Techniques Biostatistics & Bioinformatics	35	35
PAPER III (*Practical*) Fundamental Microbiology, Biomolecules & Enzymology	**20**	**50**

PART II (2nd year)

	LECTURES / CLASS PERIOD	MARKS
PAPER IV		**75**
Group A		
Bioenergetics & Microbial Metabolism	50	50
Group B		
Bacterial growth & Reproduction	25	25
PAPER V		**75**
Group A		
Microbial Genetics	35	35
Group B		
Molecular Biology	40	40
PAPER VI (*Practical*) Bacterial growth, Molecular Biology & Genetics	20	**50**

PART III (3rd year)

	LECTURES/ CLASS PERIOD	MARKS
PAPER VII		**80**
Group A		
Recombinant DNA Technology	40	40
Group B		
Food & Industrial Microbiology	40	40
PAPER VIII		**80**
Group A		
Epidemiology & Medical Microbiology	40	40
Group B		
Immunology & Immuno-diagnostics	40	40
PAPER IX		**80**
Group A		
Environmental & Agriculture Microbiology	60	60
Group B		
Microbial Biotechnology, IPR & Bioethics	20	20
PAPER X (*Practical*) Food, Industrial and Agriculture Microbiology	25	**80**
PAPER XI (*Practical*) Medical & Environmental Microbiology and Microbial Biotechnology	25	**80**

Note : The duration of each theory lecture period is 45 minutes;

The duration of each Practical class is 180 minutes

Since all students studying Microbiology (Honours) have to offer compulsory c ourses in Chemistry, lectures/topics on general chemical background have not been duplicated. However, in cases where emphasis on certain topics is essential relevant aspects have been included.

PART- I

PAPER- I

Group A : (Overview of Microbiology and Diversity of Microbes) 50

Overview of Microbiology, Virology and Diversity of Microorganisms. Its importance in the sustenance of all forms of life on Earth, ecological balance, contributions to human welfare and understanding of life processes. Land marks in Microbiology. (3)

Origin of life:

The theory of Extraterrestrial contact – import of life through meteorites. Theory of Chemical Evolution, Primitive Earth conditions – anoxic reductive atmosphere, relatively high temperature, volcanic eruption, radioactivity, high frequency UV radiation. Abiotic formation of sugars, amino acids, organic acids, purines, pyrimidines, glycerol, and formation of nucleotides and their polymerization to RNA on reactive surfaces, polymerization of amino acids to polypeptides and proteins. Ribozymes. Formation of DNA. Formation of nucleoproteins. Natural Selection of self replicating polymers. (5)

Viruses:

Viruses as nucleoproteins. Their origin by retrograde evolution. Structures and properties of viruses, virion size, enveloped (Herpes), helical (TMV) and icosahedral (Polyoma) capsids, viral envelopes and enzymes. Classification of viruses on the basis of their nucleic acid structures. Virus related components: Viroids and prion (8)

Bacteriophages – viruses of Bacteria, single stranded and double stranded RNA and DNA phages. Reproduction of DNA and RNA phages. Lytic and temperate phages. Lysogeny, life cycles of T_4 and λ phages. Typing of phages. (7)

Phylogeny of prokaryons:

Diversity of more complex unicellular complex microorganisms: Monera (Prokaryote), Protista. Five kingdom domains in Whittaker's system of classfication and Archaea, Bacteria and Eukarya, RNA world. Theory of endosymbiogenesis. (7)

An account of prokaryons:

Brief accounts of major subgroups of these classes. The thermophlic, methanogenic and halophilic Archaea; photosynthetic bacteria, Cyanobacteria, Gram positive and Gram negative Eubacteria; including the five classes of Proteobacteria, Spirochetes and Actinomyectes. (10)

An account of eukaryotic microbes:

Brief description of eukaryotic micro-algae, particularly Cholorophyta and Bacillariophyta, Fungi including Zygomycetes, Oomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes (imperfect and perfect stages) and Protozoa (*Giardia*, *Entamoeba* and *Plasmodium*). (10)

Group B : (Microbial cell & cell components) 25

Structure and function of prokaryotic cells and cell components:

Bacterial cell size and shape: Physiological benefit from size and shape; skeletal proteins for shape. (2)

Cell envelope: The Slime layer and the cell-wall of bacteria containing peptidoglycan and related biomolecules; the outer membrane of Gram negative bacteria, the cytoplasmic membrane and their functions. (4)

Cytosolic structural and functional components: Mesosomes, ribosomes; polyhydroxy alkanoates, magnetosomes, carboxysomes, sulfur granules, glycogen, polyphosphate bodies, fat bodies and gas vesicles. The bacterial genome (linear and closed); a brief account of plasmids and episomes. (7)

Cellular appendages and motility: flagella, pilus/ fimbraiae, Gliding and flagellar motility with special reference to chemotaxis. (3)

Bacterial way of perennation: Endospores, exospores, cysts, myxospores, heterocysts and akinets (4)

Structure and function of eukaryotic cells and cell components:

Structure and function of cell envelope with special reference to membrane structure. Organellar structures, ultrastructure of chromosome and its organization. Cytoskeleton. (5)

PAPER- II

Group A : (Bio-molecules and Enzymology) 40

Biomolecules in life:

Water and its importance in life. Essential macronutrients and micronutrients, Carbohydrates, amino acids, saturated and unsaturated fatty acids – their structures, types and properties. (9)

Detailed discussion on the types, structure, constitutents, properties and stability of DNA and protein. Determination of base composition from helix-coil transition temperatures and nucleotide sequences of DNA. Determination of amino acid sequences of protein, extraction and separation of proteins and nucleic acids. Determination of their molecular weights. (13)

Enzymes:

Nature, nomenclature, properties and classification; coenzymes and cofactors, metal ion requirements, isolation and characterization. Enzyme kinetics, Michaelis-Menten constant, factors affecting enzyme action. Mechanism of action of enzymes. Inhibition of enzyme action - competitive, non-competitive and uncompetitive. Allosteric and feed back effects. (18)

Group B : (Biophysico-chemical Techniques, Biostatistics & Bioinformatics) 35

Biophysico-chemical Techniques:

Microscopy: Light, phase contrast, fluorescence and electron microscopy – scanning and transmission. (3)

Principles of spectrophotometry, Chromatographic techniques, tracer technique, autoradiography, ultracentrifugation and electrophoresis. (8)

Biostatistics:

Population, Sampling, Ramdomized Block Design. Central Tendency. Determination of mean, median, mode, standard deviations and standard error of the means. Laws of probability. Test of hypothesis: Students' t-test, Chi-square tests. Correlation coefficients and regression. Analysis of variance. (12)

Bioinformatics:

Overview of bioinformatics. Database types used for nucleic acid and protein sequence study, relatedness study. Molecular phylogenetic lineage study. (12)

PAPER- III (Practical)

(Fundamental Microbiology, Biomolecules & Enzymology) 50 marks

1. Microscope and its operation, Microscopic measurements, micrometer, haemocytom eter
2. Observation of bacteria, yeast, microalgae, protozoa under light microscope.
3. Bacterial staining – Gram stain, capsule and spore staining.
4. Observation of morphology – shape and arrangement of cells.
5. Sterilization : principles and techniques – dry heat, wet heat, steam sterilization, filter sterilization, use of *uv*-radiation, sterilization, use of disinfectant, use of laminar air flow chamber.
6. Preparation of culture media – media for bacteria, fungi and actinomycetes according to nutritional needs of microbe (selective, differential, enrichment).
7. Methods of inoculation.
8. Preparation of solid and broth – slant, stab and plate culture technique.
9. Pure culture and dilution plate techniques.
10. Microscopic study of phytoplankton and zooplanktons.
11. Isolation and culturing of soil fungi and their microscopic study.
12. Sampling and quantification of microorganisms in air, soil and water using dilution plating technique.
13. Isolation and their quantification of protein and nucleic acid (DNA and RNA) from microorganisms or other sources by colorimetry.
14. pH, pK Henderson-Hasselbach equation, preparation of buffers.
15. Techniques of paper, thin layer and column chromatography.
16. Determination of Km and V_{max} with and without competitive and non-competitive inhibitors.
17. Extraction of bacterial alkaline phosphatase and its assay.
18. Viscometric determination of enzyme activity (Pectinase /Cellulase).
19. Estimation of carbohydrates (Anthrone) and proteins (Lowry).
20. Identification and estimation of amino acids, organic acids.
21. Quantification of DNA and RNA by diphenylamine and orcinol methods.

PART- II

PAPER : IV

Group A :(Bioenergetics & Microbial Metabolism) 50

Thermodynamics:

Laws of Thermodynamics. Redox Systems. Relationship between re dox-potential and free energy, entropy and enthalpy. Exergonic and endergonic reactions Activation energy. (4)

Nutritional types:

Autotrophy, chemolithotrophy, organotrophy, mixotrophy, syntrophy (2)

Anabolic functions and energetics:

The conversion of light energy into chemical bond energy. Role of bacterio -chlorophyll in photosynthetic bacteria and chlorophylls in green algae. The role of accessory pigments. Oxygenic & anoxygenic photosynthesis and electron flow. Cyclic and non -cyclic phosphorylation. (7)

Chemolithotrophy:

Energy from the oxidation of inorganic electron donors, sources of donors; energetic of chemolithotrophy with special reference to nitrifying, iron and hydrogen bacteria. (4)

Carbon assimilation:

The reduction of CO_2: Calvin cycle, Reverse citric acid cycle and hydroxypropionate cycle; their stoichiometry and key enzymes involved therein. (4)

Catabolic functions and energetics:

Oxidation of pyruvate through Krebs' citric acid cycle. Chemiosmotic theory of ATP Synthesis. Electromotive and protonmotive forces. Substrate level and oxidative phosphorylation. (5)

Electron donors and acceptors in biological systems. Inorganic electron donors and acceptors and energy efficiency of such systems. Oxidation of H_2, reduced S-compounds and Fe^{2+}. The reduction of nitrate and denitrification. Reduction of sulphate. Methanogenesis, acetogenesis. (7)

Energetics and redox considerations in fermentation. EMP, HMP and Entner -Doudoroff pathways. Production of ethanol and lactic acid. (4)

Biological N_2-fixation:

Diversity of N_2-fixers. Free living N_2-fixation by anaerobic (*Clostridium*), facultatively anaerobic (*Azospirillum*), and aerobic (*Azotobacter*), N_2 - fixers associated with stem, root and leaf. Symbiotic N_2-fixation in legumes and non-legumes by *Rhizobium* and *Frankia*,. N_2-fixation by cyanobateria. Energetics of N_2-fixation, O_2-sensitivity and inhibition by ammonia and nitrogenous substance in the case of nitrogenase. Biochemical regulation of nitrogenase and co - factors. A brief idea on alternate nitrogenase of *Streptomyces thermoautotrophicus*. (8)

Lipids as source of energy

Fat breakdown: β-oxidation and ω-oxidation of fatty acids. Synthesis of fatty acids. (5)

Group B : (Bacterial growth & Reproduction) 25

Growth:

Definition of microbial growth; methods of growth measurements; growth phases and its expression. Mathematical expression of growth; determination of generation time and growth rate constant; growth yields. Diauxy (8)

Growth conditions: Environmental factors affecting growth: temperature, pH, osmotic pressure and nutrient concentration. Culture type; Batch, fed -batch, continuous and synchronous cultures. (3)

Reproduction:

Binary fission, budding and fragmentation. Bacterial cell cycle and its regulation with special reference to the involvement of different functional proteins (Fts, MreB, Min); divisome; brief outline of cell wall synthesis and its assembly outside the membrane. Regulation of bacterial endosporulation. (7)

Microbial growth control:

Physical methods: dry and moist heat, pasteurization, tyndalization; radiation, ultrasonication, filtration. *Chemical methods*: disinfectants, antiseptics and sterilants; fumigation; antimicrobial agents like β-lactam, macrolids, aminoglycosides, polyene, quinines and peptide antibiotics; growth factor analogs. (7)

PAPER- V

Group A : (Microbial Genetics) 35

Bacterial genetics and its deviation from Mendelian concept. Genomic organization in prokaryotes. Concept of gene: cistrons, recon, muton, intron and extron; Central dogma. (8)

Genetic recombination in bacteria:

Transformation, Conjugation (F^-, F^+, Hfr and F′), Transduction (generalized and specialized). Homologous and site-specific recombination. Genetic mapping in bacteria and genetic linkage study, interrupted matting. Horizontal gene transfer and its role on microbial diversity and evolution. Plasmids: structure, function, their maintenance; plasmids for genetic analysis. (10)

Mutation:

Spontaneous and induced mutations. Spontaneous mutation and its mechanisms. Determination of mutation rates, replica plating, prototrophs and auxotrophs. Luria and Delbruck's fluctuation tests. Types of mutation: point mutation, deletion, insertion, frame-shift mutation, silent mutation, non-sense mutation and missense mutation; Mechanisms of mutation: transition, transversion and tautomeric effects. Mutagenic agents: physical and chemical mutagens; their mode of action as mutagen. (9)

Transpositon: Transposon and insertion sequence; their role as mutagen and evolution. (3)

***DNA repair*:** Photoreactivation, dark repair, SOS response, mismatch repair (5)

Group B : (Molecular Biology) 40

Nucleic acid as genetic material*:* its proof; DNA replication in bacteria and virus – replication fork, bidirectional replication (θ-model), rolling circle model. (6)

***Nucleic acid synthesis*:** synthesis of DNA – initiation, proof reading and termination, DNA polymerases and reverse transcriptase. Synthesis and processing of RNA – promoters and terminators, transcription factors, post-transcriptional modification. Differences between prokaryotic and eukaryotic transcription. DNase and RNase, restriction endonuclease and its use. (11)

***Protein synthesis*:**

The genetic code and its nature. Activation of amino acids and initiation, elongation and termination of polypeptide chain. Role of rRNA. Differences between prokaryotic and eukaryotic processes. Post-translational modification of peptide, its transportation. Non-ribosomal peptide synthesis with special reference to cyclic polypeptide antibiotics synthesis in bacteria (10)

***Gene function regulation*:**

Regulation of nucleic acid and protein synthesis. Positive and negative control. Regulatory and structural genes. Catabolite repression. Antisense nucleic acids. (7)

Genomics and Proteomics:

A basic idea. Basic concept of molecular phylogeny of bacteria : use of 16s rDNA sequence abd signature (4)

PAPER - VI (Practical)

(Bacterial growth, Molecular Biology & Genetics) 50 marks

1. Microbial growth measurements – cell count, turbidity measurement, percentage transmission/OD, and estimation by dry weight in broth culture.
2. Isolation of microorganism for different habitats –using selective medium.
3. Antibiotic assay : cup method and MIC method.
4. Determination of phenol coefficient.
5. Determination thermal death point.
6. Phage assay – phage induction.
7. Plasmid DNA isolation.
8. Induced mutagenesis in bacteria (auxotrophy) and in fungi (spore colour in *A. niger*).
9. Replica plating technique.
10. Auxotrophic mutant/ antibiotic mutant isolation.

PART-III

PAPER - VII

Group A : (Recombinant DNA Technology) 40

Techniques: Detection, isolation and characterization of genes. Polymerase chain reaction. U se of restriction and modification enzymes in recombination DNA techniques – DNA ligase, polynucleotide kinase, reverse transcriptase, cDNA and genomic libraries. (12)

Vectors used for cloning, natural vectors – plasmids, viruses. Shuttle vectors, Specia lized vectors – yeast, bacterial artifical chromosomes, cosmid and phagemids. Methods of introduction of foreign DNA, transformation, electroporation and use of nanoparticles. Reporter genes. (10)

Expression and detection:

Expression of introduced genes in prokaryotes from eukaryotes and *vice versa*. Northern Blot, Southern Blot and Western Blot. Detection of introduced gene and its expression by tagging and by probes. (8)

Application of transgenesis:

Genetic Engineering in Plants: Use of *Agrobacterium tumefaciens, A. rhizogenes* and antisense nucleic acids as the tools for the development of transgenic plants. Genetically modified (GM) crops: insect resistance – BT crops, plants for the production of vaccines. (5)

Genetic engineering in animals: Development of transgenic animals. Therapeutic products by genetic engineering – blood proteins, immune modulators and vaccines (5)

Group B : (Food & Industrial Microbiology) 40

Food Microbiology:

Microbiology of milk, production of cheese and yogurt; production of traditional fermented foods- idli, kinema, pickles. Production of single cell proteins from algae and yeast. Mushroom cultivation. Use and production of probiotics. (7)

Food spoilage: Reasons of spoilage of fresh and cooked food, canned food and other edible products. (2)

A brief account on common food-borne infections and toxicoses – salmonellosis, botulism, mycotoxicosis. (3)

Food preservation: Principles and techniques- pasteurization, appertization, aseptic packaging; use of high temperatures, freezing, dehydration, ionizing radiation, osmotic pressure; use of chemicals as preservatives – organic acids, esters, sulphur-dioxide, salts and high sugar concentration; canning (6)

Industrial Microbiology:

Scope of industrial microbiology. Principles of screening, selection, improvement and maintenance of industrially important microbial cultures with high yield potential. (4)

Bioprocessing: Fermentation media, fermentation system- prerequisite of a fermenter. Types of fermenter: Stirred tank, bubble columns, airlift bioreactors. Static, submerged and agitated fermentation. Batch, fed-batch and continuous cultures. Monitoring growth conditions in bioreactors, Concept of hazard analysis and critical control points. Solid state fermenta tion. Use of immobilized cells and enzymes. (8)

Industrial Production: ethylalcohol, acetic acid (vinegar), citric acid, α-amylase and protease B_{12} using cost effective raw materials. Production of penicillin. Production of microbial biopolymers, Biomining and bioleaching of ores. Retting of jute. Hybridoma techniques for monoclonal antibody production. (10)

PAPER: VIII

Group A : (Epidemiology & Medical Microbiology) 40

Human and microbes: Normal microbial flora of the human body. Direct and indirect host to host transmission, zoonosis, hospital borne infections. General account of epidemiology and disease surveillance. Measures for prevention of epidemics. Disease forecasting. Disease cycle. Herd immunity (10)

Mode of entry, colonization and growth. Damage to host cell, virulence, virulence factors- exotoxins, endotoxins, neurotoxins and enzymes with special reference to Cholera toxin, enterotoxin, dephtheria toxin and tetanospasmin. (10)

Pathogens, symptomatology, epidemiology, and measures of AIDS, viral influenza, Cholera, Tuberculosis, Tetanus, Plague, Dermatomycosis, Malaria (9)

Chemical control of Pathogens*:* Naturally produced drugs. Antibiotics produced by bacteria, actinomycetes and fungi used in chemotherapy. Classification of antibiotics on the basi s of structure and mode of action. Assay of antibiotics, antibiotic spectrum Semisynthetic antibiotic. Sulfa drugs, their use and mechanism of action. Naldixic acid, nitrofurans, isonicotinic hydrazide, metronidazole; Prophylactic agents. Drug toxicity. Dr ug resistance – chromosomal mutation and plasmid-borne multiple drug resistance. (11)

Group B : **(Immunology & Immuno-diagnostics)** **40**

Human and its defenses against pathogens :

Different line of defenses: physical barrier, chemical defense and cellular defense. Components of cellular defense – blood and lymphatics, leukocytes, lymphocytes (B-cell, and T-cells), phagocytes, macrophages. The immune response – non-specific defense, opsonization, phagocytosis; specific immune response and acquired immunity, antigens and antibodies: nature and functions; Immunoglobulins - structure and diversity. Antigen – antibody reactions. Cytokines, T-Cell receptors. Antigen presentation; Major histocompatibili ty complexes. B-lymphocytes and antibody production, memory cells; complement system; Hypersensitivity; Inflammation autoimmune response. Graft rejection. Super antigens, Immunodeficiencies and parasitic infections. (29)

Immuno-diagnostics:

Neutralization, precipitation, agglutination. Completement fixation, immunoduffusion, Enzyme-linked Immounosorbent Assay (ELISA). Immuno-fluorescence. Radioimmunoassay. immunobloting. Serotyping. (7)

Immunization for prevention of diseases: vaccines, toxoids. Immuniz ation programmes – role of WHO. (4)

PAPER – IX

Group A : (Environmental & Agriculture Microbiology) 60

Environmental microbiology:

Concept of microbial ecology, microbial community, diversity: thermophiles, mesophiles, psychrophiles and other extremophiles. Global warming and its impact on microbial diversity. (5)

Microbes in marine environment, ocean thermal vents and hot springs (2)

Microbiology of Air: Occurrence and survival of microorganisms in air. Normal air-borne microorganisms and fungal spores. Air borne diseases. Room sterilization. Aeromicroflora of hospitals. (4)

Microbiology of fresh water: Factors affecting survival of microbes in aquatic systems. Microbiology of drinking water - microbes as indicator of water quality, Coliforms and its further test. Determination of potability of water. Purification of drinking water. (7)

Microbiology of liquid and solid waste: Biomonitoring of pollution in water, physiocochemical parameters for water quality study - pH, presence of heavy metals, BOD and COD. Microbiological treatment of sewage and industrial waste, composting. (7)

Microbiology of Soil: Factors affecting survival of soil microbes, microsites. Water availability and nature of water-logged soil environment. Microorganisms in deep subsurface soil layers. Availability of minerals and microbial activity. Microbiology of forest soil. (6)

Biogeochemical Cycles: Nitrogen, Sulfur, Phosphorus, Carbon and Oxygen cycles, their role in maintaining soil fertility and ecological balance, and role of different microbial communities therein. (7)

Biodeterioration: Deterioration of paper, leather, textile production, painted surfaces and their prevention; microbial corrosion of metals (3)

Agricultural Microbiology:

Plant-Microbe interactions: Microorganisms in the rhizosphere, rhizoplane and phylloplane. Principles and attributes of selecting biofertlizers (PGPR/ PGPF) - phosphate solubilizing, IAA, GA, siderophore producing, and N_2-fixing microbes; Formulation of biofertlizer for marketing, preparation of inoculum and carrier materials. *Methods of inoculation* : Seed treatment with *Rhizobium* to ensure nodulation with effective strains. Inoculation of inundated rice fields with N_2-fixing cyanobacteria or *Azolla* harbouring *Anabaena azollae*. Foliar spray of N_2-fixing bacteria like *Klebsiella* on crop plants. Advantages and limitations of such treatments. N_2-fixation in fallow lands. Use of vesicular arbuscular mycorrhizal (VAM) fungi in sustainable agriculture. (13)

Biological control of soil-borne microbial pathogens and nematodes. Microbial pesticides. Entomopathogenic fungi for pest management. Interaction of synthetic pesticides with soil microorganisms. (6)

Group B : (Microbial Biotechnology, IPR & Bioethics) 20

Biotechnological approach for ecorestoration; Bioremediation of pollutants – hydrocarbons, heavy metals, halogenated hydrocarbons. Concept of biosensor. (6)

Biotransformation of steroids and commercial production of hormones (insulin). Conversion of waste into energy. Biofuel/ biogas production at commercial level. (4)

Large scale commercial production of recombinant vaccine and interferon. (1); Bioterrorism (1)

Problems related with release of GMMs with special reference to biohazards, ethics, and ecohazards. Intellectual property rights and its importance, patenting of biotechnological product and process. (8)

PAPER- X (Practical)

(Food, Industrial and Agriculture Microbiology) 80 marks

1. Preparation of Yoghurt.
2. Microbial quality study of fresh salad vegetables using di lution plating technique.
3. Microbial quality assessment of drinking water (coliform count, MPN count), presumptive and confirmatory tests of coliforms.
4. Mush room cultivation (lab type).
5. Citric acid production, its qualitative assay by TLC.
6. Isolation of symbiotic N_2-fixing bacteria from root nodules from leguminous plants.
7. Isolation of free-living N_2-fixing bacteria from soil.
8. Phosphatase test of milk.

PAPER- XI (Practical)

(Medical & Environmental Microbiology and Microbial Biotechnology) 80 marks

1. Isolation and enumeration of phosphate solubilising, cellulose decomposing and starch hydrolyzing bacteria from different habitats (plate count method).
2. Assessment of nitrifying activity in soil.
3. Measurement of soil pH, N-content (kjeldahl method), P-content, C-content.
4. *In vitro* study of antagonism (dual culture technique).
5. Effect of heavy metals on microbial ghrowth (in vitro).
6. Microscopic study of protozoan pathogen in clinical sample (Demonstration).
7. Antigen-Antibody interaction – agglutination test.
8. Antibiotic sensitivity test on isolated *E. coli* strain.
9. Widal and tuberculin test (Demonstration).