To
The Principals/T.I.C.
of all the Undergraduate Colleges
offering B.Sc. (Honours) in Microbiology
affiliated to the University of Calcutta

Sir/ Madam,

The undersigned would like to forward you the Draft Syllabus for Microbiology (Honours), to be implemented from the academic session 2017-2018 to get feedback from the Department of Microbiology in your college.

You are requested to send your feedback within 15th February, 2017.

In this regard you may send your observations/ suggestions to the Department of U.G. Councils, C.U. or through email (u.g.councilsc.u@gmail.com) or you may contact Prof. Sanjay Ghosh, Department of Biochemistry, C.U. (Mob:9433394502; email: sgbioc@caluniv.ac.in and sgbioc@gmail.com).

Your cooperation in this regard will be highly appreciated. Kindly treat the matter as urgent.

Thanking you,

Yours faithfully,

(Milan Kr. Pal)
O.S.D., C.U.
UNIVERSITY OF CALCUTTA

DRAFTSYLLABUS

FOR

THREE-YEAR HONOURS
DEGREE COURSE OF STUDIES

MICROBIOLOGY
2017
Syllabus for Microbiology Honours

Part I: 200 Marks

Paper I: 100 Marks

Group A: Biomolecules

Unit I
1. Carbohydrates
2. Amino acids

Unit II
1. Proteins
2. Nucleic Acids
3. Lipids

Group B: General Microbiology

Unit I
1. The evolution of microorganisms and microbiology
2. Fundamentals of Taxonomy
3. Stains and Staining techniques
4. Bacterial morphology and subcellular structures

Unit II 1
1. Eukaryotic microbes
2. Microbial nutrition
3. Bacterial growth
4. Control of growth of microorganisms
Paper II: Marks

Group A: Environmental Microbiology and Biophysical Chemistry

Unit I

1. Air Microbiology
2. Soil Microbiology
3. Biogeochemical cycles

Unit II

1. Fundamentals of thermodynamics and bioenergetics
2. Fundamentals of Spectroscopy
3. Physical and chemical properties of water
4. Microscopy

Group B: Practical

UNIT I

1. Microbiology: Good Laboratory Practices and Biosafety.
2. To study the principle and applications of important instruments.
3. Preparation of culture media.
5. Staining techniques for examination of microorganisms

UNIT II

1. Qualitative tests of biomolecules
2. Separation of aminoacids by Thin Layer Chromatography.
3. Estimation of amino acid by formol titration.
4. Internal assessment
PART II; 200 Marks

Paper III: 100 Marks

Group A: Molecular and Cellular Biology

Unit I
1. Replication, Transcription and Translation in Prokaryotes

Unit II
1. Eukaryotic cell biology

Group B: Metabolism and Bioenergetics

Unit I
1. Enzymes
2. Amino Acid Metabolism

Unit II
1. Carbohydrate metabolism
2. Purine and Pyrimidine metabolism
3. Lipid metabolism

Paper IV: 100 Marks

Group A: Food Microbiology, Water Microbiology and Industrial Microbiology

Unit I
1. Food Microbiology
2. Water Microbiology
3. Industrial Microbiology

Unit II
1. Biometry
2. Instrumentation /Techniques for Characterization of biomolecules
3. Fundamentals of Radioactivity

**Group B: Practical**

**UNIT I**

1. Micrometry and Enumeration of microbes
2. Isolation of pure culture from natural sources:
3. Growth curve of bacteria
4. Assay of antibiotics
5. Determination of Minimal Inhibitory Concentration (MIC) of antibiotic

**UNIT II**

1. Water microbiology
2. Milk microbiology
4. Internal assessment
PART III: 400 Marks

Paper V: 100 Marks

**Group A: Microbial Genetics**

Unit I

1. Mendelian genetics  
2. DNA, Gene and Chromosomes  
3. Linkage and Crossing over  
4. Genetic Exchange

Unit II

1. Mutation and Repair  
2. Recombination

**Group B: Recombinant DNA Technology and Bioinformatics**

Unit I

1. Recombinant DNA Technology  
2. Genomics and Bioinformatics

Unit II

1. Mycology
Paper VI: 100 Marks

Group A: Medical Microbiology and Virology

Unit I

1. Medical Microbiology

Unit II

1. Virology
2. Microbial community

Group B: Immunology

Unit I

1. Introduction: overview of the Immune system
2. Cells and organs of Immune system
3. Types of Immunity
4. Antigens

Unit II

1. Immunoglobulins
2. Antigen - Antibody interactions
3. Complement
4. Hypersensitivity: definition, types, examples.
5. Vaccines

Paper VII (Practical): 100 Marks

UNIT I

1. Isolation and characterization of one industrially important enzyme (amylase) and immobilization of amylase producing cells.

2. Determination of Km, Vmax and pH optima, effect of activator, inhibitor of alkaline phosphatase.
3. Industrial/Institutional visit and report preparation

UNIT II

1. Protein estimation by Lowry method.
2. Absorption spectra of DNA and protein, hyperchromic shift of DNA.
4. Internal assessment

Paper VIII (Practical): 100 Marks

UNIT I

1. Antigen-Antibody reaction:
   a) Agglutination (blood typing method)
   b) Ouchterlony's agar double diffusion method (Dilution study and study of patterns)
   c) Single radial immunodiffusion (Mancini's method),
   d) Immunoelectrophoresis.

2. Restriction digestion of lambda and plasmid DNA.
   Visualisation of the DNA fragments by Agarose gel electrophoresis.

UNIT II

1. Isolation of plasmid-DNA (E.coli - DH 5α)
2. Agarose gel electrophoresis.
3. Quantification of plasmid DNA and checking the purity.
   4. Isolation of Genomic DNA and visualisation of the DNA fragments by Agarose gel electrophoresis.
   5. Transformation of E. coli using plasmid DNA by CaCl₂ method.
6. Internal assessment.
UNIVERSITY OF CALCUTTA

DRAFTSYLLABUS

FOR

THREE-YEAR HONOURS
DEGREE COURSE OF STUDIES

MICROBIOLOGY

2017
PART –I: 200 marks

Paper I

Group A: Biomolecules (50 marks)

UNIT I

1. Carbohydrates (12)
   Definition, classification, properties and structural concept of: Monosaccharides: Hexoses (only Glucose, fructose), Pentoses (Ribose, Ribulose, Xylose)
   Disaccharides: Sucrose, Lactose, Maltose Amino Sugars: Glucosamine, Muramic Acid, Sialic acid. Inversion (hydrolysis) of cane sugar. Chemical reactions of monosaccharides (glucose & fructose i.e., aldose and ketose) with HN0₃, Br₂ - water, HI0₄, Phenylhydrazine. Glycosides, Principle of chemical estimation of sugar. Anomeric effect (Methylation effect). Polysaccharides: Chemical structure of Starch (α- amylose, amylopectin), glycogen & cellulose, cell wall. Smith degradation and enzymic hydrolysis of α-amylose & amylopectin. Projection formula (Fischer & Howarth); Pyranose and Furanose forms of carbohydrates; Isomers: anomers, epimers. Stereochemistry of cyclohexane: idea of axial & equatorial bonds (related to chair form conformation) for representing the structures of carbohydrates in chair form. Mutarotation and its mechanism.

2. Amino Acids (13)

UNIT II

1. Proteins (10)
   Peptides: peptide bond, biologically important peptides (glutathione, oxytocin-important functions). Classification (Primary, Secondary, Tertiary, Quaternary-definition, examples) Forces that stabilize structure of proteins: H-bonds, hydrophobic interaction, electrostatic attraction, Van der Waal's interaction, dipole-dipole interaction. Types of proteins: i) Fibrous (α -helix, β - sheet, e.g. collagen): definition and structure. ii) Globular (Haemoglobin, Myoglobin): definition & structure , examples. iii) Simple proteins and conjugated protein: definition & examples—physical denaturation and renaturation.

2. Nucleic acid (7)

3. Lipids (8)

Definition, nomenclature, classification - (simple, complex, derived lipids - structure & example) phospholipids, glycolipids, - (structure, composition); hydrolysis, saponification, saponification number, Iodine number, acetylation, acetyl number, volatile fatty acid number - definition and related problems, Isomerism - cis-trans isomerism. Fatty acids: Saturated (palmitic acid, stearic acid), unsaturated (oleic acid): Structure of free fatty acids (example only). General chemical reaction of fatty acids - esterification. Hydrogenation and halogenations. Rancidification of Oil.

Suggested textbooks:
- 1. Finar, IL. Organic Chemistry, Part I and Part II
- Lehninger, Stryer, Voet and Voet, Debajyoti Das, Biochemistry
- Morrison Boyd, Organic chemistry
- Solomons, Organic chemistry
- Subroto Sengupta, Organic Chemistry

Group B: General Microbiology (50 marks)

UNIT I

1. The evolution of microorganisms and microbiology (5)
   A brief idea of the members of the microbial world
   Microbial evolution- evidence for the origin of life, preliminary concept of RNA world, endosymbiotic hypothesis. Basic concept of microbial species
   Theory of abiogenesis and biogenesis- Pasteur’s experiment with swan-necked flask
   Germ theory of disease and Koch’s postulates, its drawbacks and Molecular Koch’s Postulates.
   Discovery of antibiotics- contribution of Alexander Fleming
   Microbial ecology – contribution of Winogradsky and Beijerinck

2. Fundamentals of Taxonomy(5)
   Whittaker’s five-kingdom classification- classification basis, major characteristics of the kingdoms, drawbacks of the classification scheme. Three domain classification scheme of Carl Woese- classification basis, major characteristics of the kingdoms, drawbacks of the classification scheme. Morphological features of Eubacteria, Archaeabacteria and Eukarya
   Outline of Principles of Bacterial taxonomy-Phenetic, Cladistic and Polyphasic approach, Numerical taxonomy, Bergey’s Manual

3. Stains and staining techniques (5)
   Definition of stains and their components- auxochrome, chromogen and chromophore
Physical basis of function of stains
Classification of stains on the basis of their structures.
Simple, differential and negative staining methods.
Mordants and their functions.
Gram staining and its mechanism.
Endospore staining.
Capsule staining.
Acid fast staining.
Flagella staining

4. **Bacterial morphology and subcellular structures (10)**
   General features of a typical bacterial cell- its shape, arrangement and size.
   Bacterial cell envelope- chemical composition, structural features and functions of bacterial plasma membrane (eubacterial and archaeabacterial), cell wall including Gram negative outer membrane (porins, periplasm, teichoic acid, protoplast, spheroplast, cell wall less bacteria, archaeabacterial cell wall), capsules and slime layers, S-layer.
   Bacterial cytoplasm- chemical composition, structural features and functions of bacterial cytoskeleton, bacterial inclusion bodies, bacterial ribosomes, nucleoid, plasmids.
   Bacterial cell external structures- chemical composition, structural features and functions of bacterial flagella, pili and fimbriae, flagellar movements (swimming, swarming), spirochaete motility, twitching and gliding motility, chemotaxis.
   Bacterial endospores- location, size, structure, resistance, sporulation process and germination process, exosporis and cysts- structural and functional comparison.

**UNIT II**

1. **Eukaryotic microbes (5)**
   General characteristics, vegetative and reproductive structures of fungi (yeasts and molds), fungal classification with example.
   Algae-classification with example (special emphasis on cyanobacteria).
   Protozoa (Giardia, Plasmodium and Entamoeba)

2. **Microbial Nutrition (7)**
   Nutritional types (definition and example)- photoautotroph, photoorganotroph, chemolithotroph (overview and example of ammonia, nitrite, sulfur, hydrogen and iron oxidizing bacteria), chemoorganotrophs, copiotrophs, oligotrophs and myxotrophs. Different types of growth media for laboratory culture of microorganisms (defined, undefined, selective, differential, enriched media and example, anaerobic culture media).
   Classification of microorganisms on the basis of oxygen requirement and tolerance.

3. **Bacterial growth (7)**
   Characteristics of bacterial growth phases, generation time, kinetics of bacterial growth, growth rate constant, semilogarithmic pattern of bacterial growth curve, cryptic growth, diauxic growth,
   Measurement of bacterial growth (total count and viable count, pour plate and spread plate technique, serial dilution- its merits and demerits in culturing microorganisms, pure culture isolation). Batch culture and continuous culture; synchronous culture
Physical factors influencing bacterial growth—temperature, pH, osmotic pressure, salt concentration; molecular adaptation of microorganisms to thermophily, psychrophily and osmophily.

4. **Control of growth of microorganisms (8)**
   General concept of sterilization, disinfection, antiseptic, sanitizer, germicide, antimicrobial agents (definition, application and example)
   Physical methods of sterilization and disinfection – dry heat (incineration, hot air oven), moist heat (autoclave, fractional sterilization), filtration, radiation (ionizing and non-ionizing)
   Chemical methods of sterilization and disinfection – alcohol, acid, alkali, halogens, heavy metals, phenol and phenol derivatives, dyes, formaldehyde, ethylene oxide, detergents, Quarternary ammonium compounds; assessment of chemical disinfectants, phenol coefficient- definition and method of determination, factors affecting phenol coefficient
   Chemotherapeutic agents- growth factor analogues (sulfonamides), antibiotics (penicillin, streptomycin, tetracycllin, erythromycin, chloramphenicol, nalidixic acid and metronidazole). Definition and types on the basis of their mode of action.

**Suggested Textbooks:**
- Madigan, MT., et al., Brock Biology of Microorganisms, 13th edition, Benjamin Cummings
- Black, JG., Microbiology-Principles and explorations, 7th edition, John Willey & Sons, Inc.
- Slonczewski, JL., Foster, JW., Gillen, KM., Microbiology-an evolving science, 2nd edition, Norton
Paper II

Group A: Environmental Microbiology and Biophysical Chemistry (50 marks)

UNIT- I

1. Air Microbiology (5)
   Different types of microorganisms in the air, Bioaerosols, Factors affecting survival and growth of microorganisms in air. Aeromicrobiology of hospitals, laboratories and homes; Impact of aeromicrobiological content upon public health- role of air pollution, airborne pathogens, techniques of room sterilization. Air sampling techniques- impaction, liquid impingement, filtration, gravity sampling

2. Soil Microbiology (12)
   Soil as a habitat for microorganisms; Physico-chemical properties of different soil types; soil microbes, factors affecting microbial community in soil, Soil food web
   Basis of plant-microbe interaction in soil; Epiphytes and endophytes; Rhizosphere and rhizoplane microorganisms; factors affecting growth of microorganisms in the rhizosphere; Role of rhizosphere microbial community in soil fertility as decomposers; Brief idea about plant growth promoting rhizobacteria (PGPR),
   Brief account of microbial interactions in soil- symbiosis, neutralism, commensalism and co-metabolism, competition, amensalism, synergism, syntrophism, mutualism parasitism and predation; Mycorrhiza (VAM) and plant interaction
   Biological nitrogen fixation- symbiotic and non-symbiotic; Biochemistry of nitrogen fixation; Plant-microbe interaction in soil for symbiotic nitrogen fixation- cross inoculation group, leghemoglobin and root nodule; role of sym plasmid, nif genes and nod factors in nitrogen fixation
   Compost and biofertilizers- their advantages over chemical fertilizers; General production process of compost and microbial biofertilizers with examples, role of nitrogen fixing and phosphate solubilizing microorganisms in biofertilizers; Mycorrhizal biofertilizers
   Biological pest control and its advantages; Brief idea about bacterial, viral and fungal insecticides with examples; Integrated Pest Management
   Brief description about some microbial diseases of agriculturally important plants- blast and brown spot of rice, black stem rust of wheat, stem rot of jute, red rot of sugarcane, late blight of potato, grey blight of tea

3. Biogeochemical cycles (8)
   Definition and ecological importance of biogeochemical cycles
   Carbon, nitrogen, phosphorus and sulfur cycles- role of microorganisms in the process
Suggested textbooks:

- Madigan, MT., et al., Brock Biology of Microorganisms, 13th edition, Benjamin Cummings
- Black, JG., Microbiology-Principles and explorations, 7th edition, John Willey & Sons, Inc.
- Tortora, GJ., Funke, BR., Case, CL., Microbiology- an introduction, 10th edition, Benjamin Cummings

UNIT-II

1. Fundamentals of thermodynamics and Bioenergetics(7)
Concept of thermodynamic system and surrounding, types of thermodynamic systems, extensive and intensive variables, State functions and path functions, Zero-th law, 1st law & 2nd law of thermodynamics: concept of internal energy, enthalpy and entropy; isothermal and adiabatic processes, reversible and irreversible work done, application in biological systems as typical example of isothermal, isobaric and isochoric process, Deduction of the concept of free energy from the second law, standard free energy change and its use as an indicator of spontaneity of reactions. Equilibrium constant; Concept of “High Energy bond” High energy compounds, Coupled reactions, Concept of chemical potential and its significance as chief determinant of free energy change in biological processes, gradient of chemical potential as driving force in transport, Donnan equilibrium, Nernst potential.
Transport across biomembranes: Fick’s laws of Diffusion, passive diffusion, facilitated diffusion & active transport - (definition and examples of primary and secondary active transport); uniport, symport, and antiport; osmosis and osmotic pressure.
Forces in biological systems: Concept of strong bonds/interactions (Covalent bonds, co-ordinate covalent bonds, ionic bonds, hydrogen bonds, hydrophobic interaction), Charge-dipole interactions and weak forces (induced dipole and Van der Waal’s interaction-London’s dispersion forces, 6-12 potential) and their significance in biological interactions.

2. Fundamentals of Spectroscopy (7)
Concept of electromagnetic radiations - UV, visible, IR.
Preliminary ideas of Molecular Orbital theory- Linear Combination of Atomic Orbital (LCAO), Bonding and antibonding orbitals, Interaction of electromagnetic radiation with matter-Jablonski diagram, Franck-Condon Principle; Scattering Spectroscopy- Preliminary ideas about Rayleigh and Raman scattering, applications and drawbacks; Absorption spectroscopy-Concept of chromophore - Wit's chromophore theory, auxochorome. Quantum
mechanically allowed and forbidden electronic transitions (HOMO to LUMO) 
Hyperchromic, hypochromic, hypsochromic and bathochromic shifts-effect of conjugation 
and solvent polarity, Lambert-Beer's law- applications and reasons accounting for deviation, 
molar extinction co-efficient; 
Infrared spectroscopy: Origin of IR spectra, relation of vibrational frequency with force 
constant ad reduced mass, different types of molecular vibrations, concept of fingerprint 
region of an IR spectra, limitations of IR spectroscopy. 
Fluorescence spectroscopy: Explanation of red shift in emission spectra from Jablonski 
diagram, competing processes of fluorescence, internal conversion and intersystem crossing, 
idea of singlet and triplet state, concept of phosphorescence, fluorescence lifetime and 
quantum yield, quenching phenomena-static and dynamic quenching, examples of typical 
quenchers, biologically relevant applications of fluorescence, fluorescence energy transfer. 
Instrumentation: Schematic diagram & working principle of UV-VIS and IR 
spectrophotometer,fluorimeter and their accessories including cuvettes. 
Nuclear Magnetic Resonance Spectroscopy- Preliminary concepts, NMR active nuclei, 
Chemical shift, TMS as reference compound, Scalar and Dipolar interactions 
NuclearOverhauserEffect, applications in biology. NMR of simple molecules such as HCHO 
and CH₃OH.

3. Physical and chemical properties of water (4) 
Ionic product of water; pH - definition, effect of pH in enzyme catalyzed reaction. Acids, 
bases; Arrhenius, Bronsted-Lowry theories of acid and bases. Polyprotic acids, ampholytes, 
dissociation of polyprotic acid; titrable and true acidity. Buffers in biological systems- 
Concept of weak acid,HendersonHasselbalch equation, buffer capacity, Amino acids as 
buffers, Formol titration and titration profile of amino acids (acidic, basic and neutral, one 
each), determination of isoelectric pH from titration profile. Physical properties of water- 
Surface tension, intrinsic and specific viscosity: Measurement, factors affecting and 
application to biomolecules. 

4. Microscopy (7) 
General principles of optics in relation to microscopy; different components of light wave 
(UV, IR, visible); principles and applications of Compound Microscope; Resolving power; 
Numerical aperture: Chromatic Aberration. Light Microscope; Dark field Microscope; 
Bright field Microscope; Phase Contrast Microscope; Fluorescent Microscope; Confocal 
Microscope, Electron Microscope;
UNIT I

1. Microbiology: Good Laboratory Practices and Biosafety.

2. To study the principle and applications of important instruments (laminar air-flow, autoclave, incubator, hot air oven, light microscope, pH meter, BOD incubator, spectrophotometer) used in the Microbiology laboratory.

3. Preparation of culture media: Complex media (Nutrient Broth, NA slant, Lactose broth); Chemically defined, Synthetic media (Czapekdox broth / agar). YEPD / select media which will be used for the experiments specified.


UNIT II

1. Qualitative tests of biomolecules (carbohydrates, proteins, amino acids, lipids): Glucose, fructose (Benedict’s Test, Barfoeds’ test); sucrose (Acid hydrolysis & Benedict's Test); starch; Proteins (Biuret method); lipids (Salkowski test, TLC with detection by Iodine vapor).

2. Separation of amino acids (Lysine, glycine, tryptophan, proline) by Thin Layer Chromatography.

3. Estimation of amino acid (Glycine) by formol titration.

4. Internal assessment
PART –II: 200 marks

Paper-III

Group A: Molecular and Cellular Biology (50 marks)

UNIT I

Replciation, Transcription and Translation in Prokaryotes

Replication(5)

Transcription (12)

Translation (8)

UNIT-II

Eukaryotic Cell Biology (15)
Mechanism of action and antimicrobial spectrum of and cephalosporin group of antibiotics, Mechanism of drug resistance with example, selective toxicity of antibiotics, therapeutic index, MIC and MLC- concept and determination, Antibiotic sensitivity test, Fitness cost of antibiotics, subclinical application of antibiotics and its implications.

Protein degradation: prokaryotic and eukaryotic, elementary concepts of GroEL, GroES system, elementary concepts of proteasomal system, Chaperones and chaperonins.

**Mycology (10)**

General Characteristics and Classification of Fungi upto class with diagnostic features.

Fungal Morphology—Hyphaland mycelia types, types of asexual reproductive structures and spores. Sexual reproduction—mechanisms involved in fusion of gametes and types of resultant fruit bodies, parasexuality in fungi.

Yeast—fission and budding yeasts, haplo and diplobiotic life cycles, mating types and switching of mating pairs, sec mutants and protein secretion in yeast.

Molds—difference with yeasts, life cycles of common molds—Rhizopus and Penicillium

Common fungal pathogens of human body, fungal diseases of common crops—paddy (brown spot), wheat (rust), potato (late blight)—symptom, causal organism, dissemination and control measures

Beneficial role of fungi—antibiotic producers, mycorrhizain agriculture, biofuel production, food production—mushroom, bakery, beverage and cheese, detritous fungi.

**Suggested textbooks:**
- Biochemistry—D. Voet and JG Voet
- Snyder et al.-Mol.Gen.of Bacteria
- Frifelder D
- Lewin et al. GENES
- Alberts B
- Lodish, H., et al. Molecular Cell Biology
- Prescott’s Microbiology: Joanne M Willeyet al
- Microbial Physiology: A.G. Moat
- Bacterial metabolism: Gerhard Gottschalk

**Group B: Metabolism and Bioenergetics (50 marks)**

**UNIT I**

**Enzymes and Amino Acid Metabolism**

Enzymes(15)

General properties, Nomenclature and Classification; Enzyme units, Co-factors: Definition and function with special reference to the representative substances - a) Co-enzymes (NAD+, NADP+, Co-enzyme-A, TPP, Pyridoxal phosphate, Biotin, Lipoic acid, tetrahydrofolate); b) Prosthetic groups (FAD—Succinic dehydrogenase); c) Metal ions Zn+2, Mg2+, Fe2+, Fe3+,
Mn2+ - required for enzyme action, Enzyme Kinetics – Thermodynamics of Enzyme kinetics, Michaelis-Menten equation and derivation Graphical presentation; L-B plot, Factors affecting Enzyme activity, Enzyme Inhibition - Competitive-cite: Malonate on succinate dehydrogenase as example, Non-competitive – Cite: Iodoacetamide on triose phosphate dehydrogenase and EDTA as example; Irreversible inhibition-eg. Di-isopropyl fluorophosphate, Suicide inactivation-action of Penicillin on bacterial cell wall biosynthesis as an example; Regulatory enzymes-Allosteric – Cite: CTP on Aspartate transcarbamoylase as example; Feedback inhibition - Cite: Threonine to Isoleucine as example; Ribozyme (catalytic RNA) and Abzyme (use of antibody as enzyme) - Definition and example.


Unit II

Carbohydrate Metabolism, Nucleic Acid Metabolism and Fat Metabolism

1. Carbohydrate metabolism (12)
Aerobic respiration-Glycolysis (EMP-pathway) with energy production: entry of galactose & fructose in EMP-path; TCA-cycle with energy production: Glyoxylate cycle: Pentose-phosphate pathway: Glycogenesis and Glycogenolysis, Electron Transport Chain (in brief) & ATP generation sites; Gluconeogenesis, Cori cycle, ATP & ADP cycle (oxidation reduction potential and electromotive force). Photophosphorylation, Oxidative phosphorylation (Chemiosmotic theory); Anaerobic respiration - Utilizing NO3⁻ Sulfur SO4²⁻,CO2 as electron acceptors; Stickland-reaction; Entner-Doudoroff pathway, Fermentation - Glucose metabolism in anaerobic condition general concept only Bacterial photosynthesis (Cyanobacteria and Green-sulphur bacteria); Difference with eukaryotic photosynthesis.

2.Purine and Pyrimidine metabolism (5)
Synthesis of purines: elementary concept only, source of the precursors of purines, ribose 5phosphate; synthesis of AMP and GMP from IMP-only preliminary idea; Importance of folic acid and target of sulfonamides; Microbial reduction of purines to deoxy-purines: Role of Thioredoxine; Salvage pathways, Biosynthesis of pyrimidines: Aspartate transcarbamoylase (ATCase); Origin of Thymine: importance of folic acid (conceptual); Degradation of nucleotides: xanthines, uric acid; catabolites of pyrimidines: NAD+ and Coenzyme A (only elementary ideas). Use of Fluorouracil, Trimethoprim, Methotrexate as chemotherapeutic agent by blocking the synthesis of Thymidylate.

3.Lipid metabolism(8)
Importance of fat, Types of Fatty acids, Detailed account for oxidation of even-andodd-carbon numbered, saturated and unsaturated fatty acids; Role of Carnitine in oxidation of
fatty acids, and β-oxidation, formation of ketone bodies, Brief idea of fatty acid biosynthesis; Metabolism of Triglycerides and phospholipids

Suggested textbooks:

- Biochemistry—D. Voet and JG Voet,
- Biochemistry—L. Stryer,
- Biochemistry—Lehninger,

Paper IV
Group A: Food, Water and Industrial Microbiology (50 marks)

UNIT I

1. Food Microbiology (7)
Food as a substrate for microorganisms- pH, Moisture requirement (water activity), Oxidation-reduction potential, Nutrient content, Vitamins, microbial growth inhibitory substances in foods
Contamination of foods- from plants, animals, sewage water, soil and air
Food spoilage and its causes, classification of foods on the basis of ease of spoilage, factors affecting microbial spoilage of foods
General principles of food preservation; Preservation by use of high temperatures (canning, Pasteurization), low temperatures, drying, food additives (salts, sugars, acids, spices, preservatives, antibiotics) and radiation; benefits and drawbacks of food preservation techniques
Contamination, preservation and spoilage of cereals, vegetables and fruits, meats and meat products (TA spoilage, sulfur stinker spoilage etc.), fish and other sea foods, eggs and poultry, milk and milk products (stormy fermentation, ropy milk, coloured milk)
Food-borne poisonings, infections and intoxications - bacterial and viral food borne diseases, mycotoxins, sea food toxicants, poisoning by chemicals
Fermented milk and other food products- yoghurt, curd, acidophilous milk, butter milk, cheese, butter, bread, wine, malt beverages, vinegar, idli, dhokla; spoilage and defects of fermented dairy products
General methods for assessment of microbiological contamination of cooked, preserved and fermented dairy and other food products; concept of food safety and good manufacturing practices; Hazard Analysis and Critical Control Points (HACCP)

2. Water Microbiology (7)
Water as a habitat for microbial growth; different types of microorganisms found in water; factors affecting microbial growth in water; marine microbiology and fresh water microbiology
Microbial analysis of water – BOD and COD (basic concept and methods of determination and implication), Coliform test (detection of fecal and non-fecal coliform), Defined substrate tests (ONPG and MUG tests), IMViC tests, Determination of potability of water sample (MPN test)
Indicator organism, Eutrophication, algal bloom and red tide (their implications in public health)
Water treatment- sewage, industrial and drinking water and its importance in public health; Primary sewage treatment and secondary sewage treatment (activated sludge, trickling filter, rotating biological contactor, anaerobic sludge digesters, septic tank, oxidation ponds), tertiary sewage treatment

3. Industrial Microbiology (11)
Microbial culture selection by screening method with reference to the antibiotic and enzyme production (Primary and secondary screening techniques), Strain improvement – importance and procedure (in brief), Ideal features of an industrially important microorganism, Concept of Primary and secondary metabolites
Equipments and instrumentation, Fermenters (General description of different types- stirred tank, bubble column, air-lift, packed-bed bioreactor, photobioreactor), General strategy of fermenter designing, maintenance of aseptic condition in bioreactors, scale up of fermentation, ideal features of a bioreactor
Fermentation- static, submerged, agitated, solid phase, batch, feed-batch, continuous (general process, merits, demerits and comparison)
Preservation and maintenance techniques for industrially important microorganisms (general process, merits, demerits and comparison)
Immobilization of cells and enzymes- definition, general characteristics, general description of different processes (Ca-alginate beads, polyacrylamide, micro-film), their importance in industrial microbiology, merits and demerits
Industrial production of – ethyl alcohol, acetic acid, penicillin, Vitamin B12, Lysine, α-amylase (inoculum building, fermentation, separation, assay and purification of products and factors affecting production- general discussion)

Suggested Textbooks:
- Ray, B., Fundamental Food Microbiology, 3rd edition, CRC Press
- Dubey, RC., Maheswari, DK., A Textbook of Microbiology, 2nd edition, S. Chand & Co. Ltd.
Unit II

Biometry and Instrumentation

1. Biometry (5)
Introduction: Types of Biological Data (variables), Concept of Population and Sample. Descriptions of Samples and Populations: Frequency Distributions, Descriptive statistics (measures of Central tendency and measures of Dispersion, Boxplot) Probability: Introductory concepts, Conditional Probability: Independent and Dependent events, Mutually exclusive events. Distribution Theory: Binomial, Normal and Poisson distribution. Inferential statistics: Statistical estimation-concept of z and t statistic, difference in their scope of application, Statistical decisions-tests of hypotheses and significance or decision rules, p value, confidence interval, type I and type II errors, z-test. ttest (paired and unpaired), one-tailed and two-tailed test. Brief discussions on the comparison of two independent population means. The Parametric and non-parametric models of significance tests (definition only), different Chi-square tests-Goodness of fit, Contingency or Independence of attributes, Linear Regression and Correlation-Least square regression line, correlation co-efficient.

2. Instrumentation/Techniques for Characterization of Biomolecules (12)
Sedimentation and ultracentrifugation, Sucrose and Cscl based Density Gradient Equilibrium Centrifugation and its application; Electrophoresis, DNA and protein gel electrophoresis, Native and SDS PAGE, Isoelectric focusing, 2D Electrophoresis, Pulsed field Gel Electrophoresis; Chromatography-General principles of separation, types and scope of application of each- Thin Layer Chromatography, Gel-filtration chromatography, Ion-exchange chromatography, affinity chromatography, gas chromatography, FPLC, HPLC and UPLC.

3. Fundamentals of radioactivity (8)
Law of Radioactivity, Decay constant, half life, average life. Properties of α, β, γ

**Suggested text books:**
- Zar, JH., Biostatistical analysis, Pearson Education.
- Eisenberg & Crothers, Physical Chemistry with Applications to the Life Sciences, Benjamin/Cummings Publishing Co. (1979).
- Schaum’s outlines: Statistics by Spiegel & Stephens, Mcgraw Hill, second edition or higher.
- Biological Spectroscopy-Campbell and Dwek, Benjamin/Cummings.
- Introduction to Biostatistics, Dr. Pranab Kr. Banerjee, S. Chand.
- Principles of Molecular biology by Wilson and Walker.

**Paper IV**

**Group B Practical (50 marks)**

**UNIT I**

1. **Micrometry:**
   Microscopic measurement of bacterial cell (*B. subtilis*), yeast (*Saccharomyces cerevisiae*), fungal spores (*P. notatum, A. niger*).
   Enumeration of microbes: Yeast by Haemocytometer (Standard Deviation Estimation)
   Determination of viable cell count by Trypan Blue method.
2. **Isolation of pure culture from natural sources:**
Bacteria from soil by serial dilution and pour-plate/spread plate method. (b) Yeast from rotten banana or apple by serial dilution and pour-plate/spread plate method (c) Molds from infected citrus fruits by streak-plate method (d) Microbes from air, by agar-plate exposure method.

3. **Growth curve of bacteria** (E. coli) under normal condition and the effect of pH, temperature and salt on the growth curve.

4. **Assay of antibiotics.** Microbiological assay of antibiotics: Antibiotic sensitivity test by paper disc and by Cup-Plate method

5. **Determination of Minimal Inhibitory Concentration (MIC)** of antibiotic by serial dilution.

**UNIT II**

1. **Water microbiology:**
i) Microbiological examination of water (Drinking water, Supply water, Pond water) by
   a) Presumptive test
   b) Confirmatory test
   c) Completed test
   ii) IMViC reactions.

2. **Milk microbiology**
Microbiological examination of milk: By Methylene-blue dye reduction test. Alkaline phosphatase test to check the efficiency of pasteurization of milk.

3. **Study of the following protozoans using permanent mounts/photographs:**
*Amoeba, Entamoeba, Paramoecium* and *Plasmodium.*

4. **Internal assessment**
PART –III: 400 marks

Paper V

Group A: Microbial Genetics (50 marks)

UNIT I

1. Mendelian genetics (5)

2. Organization of genome (8)
Experimental evidence for DNA as genetic material (Experiments of Griffith, Avery and MacLeod; Hershey and Chase); Experimental evidence for RNA as genetic material. Discovery of the double helix structure of DNA by Watson and Crick. Invention of PCR technique by Karry Mullis. Chromosome banding pattern (G, C, R, Q banding) and significance, Special types of chromosome (Polytene and lambrush chromosome), Definition of Karyotype and Idiogram. Nucleic Acid structure: DNA double helix: crystallographic proof, alternative forms of DNA, intercalating agents, secondary and tertiary structure of RNA. Structure prokaryotics gene; genomic organization in prokaryotes (nucleoid, DNA supercoiling, topoisomerases), Extrachromosomal inheritance: Plasmids (genes found, copy number, compatibility). Episomes.
Structure of eucakryotic genes (description and experimental proofs), multigene family. Genome organization (ARS, centromere, telomere, chromatin structure), various forms of repetitive DNA (satellite, LINEs and SINEs), pseudogenes. Extrachromosomal inheritance (mitochondria and plastids)

3. Linkage (definition) and crossing over (5)
Concept of Linkage (definition) and crossing over (two factor and three factor crosses). Related Problems. Theory of Coupling and Repulsion

4. Genetic exchange (7)
Transformation, Conjugation, Hfr bacteria and chromosome mapping. Transduction generalized (P1) and specialized (lambda-phage). Transposable elements: Bacterial and Eukaryotic Transposons.

UNIT II

1. Mutation and Repair (15)
Spontaneous (Spontaneous mutation Luria - Delbruck's Fluctuation Test) and induced mutations, Mutagenic agents - Physical, Chemical and Biological (Phage-mu).
Different forms of mutations and how they arise: (tautomeric shift, base analog, alkylating agent, apurinic lesions, UV radiation and thymine dimers, replicational error); Ames test is used to assess the mutagenicity of compounds.

Variations in chromosome number and structure: Brief idea on Deficiencies, Duplication, Inversions, translocation and Position effects, Trisomy Polyplody, Euplody. Non disjunction and Aneuploidy.

Repair: reversal of UV damage in prokaryotes: photoreactivation, base excision and nucleotide excision repair, post replicational repair, mismatch repair, SOS repair, error prone repair.

2. Recombination (10)
Homologous recombination (Holiday structure:RecBCD system); gene conversion; site specific recombination (lambda)

Suggested textbooks:
- Concept of Genetics (6th edition): By Klug and Cummings
- Genetics: Principles and Analysis (4th edition): By Hartl and Jones
- Genetics: Analysis and Principles: By Robert J Brooker
- Principles of Genetics: By Gardner, Snustad and Simmons
- Microbial genetics: By Freifelder

Group B: Recombinant DNA Technology and Bioinformatics (50 marks)

UNIT I

1. Recombinant DNA Technology (25)
Isolation & purification of nucleic acids & protein, RFLP, RAPD, Finger printing, Southern blotting, Dot blotting, Northern blotting, Western blotting - techniques.

Cloning: Cloning vectors (pBR. 322, pUC8I9, YACs), Bacteriophage lambda and M13 based vectors. Cosmids, BAC, Ti plasmid as transformation vector. Use of linkers and adaptors

Construction of DNA libraries (Basic ideas and outlines of methods)

PCR techniques: Basic principle and application Types of PCR- Inverse, Multiplex, Nested, Real time, RT, AP PCR.

Sequencing: Overview of Maxam Gilbert, Sanger’s method of DNA Sequencing: traditional and automated sequencing.

Restriction and Modification enzymes
Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering, Restriction Mapping. Enzymes used in Recombinant DNA techniques: DNA ligase. Polynucleotide Kinase. DNA Polymerase, Calf Intestinal Alkaline phosphatase, Mung Bean Nuclease, S1 Nuclease, Terminal deoxynucleotidetransferases, Reverse Transcriptase.

Over Expression of Recombinant Proteins in Bacteria:
Expression vectors: E.coli lac and T7 promoter-based vectors, Insulin, Human Growth Hormone, Recombinant vaccines

**Gene Therapy**
Definition and outlines of ex vivo and in vivo gene therapy.

**Suggested Text Books:**

**Unit II**
**Genomics, Proteomics and Bioinformatics (25)**

Basic concepts of Genome, transcriptome, Proteome, Genome Projects-Objectives; Genome organization and diversity
Bioinformatics: Introduction, Objectives and Applications. Biological databases - nucleic acid, genome, protein sequence and structure, gene expression databases, Database of metabolic pathways, Mode of data storage - File formats - FASTA, Genbank and Uniprot. Basic Concept of Sequence Alignment (Demonstration wherever possible)

**Suggested textbooks:**
- Gene cloning and DNA analysis: T. A. Brown.
- Principles of Gene Manipulation and Genomics: S.B. Primrose and R.M. Twyman
- Molecular Biology: Weaver
- Genomes 2: T.A. Brown
- Proteins: structure and molecular properties: Thomas E. Creighton
Paper VI

Group A: Medical Microbiology and Virology (50 marks)

UNIT I

Medical Microbiology (25)

Normal Microbial Flora of human body


Antimicrobics


Common Microbial Diseases

Causative agents, Signs and Symptoms, Pathogenesis, Treatment & Prevention, and Epidemiology of the following:


UNIT II

1. Virology: (20)

2. Microbial community (5)
Concepts of microbial Populations, Guilds and Communities, Environments and Micro
environments

Suggested textbooks
- Brock Biology of Microorganisms - Madigan, Martinko, Bender, Buckley, Stahl and
  Brock
- Microbiology: A Human Perspective- Nester, Anderson, Roberts
- Principles of Microbiology-R.M.Atlas
- Medical Microbiology-David Greenwood
- Prescott's Microbiology- Joanne Willey and Linda Sherwood
- Principles of Gene Manipulation and Genomic: Primrose and Twyman
- Gene Cloning and DNA Analysis: An Introduction - T. A. Brown
- Microbial Genetics-David Freifelder and Freifelder
- Medical Virology - David O.White and Frank J. Fenner

Group B: Immunology (50 marks)

UNIT I

Introduction: overview of the Immune system

1. Cells and organs of Immune system(8): Hematopoietic stem cells, stromal
  cells, hematopoietic growth factors, Lymphoid organs (primary and secondary) and cells,
  Mononuclear cells, Granulocytic cells, Mast cells, Dendritic cells- characteristics and
  functions.

2. Types of Immunity(12): (i) Innate immunity - mechanism of immune response
  (anatomic, physiological, phagocytic and inflammatory barriers).
  (ii) Adaptive immunity: Humoral and Cell-mediated immunity - mechanism of immune
  response---antigen processing and presentation, types and structures of Major
  histocompatibility complex molecules (MHC) and their role in antigen presentation,
  clonal selection of lymphocytes, definition of cytokine, generation of humoral and cell
  mediated response by cellular interactions (general concept only).

3. Antigens(5): chemical nature, antigenicity, immunogenicity, hapten, epitopes,
  mitogens (definition, properties, examples); Adjuvant (definition, examples, function)

UNIT II

1. Immunoglobulins(5): Isotypes- definition, basic and fine structures, general
  characteristics and functions. Monoclonal and polyclonal antibody (definition and
  characteristics).

2. Antigen - Antibody interactions(5): Precipitation reactions-Radial immunodiffusion,
  double immunodiffusion, immuno electrophoresis; Agglutination reactions-Hemagglutination,
  passive agglutination, bacterial agglutination, agglutination inhibition.
3. **Complement (5):** The complement components, function, complement activation-
(i) Classical, (ii) Alternate and (iii) lectin pathways (characteristics & functions).

4. **Hypersensitivity (3):** definition, types, examples.

5. **Vaccines (7):** Development of vaccination- contribution of Edward Jenner Louis Pasteur.
Active and passive immunization (definition, characteristics, examples and functions). Attenuated and inactivated viral or bacterial vaccines (definition, characteristic, functions, examples).

**Suggested textbooks**

- Immunology—JenisKuby
- Basic Immunology—Abbas

**Paper VII (Practical 100 marks)**

**UNIT I**

1. Isolation and characterization (activity, specific activity, pH optima, thermal denaturation profile etc) of one industrially important enzyme (amylase) and immobilization of amylase producing cells.

2. Determination of Km, Vmax and pH optima, effect of activator, inhibitor of alkaline phosphatase.

3. Review Writing

**UNIT II**

1. Protein estimation by Lowry method.
2. Absorption spectra of DNA and protein, hyperchromic shift of DNA.
4. Internal assessment
UNIT I

1. Antigen-Antibody reaction:
   a) Agglutination (blood typing method)
   b) Ouchterlony's agar double diffusion method (Dilution study and study of patterns)
   c) Single radial immunodiffusion (Mancini’s method),
   d) Immunoelectrophoresis.

2. Restriction digestion of lambda and plasmid DNA.
   Visualisation of the DNA fragments by Agarose gel electrophoresis.

UNIT II

1. Isolation of plasmid-DNA (E.coli - DH 5α) by standard miniprep method.
   Visualisation of the DNA fragments by Agarose gel electrophoresis.
   Quantification of plasmid DNA and checking the purity.

2. Isolation of Genomic DNA and visualisation of the DNA fragments by Agarose gel electrophoresis.

3. Transformation of E. coli using plasmid DNA by CaCl₂ method.

4. Internal assessment.