Syllabus and Course Scheme
Academic year 2016-17

B.Sc.- Microbiology
Exam.-2017

UNIVERSITY OF KOTA
MBS Marg, Swami Vivekanand Nagar,
Kota - 324 005, Rajasthan, India
Website: uok.ac.in

B.Sc. -Microbiology Exam. - 2017

Eligibility: 10+2 Science Biology / Agriculture

Selection: Common Entrance Test to be conducted by University of Kota

Scheme of Examination and Courses of Study

The number of papers and maximum marks for each paper together with the minimum marks required for a pass are shown against each paper separately. It will be necessary for a candidate to pass in the theory papers as well as in practical separately.

First Division 60% of the maximum marks prescribed at part
Second Division 48% I, II and III Examination, taken together.

Rest of the candidates shall be declared to have passed the examination, if they obtain the minimum pass marks in each paper viz. 36%. No division shall be awarded at Part I and Part II Examination.

A candidate may be allowed to appear at the Supplementary examination upto a maximum of two theory papers, provided that she/he has passed in all the practical examination.

A candidate may be allowed grace marks in two theory papers upto the extent of 1% of the total marks prescribed for the examination.

TEACHING AND EXAMINATION SCHEME FOR

B.Sc. Microbiology Pt-I Examination

Compulsory paper	**Lec Hrs/week**	**Exam hrs.**	**Max Marks**
MB – 00 Environmental studies	3	3	50
Core paper (Theory)			
MB – 01 General Microbiology	3	3	50
MB – 02 Computers and Biostatistics	3	3	50
MB – 03 Fundamentals of Food Microbiology		3	50
MB – 04 General Microbiology and Basic Biochemistry	3	3	50
MB – 05 Inorganic, Organic and Physical Chemistry	3	3	50
MB – 06 Biochemistry	3	3	50
Total of Theory Papers			**300**
Core Paper (Practicals)			
MB – 07 General microbiology Computer and Biostatistics		3	50
MB – 08 Fundamentals of Food Microbiology & General Microbiology and Basic Biochemistry		3	50
MB – 09 Inorganic, Organic and Physical Chemistry & Bio Chemistry		3	50
Total of Practical Papers			**150**
Grand Total (Theory + Practicals)			**450**

The marks secured in the Compulsory paper of Environmental Studies shall not be counted in awarding the division to a candidate.

Maximum of three chances will be given to a candidate to pass compulsory paper.

Non appearing or absent in the Examination of compulsory paper will be counted a chance.

A candidate shall be eligible to appear in supplementary examination in maximum of two Core theory papers as per University Rules.

One percent of the maximum marks may be awarded as Grace Marks to the candidates in accordance to the University Rules as applicable to all other Under Graduate examinations.

Minimum requirement of lectures completing each core theory and compulsory paper shall be 78 hours, and for each practical 156 hours.

MICROBIOLOGY PRACTICALS – (I, II, III)

Distribution of Marks

Min. pass marks: 18	**Duration: 3 hours**	**Max. Marks: 50**
	REGULAR	**EX-STUDENT**
1. Major Exercise	12	12
2. Minor Exercise	10	10
3. Preparation	8	8
4. Spots (5)	10	10
5. Record	5	-
6. Viva-voce	5	10
TOTAL	**50**	**50**

B.Sc.(Pt-I) Microbiology Exam.- 2017

MB - 01 GENERAL MICROBIOLOGY

Duration: 3 hrs Max.Marks 50

Note -The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit I

Introduction: Definition, scope and history of microbiology. Contributions of pioneers. Introduction to major groups of microorganisms and fields of Microbiology. Spontaneous generation versus biogenesis hypothesis. Taxonomy and Classification: History of microbiology- (Haeckel's three kingdom concept, Whittaker's five kingdom concept). Difference between the prokaryotic and eukaryotic microorganisms. Microbes and origin of life.

Unit II

Microbial Diversity: General characters and classification of Bacteria, Algae, fungi, Viruses, Protozoans. Classification according to Bergey's manual of determinative and systematic classification. Bacterial nomenclature.

Unit III

Morphology of Bacteria :Size, shape and arrangement of bacterial cells. Ultrastructure of bacteria: Cell wall, cell membrane, capsule, pili, flagella, slime, capsule, cell inclusions, biosyntheis of bacteria cell wall, Biomembrane, liposomes. Membrane transportation – diffusion, active and passive transport and osmoregulation.

Unit IV

Microscopy: Bright Field, Dark Field, Phase Contrast, Fluorescence and Scanning and Transmission Electron Microscopy. Stains and staining techniques- Stains and Dyes: Types of staining- Simple Differential (Gram and Acid fast).

Unit V

Sterilization: Principles and methods- Physical and chemical methods(Moist Heat, Dry Heat, Filtration, Pasteurization, tyndallization, radiations and Alcohols, aldehydes, phenols, halogens, hypochlorites), Antimicrobials with mode of actions.

Culture techniques: Types of media; simple, defined, enriched and transport media with specific examples. Methods of maintenance and preservation of cultures. Isolation and cultivation techniques.

Text Book Recommended:

1. Alexopoulos, C.J and Mims, C.W. (1979), Introductory Mycology, 3rd ed. Wiley, New York.
2. Pelczar Jr. M.J. Chan E.C.S., and Kreig N.R. (1993). Microbiology – McGraw Hill, Inc., New York.
3. Stainer R.Y., Ingraham J.L., Wheelis M.L., and Painter P.R. (1986), General Microbiology macMillan Education Ltd., London.
4. Starr, M.P. Stolp, H., Truper, H.C. Balows, A and Schegel, H.C. (1991). The Prokaryotes. A hand book of Habitats, Isolation and Identification of Bacteria. Springer Verleg.

MB – 02 Computers and Bio-Statistics

Duration : 3 hrs Max.Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit – 1

Introduction to computers – classification of computers – computer generation – low, medium and high level languages – software and hardware – operating systems – compilers and interpreters – personal, mini, main frame and super computers, their characteristics and application, BIT, BYTE, WORD, computer memory and its types; data representation and storage binary codes, binary system and its relationship to Boolean Operations.

Unit – 2

Microsoft Excel – Data Entry – graphs – aggregate functions – formula and functions. Different number systems and conversions input-output devices, secondary storage media.

Unit-3

Nature and scope of statistical methods and their limitations, Graphical representation.
Measures of average and dispersion stem and leaf plots; Box and whisker plots, : coplots.
Introduction to probability theory and distributions (concepts without derivations) binomial, Poisson and normal (only definition and problems).

Unit-4

Correlation:Types, Karl pearsons. Regression: types, simple linear regression
Tests of significance based on t, chi-square and F for means, proportions, variances, theory of attributes

Unit-5

Concepts of sampling and sampling distribution: Sampling methods: Simple, Random, stratified, systematic and cluster sampling procedures, sampling and non-sampling errors,
Analysis of variance – one way and two way classification – CRD, RBD and Latin Square Designs.

Note: The emphasis is solely upon the application, understanding the practice of statistical methods with specific References to problems in microbiology.

Reference:

1. Snedecar, G.W. and Cochram WG. (1967) Statistical Methods, Oxford Press.
2. Danial, W.W. (1995) : Biostatistics : A Foundation for analysis in Health Sciences (6th Ed.) John Wiley. 780pp

3. Cotton T. (1974); Statistics in Medicine, Little Brown, Boston.
4. Compbell, R.C. (1989): Statistics for Biologists, Cambridge University Press. 464 pp.
5. Bland. M. (1989). An introduction to Medical Science. Oxford Medical Publication.

MB – 03 Fundamentals of Food Microbiology

Duration: 3 hrs Max. Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit-I

Introduction and history of food microbiology. Nature and properties of prokaryotic and eukaryotic micro-organisms. Brief discussion on taxonomy of microorganisms associated with food. Growth of microorganism in Food – growth curve of microbial cultures.

Effect of microorganisms –pH, water activity, oxidation – reduction potential, nutritional requirements, temperature, relative humidity, gaseous environment.

Unit-II

Microorganisms associated with food. Environmental microbiology and sources of contamination of food, water, air, soil, sewage, animal products, handling and processing.

Unit-III

Spoilage: General principles, Chemical changes, Role of microbes -cereals and cereal products, fish and other seafood, eggs and poultry, milk products, canned foods and other foods.

Prevention of spoilage of food-principles and common techniques.

Unit – IV

Food and enzymes produced by microorganisms : bread, malt, beverages, fermented vegetables, fermented food, Single cell protein, fats, amino acids and enzymes.

Food borne infections and intoxications: disease, foods involved, prevention, food borne disease.

Other food hazards – chemicals, antibiotics, metal contaminants, poisonous food.

Unit – V

Sanitation and Hygiene in food Industries: Microbiology in Food plant Sanitation – bacteriology of water, sewage and waste treatment and disposal, test of contamination, methods of rendering water potable.

Microbiological standard of food and water. Quality control during food processing and storage. Enforcement and Control agencies.

Personal hygiene, Safety, storage, Cleaning methods – sterilization and disinfection; maintenance of clean environment in Food Industry.

Reference:

1. Pelczar, M.J.: Chan, ECS and Krieg. N.R. Microbiology. Fifth edition.
2. Frazier, W.C. and West haff, D.C.Food Microbiology. Tata Mc Graw Publishing Co. Ltd. N.B.
3. Jay J.N. Modern Food Microbiology, CBS Publishing N.
4. Hobbs, B.C. and Roberts, D. Food Poisoning and Food Hygiene Fifth edition, Edward Arnold, London.
5. Longree, K. Blanker, G.G. Sanitary techniques in food Service 2nd edition, John Wiley & Sons.
6. Chrlstie A.B. and Christie M.C. Food Hygiene and Food Hazards for all who handle food, Faber and Faber Ltd.

7. Banwart G.J. Basic Food Microbiology, CBS Publishers and Distributors.
8. Kanawat, K. Environmental sanitation in India, Lucknow Publishers House.
9. Jacob, M (1989) Safe food Handling – A training guide for Manager W.H.O. Geneva.
10. Principles of Food sanitation –II Edition, AV Book Van Nostrand Reinhold, N.Y.
11. Minor, L.J. (1983), Sanitation, Safety and Environmental Standards, AVI Publishing Co. Westport, Connecticut.

MB – 04 General Microbiology and Basic Biochemistry

Duration : 3 hrs Max.Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit – 1

Unity of microbial world, Microbiology and Human health, Beneficial and Harmful microbes. Fungi –Ultrastructure. Salient features, classification, reproduction and significance of major groups of fungi (phycomycetes, Ascomycetes, Basidiomycetes, and Deuteromycetes). Protozoa-General features, classification and significance.

Unit – 2

Diversity of microbial world : Comparison of the three domains of organisms: Bacteria, Archaea, Eucarya (tabular and diagrammatic), Classification, Morphology, Cultivation, Reproduction and significance of: Rickettsia, Chlamydia, Mycoplasma, Actinomycetes, Cyanobacteria, Multiplication in bacteria-binary fission, budding and fragmentation.

Unit –3

Biological nitrogen fixation, microbiology of geochemical cycles. Study of Viruses: Early developments of virology, General structure and properties of viruses, Virus Purification and assay, Principles of Viral Taxonomy, Structure, reproduction, cultivation and significance of Bacteriophage. Prions and Viriods – Nature and significance

Unit – 4

Biochemistry of microbes : Chemical elements, Structure of atoms, Molecules and Chemical bonds, Chemical reactions, Molecules of living systems, pH and pK, Buffers, Carbohydrates, Lipids, Proteins, DNA & RNA.

Unit 5

Microbial growth, Nutritional requirements of microorganisms-Macronutrients, micronutrients and growth factors. Nutritional types of microorganisms: Autotroph and heterotrophy, phototrophs and chemotropism. Physical factors affecting growth of microorganisms: Temperature, pH and Oxygen. Continuous cultivation-chemo stat and turbid stat, Counting of bacteria-Viable count- SPC, Total count-DMC and turbidometric estimation.

Text Books :

1. Ronald M. Alfred. Alfred E. Brown, Kenneth W. Dobra, Llonas Miller (1986). Basic Experimental Microbiology, Prentice Hall. 361pp
2. Robert F. Boyd. (1984). General Microbiology. Times Mirror/Mosby college Pub. 22pp.
3. Berg etal. Biochemistry 5th ed. Freeman Publication.
4. Mathews, Van Holde Ahern Biochemistry 3rd ed. Pearsen Education

MB – 05 Inorganic, Organic & Physical Chemistry

Duration : 3 hrs Max.Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit – 1

a) **Hydrogen :** Isotopes of hydrogen, separation of the isotopes, properties and uses of heavy hydrogen, position of hydrogen in the Periodic table, ortho and para hydrogen – separation, difference in structure and properties, hydrides – definition, classification, preparation and properties.

b) **Oxides** : Definition, classification, properties.

c) **Water :** Hardness of water, types of hardness, removal of hardness, industrial implications of hardness in water, estimation of hardness by EDTA method (outline only) , units for hardness of water.

Unit - 2

a) **Hydrogen peroxide :** Manufacture, properties, structure and uses of hydrogen peroxide, estimation of hydrogen peroxide by permanganimetry, strength of hydrogen peroxide in volume, strength, normality and percentage, calculation of strength on these different terms.

b) **Ozone :** Manufacture, composition, structure and properties.

c) Detection and estimation of nitrogen and halogens in organic compounds: empirical formula, molecular formula, structural formula, calculation of E.F. and M.F. from percentage composition.

Unit-3

a) Nature of valency of carbon in organic compounds: brief outline hybridizations sp^3, sp^2 and sp (with one example for each), tetrahedral arrangement of valency of carbon. Bond, breaking and bond forming in organic reactions, homolytic cleavage, heterolytic cleavage reaction intermediates, formation, stability and reactions of carbonium ion, carbanion and free radicals.

b) Nucleophiles and Electrophiles, definition, types and examples (specific reactions involving these)

c) Types of reactions, substitution, addition, elimination, rearrangements and polymerization, illustration with specific examples.

Unit – 4

a) Gaseous state, Postulates of kinetic theory of gases, derivation of expression for pressure of gas on the basis of kinetic theory, deducing the basic gas laws, derivation of real gases from ideal behaviour, reasons for deviation. derivation of Vander Waal gas equation – explanation of behaviour of real gases on the basis of Vander Waal gas equation.

b) Average, RMS and most probable velocities (equations only – no derivation), relationship between these different velocities, Liquifaction of gases – critical phenomenon, modern methods, Joule – Thomson effect, inversion temperature.

Unit – 5

a) Structure of atom : Rutherford model of the atom, defects of Rutherford model, Bohr model of an atom, merits and demerits, Sommerfeld modification, wave theory, de Broglie's concept, dual nature, Heisenberg's uncertainty principle, difference between orbit and orbital, shapes of atomic orbitals.

b) **Bonding :** (i) V.B. theory: Postulates of V.B. theory, application to the formation of simple molecules like H_2, and He, Overlap of atomic orbitals – s-s, s-p, and p-p overlap, principle of hybridization (ii) M.O. theory : Formation of M.O.s, bonding and antibonding and non bonding M.O.s, M.O diagram for H_2, He and F_2.

MB – 06 Biochemistry

Duration : 3 hrs Max.Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit – 1

Protein and nucleic acid structure and conformation, allosteric proteins, enzymes structure and kinetics, biological membrane.

Unit – 2

Metabolism: Basic concepts, carbohydrate, lipid and nucleic acid metabolism, photosynthesis.

Unit – 3

Biosynthesis of macromolecules, lipids, hormones, aminoacids and nucleotides.

Unit – 4

DNA transactions, gene concepts, DNA replication repair and recombination, protein synthesis control of gene expression.

Unit – 5

Membrane transport, cell walls, hormone action, muscle contraction, clinical applications of Biochemistry.

Reference :

Stryer, (1995), Biochemistry, W.H. Freema & Co. 1064pp.

PRACTICAL

MB – 07 General microbiology + Computer and Biostatistics

Max. Marks – 50 Min Marks – 18

1. Gram staining and endospore staining.
2. Physical & chemical sterilization.
3. Micrometry : Calibration of micro organism and measurement of size of microbes
4. Study of algae, fungi, viruses & bacteria.
5. Preparation of culture media.
6. Creating charts in excel using different data.
7. Design a worksheet for numeric entries and perform required calculation.
8. Design a worksheet enter required data and perform aggregate function like sum, average, count etc.

9. Perform segremic analysis and calculate future value.
10. Changing settings of keyboard, mouse and display.
11. Perform file operation like copy, save, rename, delete using window explore.
12. Calculate mean, mode and median of following data :
13. Calculate correlation & regression of following data.
14. Principles & application of instruments – Autoclave, Oven, Incubators & Spectrophotometer.

PRACTICAL

MB – 08 Fundamentals of Food Microbiology & General Microbiology and Basic Biochemistry

Max. Marks – 50 Min Marks – 18

1. Cleaning and sterilization procedure of glassware.
2. Preparation of nutrient Media.
3. Basic light microscopic techniques-
   (a) Preparing slides of staining – gram, spore, acid fast and other using oil immersion count, Direct microscopic count.
4. Agar plating, SPC; most probable-count, streaking of plate.
5. Isolation of microorganisms obtaining pure cultures.
6. Study of morphological and biochemical characteristics of isolated cultures.
7. Microbiological analysis of water, milk, butter & fruit and vegetables using selected standard methods.
8. Microbiological examination of sterility of table ware containers and equipment.
9. Microbiological examination of food handler, skin.
10. Qualitative estimation of lipid, carbohydrates & proteins.
11. Reducing sugar estimation by benedicts method.
12. Specification of fats.
13. Principles & applications of Laminar air flow, Incubator, Light & phase contrast microscope.

PRACTICAL

MB – 09 Inorganic, Organic and Physical Chemistry & Bio-Chemistry

Max. Marks – 50 Min Marks – 18

1. Estimation of hardness of water by EDTA.
2. Determination of acetic acid in commercial vinegar using NaOH.
3. Preparation of solution & buffers.
4. Acid base titration morality, molality, normality, sensitivity.
5. Viscosity measurement.
6. Enzyme assays.
7. Demonstration and estimation of proteins (Lowry's methods)
8. Measurement of amylase and invertase activities.
9. Chemical test of Carbohydrates, amino acids, nucleic acid (R.N.A. & D.N.A.)
10. Demonstration of presence of secondary metabolites: Gum, tannins, anthocyanin, crystals of calcium and calcium oxalate.
11. Principles & application of pH meter, colorimeter.

B.Sc. Microbiology Part-II Exam.-2017

MB 10- Diversity and scope of Microbiology

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

UNIT I

Basic Microbiology and microbial diversity : Binomial nomenclature, Whittaker Kingdom and Carl Woese's three kingdom classification system and their utility, Acellular (prions, Viroids, Viruses) and cellular micro organism

UNIT II

Bacteria and viruses: General characters with emphasis on morphology and cell structure with reference to Archaebacteria (Methanogens, Halophiles , Thermophiles) Cyanobacteria (*Nostoc, Anaebena and Spirulina) Eubacteria (E. Coli, Bacillus, Streptococcus, Staphylococcus, Spirillum* and S*treptomyces*)

General characters of viruses and economic importance with special reference to TMV, Polio virus, Hepatitis virus, T4 and λ Phages.

UNIT III

Fungi and algae: General characters of fungi with emphasis on their occurrence, distributions and structure *with Rhizopus, Aspergillus, Saccaromyces, Agaricus , Neurospora.*

General characters of Algae on their occurrence, distruibution with reference to *Chlamydomonas, Volvox, Spirogyra* and *Ectocarpus.*

UNIT IV

Protozoology: Classification occurrence, morphology, nutrition locomotion, reproduction and economic importance of protozoa. A brief account of *Amoeba, Plasmodium, Leishmania, Tetrahymena, Euglena and Paramecium.*

UNIT V

Biofertilizers – *Rhizobia, Mycorrhiza, Azolla*, Bioluminescence, Biomagnification, Biofilm, cleaning oil spills - superbug, Microbes in composting, Landfills, Bio insecticides, and Biopesticides, Bioremediation and Bioleaching.

MB 11- Cell Biology

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit-1

Cell as a basic unit of living systems. The cell theory. Precellular evolution: artificial creation of cells. Broad classification of cell types, PPLOs, bacteria eukaryotic microbes, plant and animal cells. A detailed classification of cell types and tissue within an organism.

Unit-2

Techniques for cell studies: Light microscopy, electron microscopy, Transport across membranes – active and passive transport, ionic gradient, career proteins, Na+ Ka+ pump, ATPase, ABC transportors, Ion channels.

Unit-3

Biochemical structure and composition of cells membrane: protein, lipid, carbohydrates. Structure and function of cell organelles: Cytosol, Mitochondria, Golgibodies, endoplasmic reticulum (rough and smooth), and ribosomes.

Unit-4

Structure and function of cell organelles: chloroplast, lysosomes, peroxysomes, nucleus (Nuclear membrane, Nucleoplasm, nucleolus, chromatin).
Cytoskeletal structures and components actin, microtubules etc.

Unit-5

Cell division, cell cycle (including cell synchrony and its applications). Cell-cell interaction, cell locomotion (amoeboid, flagellar and ciliary), muscle and nerve cell, cell senescence and death, cell differentiation in plants and animals.

MB 12-Molecular biology And Microbial Genetics

Duration : 3 hrs **Max .Marks 50**

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

UNIT I

Prokaryotes and Eukaryotes–Phages λ, *E Coli*, human (Important points from human genomics), Evidence for the role of DNA and RNA as the genetic material. Plasmids and Episome. Transposable elements of prokaryotes and Eukaryotes – Types and significance.

UNIT II

Molecular structure and types of DNA. Molecular structure and types of RNA – m- RNA, t - RNA, r-RNA, Sn- RNA and HnRNA. DNA replication in Prokaryotes and Eukaryotes – detailed mechanism and role of different enzymes and proteins.

UNIT III

Genetic code , Mechanism of transcription in Prokaryotes and Eukaryotes,
Post transcriptional processing – cap formation, tail formation, mechanism of translation in Prokaryotes and Eukaryotes.

UNIT-IV

Genetic recombination- various models and mechanism, Conjugation, transformation, transduction and sexduction. DNA damage and repair. Mutation – Spontaneous and induced (physical and chemical mutagen) Molecular mechanism of mutations – point mutation, base substitution, transition and transversion.

UNIT –V

Regulation of gene action in prokaryotes , levels of gene regulation, house keeping genes and regulated genes, induction (Lac operon), attenuation, positive and negative control. Regulation of gene action in Eukaryotes – chromatin organization and role of histones as regulators of gene expression, DNA methylation, enhances and transcriptional factors, Regulation at processing levels- gene battery model of gene regulation.

MB 13- Basic Immunology

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

UNIT I

Introduction - Historical background, general concepts of the immune system. Innate and adaptive immunity.

Structure, properties and functions of the immune cells and organs - T and B lymphocytes, NK cells, monocytes and macrophages, neutrophils, eosinophils and basophils. Mast cells and dendritic cells. Thymus and bone marrow, lymph nodes, spleen, MALT, GALT and SALT.

UNIT II

Antigens and Haptens - Properties (Foreignness, molecular size, heterogeneity). B and T cell epitops. Adjuvents

Antibodies - Structure and functions and properties of antibodies, different classes and biological activities of antibodies, antibody as B cell receptor, antigenic determinants on antibodies (isotype, allo type and idio type).

UNIT III

An overview of maturation and activation of B and T cells.

B cell maturation in bone marrow, humoral immune response, primary and secondary immune response, generation of plasma and memory B cells.

UNIT IV

Immunological principles of various reactions and techniques :

Precipitation, agglutination, immunodiffusion, immunoelectrophoresis, ELISA (indirect, sandwich, competitive, chemoluminiscence), western blotting, Immunofluorescence, flow cytometry.

UNIT V

Hyper sensitivity - types and mechanisms of hyper sensitive reactions.

Auto immunity - Mechanism of induction of organ specific (Hashimoto's thyroiditis, auto immune aneamias, Good pasture's syndrome) and systemic (SLE Multiple sclerosis and rheumatoid arthritis) auto immune diseases. Therapeutic approach.

MB 14-Microbial Physiology

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

UNIT I

Growth and transport - Passive and facilitated diffusion, active transport, secondary active transport, group translocation. Specific transport systems - ATP linked ion motive pumps, electroneutral and elecrtrogenic transport. Iron transport.

Growth cycles - one step and diauxic growth curve, primary and secondary metabolite production during different growth phases, Mathematics of growth - geometric and arithmetic growth, calculation of growth rate and generation time. Growth yield.

UNIT II

Effect of environment on microbial growth - Osmolarity, water activity, oxygen, pH, temperature, radiations, pressures. Molecular adaptations to psychrophily and thermophily. Stress responses of extremophiles. Growth limitation by environmental factors, Liebig's law of the minimum, Shelford's law of tolerance.

UNIT III

Carbon metabolism - Glycolysis, ED pathway, phosphoketolase pathway, oxidative pentose phosphate, TCA cycle, glyoxylate cycle, gluconeogenesis, regulatory aspects, Pasteur effect, Harden and Young effect. Carbon dioxide fixation - Calvin cycle, reductive TCA cycle, Heterotrophic carbondioxide fixation.

UNIT IV

Aerobic and Anaerobic respiration in sulphate, nitrate and carbondioxide reducers. Oxidative phosphorylation - mechanism and hypotheses with sepcial reference to Chemiosmotic theory. Chemolithotrophy - Nitrifying bacteria, iron bacteria, hydrogen bacteria, sulphur bacteria, carbon mono oxide bacteria. Reverse electron transport. Phototrophy - Photosynthesis, a historical account. Oxygenic v/s anoxygenic. Mechanism of photosynthesis in bacteria, cyanobacteria, algae.

UNIT V

Bacterial fermentations - Alcoholic, lactic acid, butyric acid, mixed acid, 2, 3 - butanediol, propionic acid and acetic acid fermentations. Fermentations balances, carbon balance, branched v/s linear, fermentation pathways.

Nitrogen metabolism - Physiology of nitrogen cycle. Nitrate reduction - Assimilatory v/s dissimilatory, nitrifiction, denitrification. Biological nitrogen fixation. Mechanism of nitrogen fixation, properties of nitrogenase, Nif genes. Ammonia assimilation.

MB 15- Environmental Microbiology

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

UNIT I

Ecology - Development of ecology as a science, its significance and the history and development of microbial ecology. Definition and concept of ecology. Scope of ecology. Autecology and synecology. Ecosystems, components of ecosystems, levels of organizations, trophic levels, food chains, food webs, ecological pyramids and energetics.

UNIT II

Micro organisms and their natural habitats -

Terrestrial environment - Soil, physical and chemical properties of soil, classification of soil, soil profile, soil microflora and soil as a natural habitat for micro organisms.

Aquatic environment - Fresh and marine water microflora, water blooms and eutrophication and biomagnification.

Atmospheric environment - Aero microflora, Air as a medium for mirobial dispersal and vertical distribution of microbes in air, droplet nuclei

Extreme environment - Habitats and microbes:Thermophiles, psychrophiles, barophiles, halophiles, osmophiles, acidophiles etc.

UNIT III

Bilogiocal interaction -
Microbe - Microbe interaction - Symbiosis, synergism, neutralism, commensalism, mutualism, amensalism, competition, parasitism, predation.
Microbe - Plant interaction - Roots, aerial plant surfaces, biological nitrogen fixation (in general)
Microbe - Animal interaction - Rumen micro biology, nematophagus fungi, microbes associated with their (animals) food and nutrition.
Biogeochemical cycles - Carbon cycle, nitrogen cycle, phosphorus cycle, sulphur cycle - manganese cycle.

UNIT IV

Sewage and waste management -
Microbial composition of sewage, BOD,COD of sewage. sewage treatment and disposal - Primary, Secondary (aerobic - activated sludge process, trickling filters) and (an aerobic - anaerobic digesters), tertiary treatment.
Solid - waste management - Composting (vermi composting)

UNIT V

Xenobiotic molecules and their recalcitrant nature - Organic pollutant and their degradation (pesticides, synthetic polymers, detergents, hydrocarbons. Biodeterioration of lubricants, cosmetics, pharmaceuticals and leather.Biodegradation of paints, rubber, wood, petroleum and petroleum products and plastics.

MB 16 PRACTICALS

PRACTICAL I
DIVERSITY AND SCOPE OF MICROBIOLOGY + CELL BIOLOGY

1 Study the life history and contributions of the following scientists using photographs: John Dalton, Albert.Einstein, G.J. Mendel, William Harvey, Marie Curie, C.V. Raman, Iasac Newton, Galileo, Euclid, Landsteiner, Barbara McClintock, Anton van Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, SergeiN. Winogradsky, Alexander Fleming, Elie Metchnikoff, Anand M. Chakraborty.

2 Isolation of bacteria, algae and fungi from natural sources using specific media:
a) Nutrient agar.
b) Potato dextrose agar
c) BG-II

3 Study the following with the help of temporary mounts:
a) *Rhizopus, Mucor, Aspergillus, Penicillium.*
b) *Chlamydomonas, Volvox, Spirogyra,* and *Ectocarpus.*

4 Study the permanent mounts of protozoa: *Balantidium, Paramecium, Plasmodium, Euglena, Giardia, Leishmania, Trypanosoma*.

5 Study the following viruses using electron micrographs: TMV, Poliovirus, T4 phage and lambda phages, HIV, Hepatitis B virus.

6 Measurement with the help of light microscope.
7 Calibration of occuIar micrometer. - Measurement of ceI! size . Measurement of chromosome length.
8 Cell counting with haemocytometer and other aids
9 Draw cell shape using Camera Lucida.
10 Separation of cell types from blood and ex-plants by maceration.
11 Study of chromosomal aberrations.
12 Isolation of chromosomal and plasmid DNA. from bacteria.
13 Cytoplasmic preparation
14 Paper chromatography.
15 Thin-layered chromatography.
16 Separation of cell organelles by sucrose gradient.
17 Preparation and study of various stages of mitosis and meiosis.
18 Preparation and study of bone marrow mitosis.
19 Colorimetric estimation of DNA
20 Determination of base composition of DNA.
21 Find out absorption spectrum of the oxidized and reduced form of a molecular species (NAD and NADH).
22 Estimation of RNA by orcinol method.
23 Extraction and estimation of phenol based secondary metabolites

MB 17 PRACTICALS

PRACTICAL II- MOLECULAR BIOLOGY AND MICROBIAL GENETICS + BASIC IMMUNOLOGY.

1 Preparation of master and replica plates

2 To study the effect of chemical (HNO2) and physical (UV)mutagens on bacterial cells

3 Study of UV survival curve of bacteria

4 Screening for drug resistance

5 Bacterial conjugation

6 Isolation of bacterial chromosomal DNA

7 Isolation of bacterial plasmid DNA

8 Gel electrophoresis of DNA and examination of Agarose gels.

9 Identification of human blood group A,B.AB,O and Rh factor

10 To perform total leucocyte count on the given blood sample.

11 To perform differential leucocyte count of the blood sample

12 To separate serum from the blood sample

13 To perform immunodiffusion by ouchterlony method

14 To perform immuno electrophoresis with a given antigen_antibody system.

15 To perform DOT ELISA

16 Metabolic pathways + General and Microbial genetics Sucrose dcnsity gradient centrifugation. Testing of blood groups

17 Preparation of Amino acid using TL.C.

MB 18 PRACTICALS

PRACTICAL III MICROBIAL PHYSIOLOGY + ENVIRONMENTAL MICROBIOLOGY

1 Physiology of microbial growth; a prokaryotic and eukaryotic system; Growth kinetics using solid and liquid media, colony measurement, dry weight method and turbidometric method.

2 Effect of physiological factors (physical and chemical) on growth of micro organisms, pH, temperature, nitrogen and carbon sources.

3 Aerobic and anaerobic respiration in microbes.

4 ANALYSIS OF Soil : Texture, pH, moisture content, water holding capacity, percolation, capillary action

5 Isolation of Rhizobium from root nodules.

6 Determination of microbial activity in soil and compost (respiratory)

7 Microbial succession on decomposing plant litter (Bacteria and fungi on 28 and 45^0 C)

8 Isolation of microbes (bacteria and fungi) from rhizosphere and rhizoplane

9 Isolation of phosphate solubilizer from soil

10 Isolation of free nitrogen fixers (*Azatobacter*, *Azospirillium*) from soil.

11 Demonstration of presence of enzymes in soil (Qualitative detection: Dehydrogenase / urease /Amylase)

B.Sc. Pt –III Microbiology Exam.- 2017

MB-19-Microbial Culture, Growth and Food Microbiology

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit-I

Microbial culture: Disinfection, Sterilization, Isolation, Screening and maintenance of micro organism, bait technique, trophic grouping

Microbial culture media (artificial natural), physical chemistry of culture medium, pH, buffer. Methods of anaerobic cultivation.Inoculation, Incubation and measurement of growth of micro organism.

Physical factors of controlling growth of microorganism (temperature gaseous)

Unit-II

Microbial growth kinetics: Definition, brief description of different type of microbial culture (batch, fed batch and synchronous), growth phases, growth kinetics, growth field, method of growth determination.

Environmental factors affecting microbial growth temperature, pH, Osmotic pressure and nutrient concentration per cell.

Unit-III

Food product: Microbial mass as food -single cell protein (Algae-*Chlorella, Spirulina, Scenedesmus*)

Mushroom cultivation: Agaricus bisporus, Pleurotus spp.

Fungi: Filamentous fungi, yeast, Candida, members of *Saccharomyces* and Torulopsis Fermented food- Bread, Cheese, Vinegar, dairy products, Kinema, Fermented Beverages (Beer, wine)

Bio Conversions: Alcohol production, steroid conversion, production of enzyme-amylases, proteinases, cellulases.

Amino acid production-glutamic acid and lysine

Unit-IV

Microbial contamination and spoilage-contamination of Sugar products, Vegetable, Fruit, meat, meat product, dairy products, Fish, Sea food and Poultry.

Spoilage and canned foods, Detection of spoilage and characterization.

Food Preservations: Pasteurization, appertization, aseptic packaging, use of high temperature, freezing, dehydration, Osmotic pressure, use of chemicals, organic acid, esters, sulphur di-oxide, salt and high sugar concentration.

Unit-V

Food borne infections and intoxications: Bacterial and non bacterial infective and toxic types – *Vibrio, Bacillus, Clostridium, Escherichia, Salmonella, Shigella*, Nematodes, Protozoa, Algae, Fungi Virus.

Infections and toxicosis: Botulism, Cholera, Mycotoxicosis, Salmonellosis *E coli*-poisoning, preventive measures. Food sanitation in manufacture and retail trade, food control agencies, role of fruit product certifying agencies and related regulations, waste treatment, disposal and quality control.

MB-20-Fermentation Technology and Government rules

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit-I

Bioreactors/Fementers: Design, components and operation of fermenters, stirred tank, bubble columns airlift, bioreactors, static submerged and agitated fermentation.

Physicochemical standards used in fermentors /Bioreactor, Limitations of Bioreactors.

Unit-II

Fermentation process: Media formulations, sterilization, solid substrate fermentation, steps of fermentation process.

Advantage and disadvantages of solid substrate and liquid substrate fermentation.

In-situ recovery of fermentation products, fermentation monitoring, Bioprocess calculations based on material and energy balance.

Unit-III

Fermentation in batch culture: Microbial growth kinetics, measurement of growth (cell number direct and indirect method)

Nutrients product formation, heat evolution, effect of environment (temperature, pH, high nutrient concentration)

Continuous culture system, Aeration, Agitation, Oxygen transfer kinetics.

Concept of Newtonian and non Newtonian fluids plastic fluids apparent viscosity foam and antifoam.

Unit-IV

Downstream processing: Filteration, Precipitation ultrafilteration, Ultra ceutrifugation, cell disintegration solvent extraction, chromatographic separation, membrane filter.

Biotransformation: Development of inoculum, Incubation production of ethyl alcohol, acetic acid, antibiotics and vitamin B_{12} with reference to easily available raw materials.

Scale up, instrumentation control, physical, chemical, environmental sensors.

Unit-V

Biosafety: Objective, rules and regulation, procedure of biosafety, containment (Physical and biological)

Risk assessment of genetically modified food.

Public opinion and ethical issues against the microbial technologies.

Patent practice and problem-patentability of micro-organisms patenting laws in India and its limits.

Rules and procedure for use of genetically modified organisms and environmental protection act 1986.

MB-21-Soil & Agriculture Microbiology

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit-I

Soil-definition, types, physical and chemical characters, soil profile, soil micro organisms Bacteria, fungi, Actinomycetes, algal, protozoa and viruses.

Unit-II

Interactions between plants and microorganisms-types of interactions (Symbiosis, mutalism, commensalisms, competition, amensalism, synergism, parasitism, predation, microorganisms of rhizosphere, rhizoplane and phylloplane. Mycorrhiza- Types and its application.

Unit-III

Microorganisms and biogeochemical cycles- Nitrogen, phosphorous, sulphur and carbon. Biodegradation. (cellulose, plastic and pesticides)

Unit-IV

Biofertilizers :-definition, types, kind of association, mode of application and merits. Biochemistry, genetics and physiology of nitrogen fixation-symbiotic, non symbiotic and associative symbiotic. Nitrogen fixation by blue green algae.

Unit-V

Biopesticides-introduction, types, mode of action and factors influencing, target pests. A brief account of the symptoms, etiology, life cycle and management of bacterial (citrus canker, blight of paddy), mycoplasmal (little leaf of brinzal), Viral (TMV, tomato leaf curl) and fungal (white rust of crucifers and stem rust of wheat) diseases.

MB-22-Medical Microbiology

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit-I

Introduction: Definition, brief history, types of medically important microbes, host-parasite relationship.

Normal microflora of human body: normal microflora of skin, conjunctive (eye), nose, mouth and upper respiratory tract, intestinal tract, urinogenital tract, blood & tissues.

Unit-II

Pathogenicity, reservoirs of infections, infections, virulence, communicability of disease/ pathogenic microbes.

Microbial ecology of pathogens of animals and birds. Effects of pathogenic microbes.

Unit-III

Diagnosis, symptoms, Toxic components, etiology and epidemiology and disease development in animals and fowls.

Fowls pox, fowl spirochetosis, infections bronchitis.

Diseases of silkworm, livestock and pets (dogs & cats)

Unit-IV

Diseases of human beings-I: Diagnosis, symptoms, toxic components, etiology and disease development in human body-bacterial diseases (Diphtheria, Tuberculosis, Leprosy, Cholera, Typhoid, Gonorrhoea, Syphilis, Tetanus, Streptococcal infection of the skin, Dysentery, Salmonellosis, Botulism and Scarlet fever). Control, treatment and management of bacterial diseases.

Unit-V

Diseases of human beings-II: Diagnosis, symptoms, toxic components, etiology and disease development in human body-viral and fungal disease.

Viral-Aids, Poliomyelites, Mumps, Influenza, Viral Hepatitis, Small pox, Chicken pox, Common cold and Rabbies.

Fungal: Superficial mycoses, cutaneous mycoses, sub-cutaneons mycoses and systemic mycoses.

Control, treatment and management of viral & fungal diseases.

MB-23-Genetic Engineering and rDNA Technology

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit-I

Introduction and historical background of genetic engineering. Isolation and purification of DNA from bacterial, plant and animal cells. Vectors: Plasmids, cosmids and phages. Restriction enzymes, ligases, S1 nucleases, DNA polymerases. Reverse transcriptase.

Unit-II

C-DNA synthesis and cloning: mRNA enrichment, reverse transcription, Linkers, adapters, blunt end ligation, homopolymer tailing. C-DNA library construction and screening. Genomic library construction and screening. PCR and DNA sequencing.

Unit-III

Cloning and expression of foreign genes in prokaryotes (E.coli). Cloning and expression of foreign genes in eukaryotes (eg. yeast). Solid phase automated synthesis of DNA, Applications of transposons in gene tagging

Unit-IV

Using yeast to study eukaryotic gene function Therapeutic products produced by genetic engineering-blood proteins, human hormones, vaccines. Transgenic animals.

Unit-V

Gene transfer-microinjection, electroporation, microprojectile, shot gun method ultra - sonication, Liposome fusion, microlasers. Use of *Agrobacterium tumefaciens* and *A.rhizogenes*, Ti plasmids, Transgenic plants.

MB-24-Tools and Techniques

Duration : 3 hrs Max .Marks 50

Note - The paper is divided into five units. Two questions will be set from each unit. The candidates are required to attempt one question from each unit. All questions carry equal marks.

Unit-I

Microscopy: General, magnification, microscopes types, use of techniques of preparing specimens, resolving power, optical microscope-Basic idea of light microscopy, Types- bright field, dark field, ultra-violet, fluorescence and phase-contrast microscopes.

Electron microscope-Basic idea of structure and functioning of E.M., Preparation of material for electron microscopy, Types-TEM, SEM, Scanning probe microscope, scanning tunnel microscope atomic force microscope.

Techniques in light microscopy-wet mount, hanging drop preparations.

Unit-II

Microbial stains: Stains V/s Dyes, various types of stains, nature of stains, uses of stains.

Staining techniques: Simple, differential negative, gram-stain, mechanism of gram stain, Ziehl Nelson (acid fast) stain, special stains.

Sterilization techniques: sterilization of glassware and culture media.

Unit-III

Micro analytical Techniques: Disintegration of microorganisms- Mechanical & non-mechanical methods.

Separation of sub cellular structures and organelles- Differential, gradient, zonal or band and equilibrium or isopycnic density gradient centrifugation.

Unit-IV

Cyto chemical Analysis: Cytochemistry of microbes, cytochemical staining methods, radio autography (autoradiography) principles and procedure of radio autography.

Chromatography: principle and procedure of absorption, column, thin layer (TLC), partition, and gas-liquid ion-exchange chromatography.

Electrophoresis: Principle, equipment and procedure of various types (vertical & horizontal) electrophoresis, SDS-PAGE electrophoresis.

Unit-V

Culture of microbes: Preparation of culture media, aseptic transfer of bacteria, pure culture, serial dilution technique, preservation and maintenance of cultures, concept of stock culture.

B.Sc- Pt-III (Microbiology)
Practicals

Practical No.	Paper No.	Max. Marks	Min. Marks	Paper Titles
Practical -01	MB-25	50	18	Microbial Culture, Growth and food Microbiology + Fermentation Technology and Government role
Practical -02	MB-26	50	18	Soil and Agricultural Microbiology + Medical Microbiology
Practical -03	MB-27	50	18	Genetic Engineering and R-DNA Technology +Tools and Techniques

Practical- Paper- I
Microbial Culture, Growth & Food Microbiology

1. Principles and application of light and phase contrast microscope, Incubator, Colorimeter, Centrifuge, Spectrophotometer (Visible and UV).
2. Preparation of liquid and solid nutrient media for growth of micro-organism, cleaning, sterilization, culturing methods, dilution technique in microbiology.
3. Isolation and maintenance of organisms by plating, streaking and serial dilution methods, slant and stab cultures, storage of micro organisms.
4. Staining techniques in microbiology-
   a. Simple staining b. Negative staining c. Differential staining d. Spore staining
5. Microscopic examination of bacteria, yeast and moulds. Study of micro organisms by Gram stain, Acid fast stain.
6. Identification of micro organisms by biochemical tests.
7. Growth, Bacterial growth curve, measurement of bacterial population by turbidometry and serial dilution method.
   Effect of physiological factors (physical and chemical) on growth of micro-organisms e.g. temperature, pH, Carbon and nitrogen sources.
8. Microbial examination of food.
9. Effect of antibiotics on microbes.
10. Microbial production of citric acid using Aspergillus niger.
11. Detection of number of bacteria in milk by standard plate count.
12. Isolation of microbes from natural sources using specific media.
    a. Nutrient agar b. Potato dextrose agar c. BG-11
13. Microbial analysis of water, milk, butter, fruit and vegetables using selective standard method.
14. Isolation of Microbes from rhizosphere and rhizoplane.
15. To perform microbial activity in composting.

Practical- Paper- II
Fermentation Technology and Government Role

1. Isolation of industrially imported micro-organism for microbial processes.
2. Determination of thermal death point (TDP) and thermal death time (TDT) of microorganism for design of a sterilizer.
3. a. Determination of growth curve of a supplied microorganism and also determine substrate
   b. Compute specific growth rate (m), growth yield (y) from the above experiment.
4. Comparative studies of ethanol production using different substrates.
5. Production and estimation of Alkaline Protease.
6. Saurkraut fermentation.
7. Use of alginate for cell immobilization.
8. Determination of mixing time in bioreactors.
9. Visit to dairy, Bakery, distillery and sugar factory and submission of visit report.

Practical- Paper- III
Soil and Agricultural Microbiology

1. Analysis of soil: Texture, pH, moisture content, water holding capacity, percolation and capillary action.
2. Isolation and study of microbes (bacteria and fungi) from Rhizosphere and Rhizoplane
3. Isolation of Rhizobium from root modules of legumes (Trigonella / Cicer / Soybean)
4. Isolation of free nitrogen fixers ((Azotobactor, Azospirillum) from soil
5. Study of plant pathogens based on theory

Practical- Paper- IV
Medical Microbiology

1. Isolation of Pathogenic bacteria from natural sources: Cough, skin-wash, blood, tissue, stool etc.
2. Culture and identification of pathogenic bacteria using specific media
3. Isolation and identification of fungi causing diseases in animals and human beings.
4. Study of causative viruses of pathogenetic importance with the help of slide, **model, election micrograph or computer simulation :**
   a. HIV b. Hepatitis B Virus c. T phage d. Polioviruses
   e. Rabies
5. Field trip or visit to a microbiological laboratory of any advanced medical college or institute of medical science to study various activities and exposure to the research being done there.
6. Study of diseases (bacterial & viral) of pets and their causative agents. (Help of veterinary hospital / college may be taken.

Practical- Paper- V
Genetic Engineering and rDNA Technology

1. Isolation of DNA from : a) Bacteria (genomic) b. Plants
2. Digestion of DNA with restriction enzymes.
3. Quantitation of nucleic acids.
4. Bacterial culture and antibiotic selection media
5. Protoplast fusion, Anthers culture and haploid production
6. Charts on genetic engineering –
    a. pBR 322
    b. pUC 180 and 19
    c. SV 40
    d. Bacteriophage
    e. Gene Cloning
    f. Selection of recombinants by replica plate technique

Practical- Paper- VI
Tools and Techniques

1. Study of organization and working of microscopes :
    a. Optical Microscopes : dissecting and compound
    b. Exposure to organization and working of phase contrast microscope and electron microscopes.
2. Preparation of various microbial stains and their use.
3. Use of staining techniques –
    a. Single and differential, negative
    b. Gram's stain
4. Sterilization of glassware and media (use of autoclave). Aseptic transfer.
5. Study and use of micro analytical techniques.
6. Separation of sub- cellular organelles (use of centrifuge and other techniques)
7. Separation of cell organelles by sucrose gradient.
8. Electrophoresis : SDS – PAGE
9. Thin layer chromatography
10. Paper chromatography : circular and vertical
11. Culture of microbes using specific media and techniques.
12. Measurement of microbes using micrometer (Ocular and stage)
13. Visit to microbiological laboratory for exposure of various advanced tools and techniques.