Course Structure and syllabus for

B.Sc. Microbiology Part I – Semester I and Semester II

(with effect from the academic year 2018-2019)

CBCS B.Sc. Microbiology Course Structure				
SEMESTER I				
PAPER CODE	**TITLE**		**CREDITS**	**TOTAL**
MIC101	Microbiology and Biochemistry I	Theory Practical	4 2	**6**
MIG101	Introduction and Scope of Microbiology	Theory	4	**4**
AECC 1	English / EVS / MIL communication	Theory	4	**4**
SEMESTER II				
PAPER CODE	**TITLE**		**CREDITS**	**TOTAL**
MIC102	Microbiology and Biochemistry II	Theory Practical	4 2	**6**
MIG102	Industrial and Food Microbiology	Theory	4	**4**
AECC 2	English / EVS / MIL communication	Theory	4	**4**

SEMESTER - I

MIC 101: MICROBIOLOGY AND BIOCHEMISTRY – I

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

Unit 1 History of Development and Scope of Microbiology **No. of Hours: 18**

Development of microbiology as a discipline, Spontaneous generation *vs*. biogenesis. Contributions of Leeuwenhoek, Pasteur, Koch, Lister, Fleming.

Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Beijerinck, Winogradsky, Waksman.

Establishment of fields of medical microbiology and immunology through the work of Ehrlich, Metchnikoff, Jenner.

An overview of Scope of Microbiology.

Unit 2 Cell organization **No. of Hours: 06**

Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili.

Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Gram staining mechanism, lipopolysaccharide (LPS).

Cell Membrane: Structure, function and chemical composition of bacterial cellular membrane.

Endospore: Structure, formation, stages of sporulation.

Unit 3 Bacteriological techniques **No. of Hours: 05**

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation of pure cultures; cultivation of anaerobic bacteria.

Unit 4 Microscopy and Principles of staining **No. of Hours: 03**

Bright Field Microscope, mordants, fixatives and decolorisers, definition of dyes, chromogen, chromophore and auxochrome group, types of staining – Gram staining, monochrome staining and negative staining.

Unit 5 Growth and nutrition **No. of Hours: 06**

Nutritional requirements in bacteria and nutritional categories.

Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential.

Physical methods of microbial control: heat, low temperature, filtration, desiccation, osmotic pressure.

Chemical methods of microbial control: types of disinfectants.

Unit 6 Macromolecules **No. of Hours: 16**

Carbohydrates

Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Furanose and pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose.

Disaccharides; concept of reducing and non-reducing sugars, Haworth projections of maltose, lactose and sucrose.

Polysaccharides, storage polysaccharides, starch and glycogen. Structural Polysaccharides, cellulose, peptidoglycan.

Lipids: Definition and major classes of storage and structural lipids. Storage lipids. Fatty acids: structure and functions. Essential fatty acids. Triacyl glycerols structure, Structural lipids. Phosphoglycerides: Building blocks, General structure.
Proteins: Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. Protein structure: Primary, secondary, tertiary and quaternary structures.
Nucleic acids: Structure of nucleotides, DNA and RNA; brief concept of central dogma of molecular biology.

Unit 7 Enzymes **No. of Hours: 06**

Classification of enzymes. Apoenzyme, coenzyme, prosthetic group, cofactors. Structure of enzyme. Mechanism of action of enzymes: active site, activation energy, transition state complex.
Multienzyme complex: pyruvate dehydrogenase; Isozyme: lactate dehydrogenase.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Microbiology Good Laboratory Practices (GLP) and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory.
3. Preparation of culture media for bacterial cultivation; synthetic media, Complex media- Nutrient agar, MacConkey agar.
4. Simple staining, negative, Gram staining.
5. Isolation of pure cultures of bacteria by streaking method.
6. Estimation of CFU count by spread plate method/pour plate method.
7. Motility by hanging drop method.
8. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non-reducing sugars.
9. Qualitative/Quantitative tests for lipids and proteins.

SUGGESTED READING (Latest editions)

- Tortora GJ, Funke BR and Case CL. Microbiology: An Introduction. Pearson Education
- Madigan MT, Martinko JM, Dunlap PV and Clark DP. Brock Biology of Microorganisms. Pearson International Edition
- Wiley JM, Sherwood LM and Woolverton CJ. Prescott's Microbiology. McGrawHill International
- Atlas RM. Principles of Microbiology. WM.T.Brown Publishers.
- Pelczar MJ, Chan ECS and Krieg NR. Microbiology. McGraw Hill Book Company.
- Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. General Microbiology. McMillan
- Cappucino J and Sherman N. Microbiology: A Laboratory Manual. Pearson Education Limited
- Salle A.J. Fundamental Principles of Bacteriology. Tata McGraw-Hill Education
- Modi H.A, Elementary Microbiology Vol I, Fundamentals of Microbiology
- Nelson DL and Cox MM. Lehninger Principles of Biochemistry. W.H. Freeman and Company.
- Voet, D. and Voet J.G. Biochemistry. John Wiley and Sons.
- Conn E and Stumpf P. Outlines of biochemistry. John Wiley and Sons.

MIG101: INTRODUCTION AND SCOPE OF MICROBIOLOGY

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

Unit 1 History of Development of Microbiology **No. of Hours: 07**

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Leeuwenhoek, Pasteur, Koch, Lister, Fleming.

Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques, Golden era of microbiology, Developments in the field of soil microbiology: Contributions of Beijerinck, Winogradsky, Waksman. Establishment of fields of medical microbiology and immunology through the works of Ehrlich, Metchnikoff, Jenner.

Unit 2 Diversity of Microorganisms **No. of Hours: 07**

Systems of classification: Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three Domain classification systems and their utility.

General characteristics of different groups: Acellular microorganisms (viruses, viroids), cellular microorganisms (Prokarya: Archaea and Eubacteria; Eukarya : Algae, fungi and protozoa) and prions - giving definitions and citing examples.

Unit 3 Microscopy **No. of Hours: 05**

Bright Field Microscope, Electron Microscope.

Principle of stains and staining techniques (Gram staining, monochrome staining, negative staining).

Unit 4 Sterilization **No. of Hours: 05**

Autoclave (moist heat), hot air oven (dry heat), Tyndallization, membrane filtration.

Unit 5 Microbes in Human Health & Environment **No. of Hours: 07**

Medical microbiology and immunology: List of important human diseases and their causative agents. Definitions of immunity (active/passive), primary and secondary immune response, antigen, antibody and their types, vaccines.

Environmental microbiology: Definitions and examples of important microbial interactions – mutualism, commensalism, parasitism.

Application of microorganisms: bio-pesticides, bio-fertilizers, biodegradation, bio-deterioration and bioremediation (e.g. hydrocarbons in oil spills).

Unit 6 Industrial Microbiology **No. of Hours: 07**

Definition of fermentation, primary and secondary metabolites, types of fermentations and fermenters, microbes producing important industrial products through fermentation. Biofuels.

Unit 7 Food and Dairy Microbiology **No. of Hours: 07**

Microorganisms as food (SCP), microorganisms in food fermentations (dairy and non-dairy based fermented food products) and probiotics. Microorganisms in food spoilage and food borne infections.

Unit 8: Ecology and Ecosystems **No. of Hours: 07**

Concept of ecosystem: Types. Structure and function of ecosystems. Trophic levels: Primary and secondary production. Energy flow: ecological pyramids (pyramid of numbers, pyramid of energy, pyramid of biomass), food chains and food webs. Community structure: succession, trophic structure - zonation and stratification.

Unit 9: Soil Microbiology **No. of Hours: 08**

Soil as a habitat for microorganisms. Microorganisms in soil and their significance: bacteria, fungi, algae, protozoa, rhizosphere and rhizoplane. Biogeochemical cycles: C, N and role of microorganisms.

SUGGESTED READING (Latest editions)

1. Tortora GJ, Funke BR and Case CL. Microbiology: An Introduction. Pearson Education
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. Brock Biology of Microorganisms. Pearson International Edition
3. Cappucino J and Sherman N. Microbiology: A Laboratory Manual. Pearson Education Limited
4. Wiley JM, Sherwood LM and Woolverton CJ. Prescott's Microbiology. McGraw Hill International.
5. Atlas RM. Principles of Microbiology. WM.T. Brown Publishers.
6. Pelczar MJ, Chan ECS and Krieg NR. Microbiology. McGraw Hill Book Company.
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. General Microbiology. McMillan.
8. Odum E. Fundamentals of Ecology. Belmont CA: Thomson Brooks/Cole.
9. Coyne M. Soil Microbiology. Cengage Learning, Inc.
10. Rao NS Subba. Soil Microorganisms and Plant Growth. Oxford and IBH Publishing Co, Pvt. Ltd.
11. Alexander M. Introduction to Soil Microbiology. Krieger Publishing Company.

SEMESTER - II

MIC 102 : MICROBIOLOGY AND BIOCHEMISTRY – II

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

Unit 1 Introduction to protozoa, fungi, algae and viruses **Hours: 08**

Discovery, nature, definition and general properties.

Unit 2 Microbial Growth and Effect of Environment on Microbial Growth **Hours: 12**

Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate.

Microbial growth in response to environment - temperature (psychrophiles, psychrotrophs, mesophiles, thermophiles, thermodurics), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophiles), oxygen (aerobes, anaerobes, microaerophilic, facultative aerobes, facultative anaerobes), hydrostatic pressure (barophiles).

Microbial growth in response to nutrition and energy – autotroph/phototroph, heterotroph; photoorganoheterotroph, chemolithotroph: chemolithoautotroph, chemolithoheterotroph, chemoheterotroph, photolithoautotroph.

Unit 3 Nutrient uptake and transport **Hours: 05**

Passive and facilitated diffusion.

Primary and secondary active transport, concept of uniport, symport and antiport.

Group translocation.

Unit 4 Chemoheterotrophic Metabolism – Aerobic respiration **Hours: 12**

Concept of aerobic and anaerobic respiration, fermentation.

Sugar degradation pathways: EMP, ED, Pentose phosphate pathway, TCA cycle and its amphibolic nature.

Electron transport chain: components of respiratory chain.

Unit 5 Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation **Hours: 05**

Fermentation - Alcohol fermentation and Pasteur effect; lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways.

Unit 6 Eukaryotic Cell Structure and functions **Hours: 18**

Eukaryotic cell organelles: nucleus, endoplasmic reticulum, golgi apparatus, mitochondria, chloroplast, lysosomes, peroxisomes, protein sorting and transport, cytoskeleton and cell movement, the plasma membrane.

Signal transduction – Receptors involved in signal transduction, extracellular matrix and cell interactions.

Introduction to cell signalling: components of various signalling pathways, downstream effects of signalling on cell adhesion, cellular differentiation, cell cycle and apoptosis.

Stem cells and their applications.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods.
2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data.
3. Effect of temperature, pH and salt on growth of *E. coli.*
4. Demonstration of alcoholic fermentation.
5. Demonstration of the thermal death time and decimal reduction time of *E. coli.*
6. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique**.**
7. Study of permanent slides of protozoans
8. Study of morphological characteristics of fungi
9. Study of morphological characteristics of algae.
10. Study of the structure of cell organelles through electron micrographs.
11. Cytochemical staining of DNA (Feulgen stain).

SUGGESTED READING (Latest Editions)

- Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. Molecular Biology of The Cell. Garland science, Taylor and Francis group.
- Carter J and Saunders V. Virology: Principles and Applications. John Wiley and Sons.
- Cooper GM and Hausman RE. The Cell: A Molecular Approach. ASM Press and Sunderland, Washington, D.C.,Sinauer Associates, MA.
- De Robertis EDP and De Robertis EMF. Cell and Molecular Biology. Lipincott Williams and Wilkins, Philadelphia.
- Dimmock NJ, Easton AL and Leppard KN. Introduction to Modern Virology. Blackwell Publishing Ltd.
- Flint SJ, Enquist LW, Krug RM, Racaniello VR and Skalka AM. Principles of Virology, Molecular biology, Pathogenesis and Control. ASM press Washington DC.
- Gottschalk G. Bacterial Metabolism. Springer Verlag
- Levy JA, Conrat HF and Owens RA. Virology. Prentice Hall publication, New Jersey.
- Lodish H, Berk A, Kaise C, Krieger M, Scott M, Bretscher A, Ploegh H and Matsudaira P. Molecular cell biology .W. H. Francis and company, New York.
- Madigan MT and Martinko JM. Brock Biology of Microorganisms. Prentice Hall International Inc.
- Moat AG and Foster JW. Microbial Physiology. John Wiley and Sons
- Reddy SR and Reddy SM. Microbial Physiology. Scientific Publishers India.
- Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. General Microbiology. McMillan Press.
- Verma PS and Agarwal PK. Genetics, Molecular biology, Evolution and Ecology. S. Chand.
- Wagner EK and Hewlett MJ. Basic Virology. Blackwell Publishing.
- Willey JM, Sherwood LM and Woolverton CJ. Prescott's Microbiology. McGraw Hill Higher Education.

MIG102: INDUSTRIAL AND FOOD MICROBIOLOGY

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

Unit 1 Introduction to Industrial Microbiology **No. of Hours: 08**

Brief history and developments in industrial microbiology.
Types of fermentation processes - solid state, batch, continuous.
Types of fermenters – laboratory, pilot-scale and industrial-scale fermenters.

Unit 2 Maintenance of sterility **No. of Hours: 07**

Sterilization of equipment: Batch and continuous.
Sterilization of production media: Batch and continuous.
Sterilization of air: filtration, heat, electrostatic precipitation, UV light and chemical agents.

Unit 3 Isolation of industrially important strains and Study of Fermentation Media **No. of Hours: 07**

Primary and secondary screening.
Preservation and maintenance of industrial strains.
Components of fermentation media - molasses, corn steep liquor, whey and yeast extract.

Unit 4 Microbial fermentation processes **No. of Hours: 08**

Downstream processing - filtration, centrifugation, cell disruption, solvent extraction.
Microbial production of industrial products - Vitamin B_{12} and Penicillin.
Industrial applications of the enzymes – amylases, pectinases and proteases.

Unit 5 Food as a substrate for microbial growth **No. of Hours: 07**

Intrinsic and extrinsic parameters affecting microbial growth in food.
Microbial spoilage of food - milk, eggs and canned foods.

Unit 6 Principles and methods of food preservation and food sanitation **No. of Hours: 07**

Physical methods - high temperature, low temperature, irradiation, aseptic packaging.
Chemical methods - salt, sugar, benzoates, citric acid, ethylene oxide, nitrate and nitrite.
Food sanitation and control – HACCP.

Unit 7 Microbiology of milk **No. of Hours: 08**

Sources of microorganisms in milk.
Microbiological examination of milk: SPC and Breed's smear, advantages and disadvantages.
Grading of milk by dye reduction test: MBRT and Resazurin test.
Pasteurization of milk: LTH, HTST, UHT and efficacy of pasteurization - Phosphatase test.

Unit 8 Dairy products, probiotics and Food-borne Diseases **No. of Hours: 08**

Butter, Fermented dairy product – cheese and yogurt.
Probiotics definition, examples and benefits.
Food intoxication by *Clostridium botulinum* and *Staphylococcus aureus.*
Food infections by *Salmonella* and *Listeria.*

SUGGESTED READING (Latest editions)

1. Crueger, W. and Crueger, A. Biotechnology: A textbook of Industrial Microbiology. Panima Publishing Company, New Delhi.
2. Patel, A.H. Industrial Microbiology. MacMillan India Limited Publishing
3. Company Ltd. New Delhi, India.
4. Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology: An introduction. Pearson Education.
5. Willey, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's Microbiology. McGraw Hill Higher education.
6. Casida, L.E. Industrial Microbiology. Wiley Eastern Limited.
7. Stanbury, P.F., Whitaker, A. and Hall, S.J. Principles of Fermentation Technology. Elsevier Science Ltd.
8. Adams, M.R and Moss, M.O. Food Microbiology. New Age International (P) Limited Publishers, New Delhi, India.
9. Banwart, J.M. Basic Food Microbiology. CBS Publishers and Distributors, Delhi, India.
10. Frazier, W.C. and Westhoff, D.C. Food Microbiology. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
11. Jay, J.M., Loessner, M.J. and Golden, D.A. Modern Food Microbiology. CBS Publishers and Distributors, Delhi, India.

Syllabus of B.Sc. Microbiology Part II – Semester III and Semester IV

SEMESTER – III

MIC 103: ENVIRONMENTAL MICROBIOLOGY

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

Unit 1 Microorganisms and their Habitats **Hours: 18**

Structure and function of ecosystems, Terrestrial Environment: Soil profile and soil microflora; Aquatic Environment: Microflora of fresh water and marine habitats; Air: Aeromicroflora and dispersal of microbes; Animal Environment: Microbes in/on human body (Microbiomics) and animal (ruminants) body; Extreme Habitats: Microbes thriving at high and low temperatures, pH, high hydrostatic and osmotic pressures, salinity, and low nutrient levels. Microbial succession in decomposition of plant organic matter.

Unit 2 Microbial Interactions **Hours: 12**

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation. Microbe-Plant interaction: Symbiotic and non-symbiotic interactions. Microbe-animal interaction: Microbes in ruminants, nematophagus fungi and symbiotic luminescent bacteria.

Unit 3 Waste Management **Hours: 15**

Solid Waste management: Sources and types of solid waste, methods of solid waste disposal (composting and sanitary landfill).

Liquid waste management: Composition and strength of sewage (BOD and COD), primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment.

Unit 4 Microbial Bio-remediation **Hours: 07**

Microbial remediation of common pesticides, organic (hydrocarbons, oil spills) and inorganic matter (metals).

Unit 5 Water Potability **Hours: 08**

Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/ MPN test, confirmed and completed tests for faecal coliforms, (b) Membrane filter technique.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Analysis of soil - pH, moisture content, water holding capacity.
2. Isolation of microbes (bacteria and fungi) from soil (28ºC and 55ºC).
3. Assessment of microbiological quality of air.
4. Assessment of potability of water by MPN, routine analysis – presumptive, confirmed, completed tests; detection of faecal streptococci and clostridia.
5. Determination of BOD of sewage.
6. Isolation of bioluminescent bacteria from sea food.
7. Isolation of *Rhizobium* from root nodules.

SUGGESTED READING (Latest editions)

- Atlas RM and Bartha R. Microbial Ecology: Fundamentals and Applications. Benjamin Cummings Science Publishing, USA.
- Madigan MT, Martinko JM, Dunlap PV and Clark DP. Brock Biology of Microorganisms. Pearson International Edition
- Maier RM, Pepper IL and Gerba CP. Environmental Microbiology. Academic Press.
- Okafor, N. Environmental Microbiology of Aquatic and Waste systems. Springer, New York.
- Singh A, Kuhad, RC and Ward OP. Advances in Applied Bioremediation. Springer-Verlag, Berlin Hedeilberg
- Barton LL and Northup DE. Microbial Ecology. Wiley Blackwell, USA
- Campbell RE. Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
- Coyne MS. Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
- Lynch JM and Hobbie JE. Microorganisms in Action: Concepts and Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
- Martin A. An Introduction to Soil Microbiology. John Wiley and Sons Inc. New York and London.
- SubbaRao NS. Soil Microbiology. Oxford and IBH Publishing Co. New Delhi.
- Willey JM, Sherwood LM and Woolverton CJ. Prescott's Microbiology. McGraw Hill Higher Education.

MIS 101: FOOD AND DAIRY MICROBIOLOGY

THEORY

CREDITS: 3 **TOTAL HOURS: 45**

Unit 1 Food as a substrate for microorganisms **Hours: 08**

Intrinsic and extrinsic factors that affect spoilage of food. Principles and spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned foods.

Unit 2 Principles and methods of food preservation **Hours: 07**

Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, sulphites, nitrite and nitrates, ethyleneoxide, antibiotics and bacteriocins.

Unit 3 Fermented foods **Hours: 15**

Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tempeh.

Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.

Unit 4 Food borne diseases (causative agents, foods involved, symptoms and preventive measures) **Hours: 08**

Food poisoning: Toxins of *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins.

Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, pathogenic *Escherichia coli*, Salmonellosis, Shigellosis, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni.*

Unit 5 Food sanitation and control **Hours: 07**

Indices of food sanitary quality and sanitizers, methods of detection of food-borne pathogens, HACCP.

PRACTICALS

CREDIT: 1 **TOTAL HOURS: 30**

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of spoilage microorganisms from spoiled vegetables/ fruits/ bread.
4. Preparation of Yogurt/ Dahi/ Sanna.

SUGGESTED READING (Latest editions)

- Adams MR and Moss MO. Food Microbiology. New Age International (P) Limited Publishers, New Delhi, India.
- Banwart JM. Basic Food Microbiology. CBS Publishers and Distributors, Delhi, India.
- Davidson PM and Brannen AL. Antimicrobials in Foods. Marcel Dekker, New York.
- Dillion VM and Board RG. Natural Antimicrobial Systems and Food Preservation. CAB International, Wallingford, Oxon.
- Frazier WC and Westhoff DC. Food Microbiology. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
- Gould GW. New Methods of Food Preservation. Blackie Academic and Professional, London.
- Jay JM, Loessner MJ and Golden DA. Modern Food Microbiology. CBS Publishers and Distributors, Delhi, India.
- Lund BM, Baird Parker AC, and Gould GW. The Microbiological Safety and Quality of Foods. Vol. 1-2, ASPEN Publication.
- Gaithersberg MD, Tortora GJ, Funke BR, and Case CL. Microbiology: An Introduction. Pearson Education.

SEMESTER – IV

MIC 104 : MOLECULAR BIOLOGY

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

Unit 1 Nucleic acids **Hours: 10**

DNA: Watson – Crick model of DNA; Prokaryotic DNA (Circular DNA, Supercoiled, Palindromic), Plasmids; Eukaryotic DNA (Repetitive sequences, split genes, nucleosomes), mitochondrial and chloroplast DNA; Guanine quadruplex (G4) DNA.

RNA: mRNA, rRNA, tRNA, non-coding RNA, micro RNA and Si RNA.

Unit 2 Replication of DNA **Hours: 20**

Modes of replication - Conservative, semi conservative (Meselson - Stahl experiment) and dispersive; Processes and enzymes involved in replication; Inhibitors of replication; Models of replication in prokaryotes and eukaryotes - Rolling circle model/sigma, theta and linear. Differences between prokaryotic and eukaryotic replication process.

Unit 3 Transcription **Hours: 15**

Initiation, Elongation, Termination; post transcriptional modification - RNA splicing (Ribozyme), Reverse transcriptase and its implication, Inhibitors of transcription. Concept of operon. Differences between prokaryotic and eukaryotic transcription process.

Unit 4 Translation **Hours: 15**

Concept of genetic code, Properties: codon / anticodon, Wobble hypothesis, start and stop codons; Ribosomes as sites of protein biosynthesis; amino acid activation and specificity; Initiation, Elongation, Termination; post translational processing and modification; Inhibitors of protein synthesis. Differences between prokaryotic and eukaryotic translation process.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Study of different types of DNA and RNA using micrographs.
2. Extraction of genomic DNA, quantitative estimation (A_{260}) and estimation of purity ($A_{260/280}$).
3. Estimations: DNA by Diphenylamine method; RNA by Orcinol method; Protein by Folin-Lowry method
4. Effect of replication inhibitor on bacterial growth
5. Effect of transcription inhibitor on bacterial growth
6. Effect of protein synthesis inhibitor on bacterial growth

SUGGESTED READING (Latest editions)

- Frobisher M, Fundamentals of Microbiology, W. B. Saunders Co, Philadelphia.
- Pelczar MJ, Chan ECS and Krieg NR. Microbiology. McGraw Hill Book Company. Willey JM, Sherwood LM, and Woolverton CJ. Prescott's Microbiology. McGraw Hill Higher Education.
- Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. General Microbiology. McMillan Press.
- Tymoczko JL, Berg JM and Stryer L. Biochemistry, W.H. Freeman and Company
- Nelson DL and Cox MM. Lehninger Principles of Biochemistry, W.H. Freeman and Company.
- Goodenough U, Genetics, Holt, Rinehart & Winston of Canada Ltd.
- Gardner EJ, Simmons MJ, Snustad DP. Principles of Genetics. Wiley-India.
- Maloy SR, Cronan JE and Friefelder D. Microbial Genetics, Jones and Barlett Publishers.
- Strickberger M, Microbial Genetics, Prentice Hall India Learning Private Limited
- Goldstein ES, Lewin's Genes, Jones and Bartlett Publishers.
- E-books / Journals.

MIS 102: INSTRUMENTATION AND BIOTECHNIQUES

THEORY

CREDITS: 3 **TOTAL HOURS: 45**

Unit 1 Microscopy **Hours: 08**

Phase contrast, Fluorescence, Confocal and Electron (Scanning and Transmission) Microscopy; Micrometry.

Unit 2 pH and Buffers **Hours: 02**

pH Meter: Principle, calibration and application. Buffers and buffering capacity.

Unit 3 Spectroscopy **Hours: 05**

Principle of UV-Vis and IR spectroscopy and their application in analysis of biomolecules.

Unit 4 Chromatography **Hours: 10**

Principles and applications: Paper, Thin layer, Si gel Column, HPLC, Reverse phase, Gel filtration, Ion exchange and Affinity Chromatography.

Unit 5 Electrophoresis **Hours: 10**

Principle and applications: Native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, and Agarose gel electrophoresis.

Unit 6 Centrifugation **Hours: 10**

Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, differential centrifugation, density gradient centrifugation and ultra centrifugation.

PRACTICALS

CREDIT: 1 **TOTAL HOURS: 30**

1. Measurement of bacterial and yeast cell by micrometry.
2. Preparation of buffer.
3. Determination of λmax and extinction coefficient of a given sample.
4. Separation of mixture of sugars/amino acids by paper and thin layer chromatography.
5. Silica gel column chromatography.
6. Separation of proteins by Polyacrylamide Gel Electrophoresis (PAGE).
7. Centrifugation of bacterial and yeast cultures as a function of speed and time.

SUGGESTED READING (Latest editions)

- Wilson K and Walker J. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
- Nelson DL and Cox MM. Lehninger Principles of Biochemistry, W. H. Freeman and Company.
- Willey MJ, Sherwood LM and Woolverton C J. Prescott, Harley and Klein's Microbiology. McGraw Hill.
- Karp G. Cell and Molecular Biology: Concepts and Experiments. John Wiley and Sons. Inc.
- De Robertis EDP and De Robertis EMF. Cell and Molecular Biology. Lipincott Williams and Wilkins, Philadelphia.
- Cooper GM and Hausman RE. The Cell: A Molecular Approach. ASM Press and Sunderland, Washington D.C.
- Nigam A and Ayyagari A. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.

Annexure I
Goa University
B.Sc. Microbiology (HONS.)
Papers and Syllabus for Semester V and Semester VI under Choice Based Credit System
(Third Year)

Paper Code	Paper title	Total credit	Theory credit	Practical credit
Semester V				
Core papers				
MIC 105	**Medical Microbiology**	**6**	4	2
MIC 106	**Industrial Microbiology**	**6**	4	2
MIC 107	**Microbial Genetics**	**6**	4	2
Elective Papers				
MID 101	**Applied Microbiology**	**4**	3	1
MID 102	**Microbial Physiology**	**4**	3	1
MID 103	**Biostatistics and Bioinformatics**	**4**	3	1
Semester VI				
Core papers				
MIC 108	**Immunology**	**6**	4	2
MIC 109	**Agricultural Microbiology**	**6**	4	2
MIC 110	**Genetic Engineering**	**6**	4	2
Elective Papers				
MID 104	**Cell Biology**	**4**	3	1
MID 105	**Virology**	**4**	3	1
MID 106	**Haematology and Clinical Biochemistry**	**4**	3	1
Project				
MIP	**Project**	**4**		

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester V
Course Code: MIC 105
Title of the Course: MEDICAL MICROBIOLOGY
Number of Credits: 6 credits = 4 (Theory) + 2 (Practical)
Effective from Academic Year: 2019-20

Prerequisites	Basic understanding of human anatomy and physiology, microbial cell structure and physiology.	
Objective:	Understand relationship between human host and pathogens and the ability of pathogens to cause disease.	
Content:	**THEORY (4 Credits)**	**(60)**
1.	**Normal microflora of the human body and host pathogen interaction**	(14)
1.1	Normal microflora of the human body: Importance of normal microflora; normal microflora of skin, throat, gastrointestinal tract, genito - urinary tract	
1.2	Host pathogen interaction: Pathogen, Invasion, Infection, Pathogenicity, Virulence, Virulence factors (Pili, fimbriae, flagella, capsule, glycocalyx, adhesins, enzymes, chelators (siderophores), endotoxin, exotoxin)	
1.3	Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection, Pathophysiological effects of LPS.	
2.	**Sample collection, transport and diagnosis**	(6)
2.1	Sample types and collection, transport and culturing from clinical samples.	
2.2	Principle and methodology of different diagnostic techniques - ELISA, Immunofluorescence, Agglutination based tests, Complement fixation, PCR, DNA probes and Microarray.	
3.	**Bacterial diseases**	(16)
3.1	List of diseases of various organ systems and their causative agents. The following diseases in detail with mode of transmission, pathogenesis, symptoms, chemotherapy and prophylaxis:	
A.	Respiratory Diseases: Pneumonia (*Streptococcus pneumoniae)*, Influenza (*Haemophilusinfluenzae*), Tuberculosis (*Mycobacterium tuberculosis).*	
B.	Gastrointestinal Diseases: Bacterial diarrhea (*Escherichia coli)*, typhoid (*Salmonella typhi)*, Cholera (*Vibrio cholerae)*, bacterial dysentery (*Shigelladysenteriae)*.	
C.	Skin infections- *Staphylococcus aureus, Vibrio parahaemolyticus*	
D.	Genito-Urinary Tract Infections: Syphilis (*Treponema pallidum),* UTI (*E. coli* and *Proteus vulgaris*)	
4.	**Viral diseases**	(14)
4.1	List of diseases of various organ systems and their causative agents.	

	The following diseases in detail with mode of transmission, pathogenesis, symptoms, chemotherapy and prophylaxis. Polio, Hepatitis (A, B, C, D and E), Rabies, Dengue, AIDS.	
5.	**Protozoan diseases**	(5)
5.1	List of diseases of various organ systems and their causative agents. The following diseases in detail with mode of transmission, pathogenesis, symptoms, chemotherapy and prophylaxis. Malaria, Amoebic dysentery	
6.	**Fungal diseases**	(5)
6.1	List of diseases of various organ systems and their causative agents. The following diseases in detail with mode of transmission, pathogenesis, symptoms, chemotherapy and prophylaxis. Cutaneous mycoses: Athlete's foot(*Tinea pedis*) Opportunistic mycoses: Candidiasis (*Candida albicans*)	
	PRACTICALS (2 Credits)	**(60)**
1.	Study of composition and use of important differential media for identification of bacteria: EMBAgar, McConkey's agar, SS agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS agar.	(12)
2.	Identification of bacteria (*E. coli, Klebsiella, Salmonella, Proteus, Staphylococcus, Vibrio*) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production, catalase, oxidase, HL, PPA, motility tests.	(30)
3.	Study of bacterial flora of skin by swab method.	(4)
4.	Study of symptoms of the diseases with the help of photographs: Polio, TB, Candidiasis, Dermatomycoses (ringworm).	(10)
5.	Study of various stages of malarial parasite in RBCs using permanent mounts.	(4)
Pedagogy:	Lectures, seminars, assignments and practicals.	
References/ Readings	**(Latest Edition)**	
	1. Kanungo R. (Editor) Ananthanarayanand Paniker's Textbook of Microbiology. University Press.	
	2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. Jawetz, Melnick and Adelberg's Medical Microbiology. McGraw Hill Publication.	
	3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. Mims' Medical Microbiology. Elsevier.	
	4. Willey JM, Sherwood LM, and Woolverton CJ. Prescott, Harley and Klein's Microbiology. McGraw Hill Higher Education.	
	5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. Brock Biology of Microorganisms. Pearson International Edition.	
Learning Outcomes	1. Students will be able to correlate disease symptoms with causative agent, isolate and identify pathogens.	

	2. They will gain knowledge of mechanism of action of antimicrobial drugs and prophylaxis.	

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester V
Course Code: MIC 106
Title of the Course: INDUSTRIAL MICROBIOLOGY
Number of Credits: 6 credits = 4 (Theory) + 2 (Practical)
Effective from Academic Year: 2019-20

Prerequisites	Basic knowledge of microbial cell types, biochemistry, metabolism and physiology.	
Objective:	To understand importance of industrially significant microorganisms and their metabolites. To understand fermentation processes and product recovery.	
Content:	**THEORY (4 Credits)**	**(60)**
1.	**Isolation of industrially important microbial strains and fermentation media.**	(12)
1.1	Sources of industrially important microbes and methods for their isolation	
1.2	Preservation and maintenance of industrial strains, strain improvement	
1.3	Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates	
2.	**Types of fermentation processes, bio-reactors and measurement of fermentation parameters**	(18)
2.1	Solid-state and liquid-state (stationary and submerged) fermentations	
2.2	Batch, fed-batch (baker's yeast) and continuous fermentations (ethanol). Kinetics of batch, fed-batch and continuous fermentations	
2.3	Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot-scale and production fermenters, constantly stirred tank and air-lift fermenters	
2.4	Monitoring and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration	
3.	**Down-stream processing**	(12)
3.1	Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray-drying	
4.	**Microbial production of industrial products** (micro-organisms involved, media, fermentation conditions, downstream processing and uses)	(18)
4.1	Citric acid	
4.2	Ethanol	
4.3	Penicillin	
4.4	Vitamin B_{12}	
4.5	Enzymes (amylase and β-galactosidase)	
	PRACTICAL (2 credits)	**(60)**
1.	Study of different parts of fermenter.	**(4)**
2.	Microbial fermentations for the production and estimation of:	**(38)**

	(a) Enzymes: Amylase (b) Organic acid: Citric acid (c) Alcohol: Ethanol (d) Antibiotic: Penicillin	
3.	Bioassay of Penicillin and Vitamin B_{12}	**(10)**
4.	A visit to any educational institute/industry to see the working of an industrial fermenter and other downstream processing operations.	**(8)**
Pedagogy:	Lectures/tutorials/assignments/self-study/Practicals/Videos/Field trip	
References/ Readings	**(Latest editions)**	
	1. Patel A.H. Industrial Microbiology. Macmillan India Limited.	
	2. Okafor N. Modern Industrial Microbiology and Biotechnology. Bios ScientificPublishers Limited. USA.	
	3. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. Industrial Microbiology: AnIntroduction. Wiley – Blackwell	
	4. Glaze A.N. and Nikaido H. Microbial Biotechnology: Fundamentals of AppliedMicrobiology. W.H. Freeman and Company.	
	5. Casida LE. Industrial Microbiology. Wiley Eastern Limited.	
	6. Crueger W and Crueger A. Biotechnology: A textbook of Industrial Microbiology. Panima Publishing Co. New Delhi.	
	7. Stanbury PF, Whitaker A and Hall SJ. Principles of Fermentation Technology. Elsevier Science Ltd.	
Learning Outcomes	1. Students will be able to understand the industrial production of important microbial metabolites and products. 2. Students will gain knowledge of isolation, maintenance and handling of industrially important microbial cultures in laboratory settings.	

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester V
Course Code: MIC 107
Title of the Course: MICROBIAL GENETICS
Number of Credits: 6 credits = 4 (Theory) + 2 (Practicals)
Effective from Academic Year: 2019-20

Prerequisites	Basic knowledge of cell biology, nucleic acids and their functions.	
Objective:	To understand mechanisms of gene transfer, expression and regulation. To comprehend the types and effects of mutations and recombination.	
Content:	**THEORY (4 Credits)**	**(60)**
1.	**Gene expression and regulation**	**(10)**
	General Structure of Operon : Structural and regulatory genes	
	Induction and repression; catabolite repression.	
	Positive and negative regulation of lac operon.	
	Structure and regulation: Trp operon.	
2.	**Gene transfer mechanisms**	**(15)**
2.1	**Transformation**	

	Griffith's experiment; Avery, MacLeod and McCarty's experiment.	
	Factors affecting transformation.	
	Competence factor.	
	Steps in transformation.	
2.2	**Transduction**	
	Davis' U-Tube experiment.	
	Lytic and lysogenic cycles.	
	Generalized, Specialized, Complete and Abortive Transduction.	
2.3	**Conjugation**	
	Gene transfer by F+ strains, Hfr donor, F-prime state.	
	Chromosome mapping.	
3.	**Mutations**	**(20)**
3.1	**Spontaneous Mutations**	
	Concept of spontaneous mutations and mechanisms. Principle, methodology and significance of replica plating and fluctuation test.	
	Auxotrophs, Complementation Test.	
3.2	**Types of mutations**	
	Point mutations: base pair substitution, tautomerism (transitions,transversions).	
	Frame shift (slippage).	
	Missense, nonsense, silent, conditional, suppressor (intragenic, extragenic).	
	Large deletions, site directed mutagenesis.	
3.3	**Induced mutations**	
	Physical /chemical mutagens.	
	Teratogenicity testing – Ames test.	
	DNA damage and repair mechanisms (light/dark repair).	
4.0	**Molecular recombination and molecular taxonomy**	**(15)**
	General features of recombination, types of recombination.	
	Models for reciprocal and non-reciprocal recombination – Fox and Holliday's model, evidence for Fox andHolliday's model.	
	Rec A and Rec BCD complex.	
	rRNA and molecular taxonomy.	
	PRACTICALS (2 Credits)	**(60)**
1.	Preparation of competent cells for transformation.	**(08)**
2.	Bacterial transformation.	**(12)**
3.	Bacterial conjugation.	**(12)**
4.	Replica plate technique.	**(12)**
5.	UV Survival curve with effect of dark repair mechanism.	**(16)**
Pedagogy:	Lectures, seminars, assignments and practicals.	
References/ Readings	**Latest Edition**	
	1. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. Microbiology. McGraw Hill Book Company.	
	2. Gardner, E.J., Simmons, M.J. andSnustad, D.P. Principles of Genetics. Wiley-India.	
	2. Stanier, R.Y. General Microbiology. Macmillan Publishers.	
	3. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott's	

	Microbiology. McGraw Hill International.	
	4. Stryer, L. Biochemistry. W H Freeman and Company.	
	5. Primrose, S.B., Twyman, R.M. and Old, R.W. Principles of Gene Manipulation. Wiley-Blackwell.	
	6. Nelson, D.L.and Cox, M.M. Lehninger Principles of Biochemistry. W H Freeman.	
	7. Sambrook, J. and Russell, D. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.	
Learning Outcomes	Students will gain knowledge ofprokaryoticgene transfer mechanisms, mutations and recombination.	

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester V
Course Code: MID 101
Title of the Course: APPLIED MICROBIOLOGY
Number of Credits: 3 + 1 = 4
Effective from Academic Year: 2019-20

Prerequisites	Basic knowledge of microbial cell biochemistry and molecular biology.	
Objective:	To study the applications of microorganisms and their components.	
Content:	**THEORY (3 Credits)**	**(45)**
1.	**Nutraceuticals**	(5)
1.1	Probiotics, Prebiotics, Synbiotics, PUFA, Antioxidants, Vitamins, Polyphenols, SCP, Applications.	
2.	**Biosensors**	(5)
2.1	Definition, Components, Basic Characteristics, Elements, Principles, Applications. Detailed study of glucose and BOD sensor.	
3.	**Bioplastics**	(6)
3.1	Definition, Properties, types and composition, synthesis, microorganisms involved in biodegradation, uses, Environmental impact.	
4.	**Applications of Microbes in Biotransformation**	(8)
4.1	Definition, types of microbial transformations/bioconversions (oxidation, reduction, hydrolysis, condensation, isomerisation, formation of C=C double bonds).	
4.2	Screening and enrichment of organisms, biocatalysts and techniques, biotransformation of hydrocarbons and heavy metals.	
5.	**Immobilisation methods and Applications**	(7)
5.1	Introduction, preparation of immobilised enzymes, support matrix.Methods of immobilisation (adsorption, covalent bonds, entrapment, copolymerisation, encapsulation), advantages and disadvantages, applications.	
6.	**RNAi**	(2)
6.1	Definition, RNA silencing, mechanism, applications (therapeutics and agriculture)	
7.	**Intellectual Property Rights (IPR)**	(5)

7.1	Introduction, types of IPR, copyrights, trademark, patents, types of patents, process of patent application.	
8	**Nanotechnology**	(4)
8.1	Definition of nanoparticles, types, characterization and properties.	
8.2	Applications - drug delivery systems, bioremediation, antifouling, degradation of xenobiotics and fiber retting.	
9.	**Omics**	(3)
9.1	Metabolomics, metagenomics, transcriptomics, proteomics.	
	PRACTICALS (1 Credit)	**(30)**
1	Estimation of Ascorbic acid by colorimetric/titration method.	4
2	Isolation of Probiotic bacteria from curd.	4
3	Isolation of Polyhydroxybutyrate producing bacteria from mangrove ecosystems	6
4	Isolation of hydrocarbon degrading bacteria by inverted plate method.	6
5	Immobilisation of cells by calcium alginate method.	4
6	Synthesis of zinc nanoparticles.	6
Pedagogy:	Lectures, seminars, assignments and practicals.	
References/ Readings	**(Latest Edition)**	
	1. Ratledge, C and Kristiansen, B. Basic Biotechnology, Cambridge University Press.	
	2. Demain, A. L and Davies, J. E. Manual of Industrial Microbiology and Biotechnology, ASM Press.	
	3. Swartz, J. R. Advances in Escherichia coli production of therapeutic proteins. Current Opinion in Biotechnology, 12, 195–201.	
	4. Prescott, Harley and Klein's Microbiology by Willey JM, Sherwood LM, Woolverton CJ, Mc Graw Hill Publishers.	
	5. Gupta PK Elements of Biotechnology Rastogi Publications,	
	6. Glazer AN and Nikaido H Microbial Biotechnology, Cambridge University Press	
	7. Glick BR, Pasternak JJ, and Patten CL Molecular Biotechnology, ASM Press	
	8. Stanbury PF, Whitaker A, Hall SJ Principles of Fermentation Technology, Elsevier Science	
	9. Crueger W, Crueger, A Biotechnology: A text Book of Industrial Microbiology Sinauer associates, Inc.	
	10. Shukla, RP and Mishra, RS.Nutraceuticals Food Processing Technology: Innovative Scientific Research Hardcover, Bharti Publications.	
	11. Dubey, RC. A Textbook of Biotechnology, S. Chand & Co. Pvt. Ltd., New Delhi.	
Learning Outcomes	Students will be able to apply the knowledge for start-ups in the field of microbiology.	

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester V
Course Code: MID 102
Title of the Course: MICROBIAL PHYSIOLOGY
Number of Credits: 4 credits = 3 (Theory) + 1 (Practical)
Effective from Academic Year: 2019-20

Prerequisites	Knowledge of basic principles of chemistry and structures of biomolecules.	
Objective:	To understand the energetics and biochemistry of metabolic pathways	
Content:	**THEORY (3 Credits)**	**(45)**
1.	**Bioenergetics and Electron transport chain** Definitions of Gibb's Free Energy, Standard free energy change and equilibrium constant, Coupled reactions and additive nature of standard free energy change, Energy rich compounds: Phosphoenolpyruvate, 1,3-Bisphosphoglycerate, Thioesters, ATP. ATP as a high energy system, ATP hydrolysis and other high energy phosphate compounds, utilization of ATP in chemical work, ETC and oxidative phosphorylation, substrate level phosphorylation	(10)
2.	**Chemoheterotrophic Carbohydrate Metabolism** Catabolism: Glyoxylate cycle (Amphibolic pathway, Anaplerotic reactions), glycogenolysis. Anabolism: Gluconeogenesis, Biosynthesis of glycogen and peptidoglycan	(08)
3.	**Chemoheterotrophic Lipid Metabolism** Catabolism: Beta oxidation, Omega-oxidation Anabolism: Biosynthesis of saturated fatty acids and poly beta-hydroxybutyric acid	(09)
4.	**Chemoheterotrophic Protein Metabolism** Catabolism: Digestion of proteins and peptides, Amino acid oxidation, Transamination, Deamination, Decarboxylation, Stickland reaction.	(08)
5.	**Chemolithotrophic and Phototrophic Metabolism** Definition and reaction of hydrogen oxidation and methanogenesis. Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic v/s oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria Anaerobic respiration: Dissimilatory nitrate reduction (denitrification, nitrate/nitrite and nitrate/ammonia respiration, fermentative nitrate reduction)	(10)
	PRACTICALS (1 Credit)	**(30)**
1.	IMViC tests	(04)
2.	Fermentation - Sugars, HL test	(04)
3.	Estimation of lactic acid/acetic acid	(04)
4.	Staining of PHB granules	(02)
5.	Quantitative estimation of total sugars by Phenol sulphuric acid method	(04)

6.	Quantitative estimation of reducing sugars by DNSA and Nelson-Somogyimethods.	(08)
7.	Detection of Nitrification	(04)
Pedagogy:	Lectures, seminars, assignments and practicals	
References/ Readings	**(Latest Edition)**	
	1. Berg JM, Tymoczko JL and Stryer L. Biochemistry, W.H. Freeman and Company.	
	2. Pawar and Daginawala General Microbiology Volume I. Himalaya Publishing House	
	3. Murray RK, Mayes PA, Granner DK and Rodwell VW. Harper's Biochemistry. Prentiss Hall International Editions.	
	4. Jayaraman J. Laboratory Manual in Biochemistry.New Age International (P). Ltd. Publishers 5. Plummer David T. An Introduction to Practical Biochemistry. Tata McGraw Hill Publishers	
	6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. General Microbiology. McMillan Press.	
	7. Willey JM, Sherwood LM, and Woolverton CJ. Prescott's Microbiology. McGraw Hill Higher Education.	
	8. Moat AG and Foster JW. Microbial Physiology. John Wiley & Sons	
	9. Nelson DL and Cox MM. Lehninger Principles of Biochemistry. W.H. Freeman and Company.	
	10. Voet, D. and Voet J.G. Biochemistry. John Wiley and Sons	
	11. Conn E and Stumpf P. Outlines of biochemistry. John Wiley and Sons.	
Learning Outcomes	1. Students will gain knowledge of energy transfers and biomolecular transformations. 2. Students will comprehend metabolic pathways unique to microorganisms.	

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester V
Course Code: MID 103
Title of the Course: BIOSTATISTICS AND BIOINFORMATICS
Number of Credits: 4 credits = 3 (Theory) + 1 (Practical)
Effective from Academic Year: 2019-20

Prerequisites	Mathematics fundamentals, computer knowledge and basics of biomolecules	
Objective:	Ability to use appropriate tools for the analysis and interpretation of biological data	
Content:	**THEORY (3 Credits)**	**(45)**
1.	**Biostatistics**	(30)

1.1	Data type:Discrete and continuous data type; nominal, ordinal, interval, ratio data type and scale.	
1.2	Measures of central tendency, Correlation and Regression: Measure of central tendency - Mean, Mode and Median. Correlation types and characteristics. Linear regression.	
1.3	Statistical methods: Scope of statistics: utility and misuse. Principles of statistical analysis of biological data. Sampling parameters. Difference between sample and Population, Sampling Errors Sampling Distributions, Standard Error, Testing of Hypothesis, Level of Significance and Degree of Freedom. Normal distribution, Fitting of Distributions, Large Sample Test based on Normal Distribution, Small sample test based on t-test, Z- test and F-test; Confidence Interval; Distribution-free test - Chi-square test.	
2.	**Bioinformatics**	(15)
2.1	Introduction to Bioinformatics and Biological Databases: Biological databases - type of biological database for nucleic acid, genome, protein sequence. Database for structure of biomolecules. Mode of data storage - File formats - FASTA, Genbank and Uniprot	
2.2	Sequence Alignments, Phylogeny and Phylogenetic trees: Local and Global Sequence alignment, pairwise and multiple sequence alignment. Scoring an alignment	
2.3	Protein Structure Predictions: Hierarchy of protein structure - primary, secondary and tertiary structures, modeling Structural Classes, Motifs, Folds and Domains	
	PRACTICALS (1 Credit)	**(30)**
1.	Mean, Median, Mode from grouped and ungrouped Data set	(4)
2.	Standard Deviation and Coefficient of Variation	(4)
3.	Correlation	(2)
4.	Regression	(2)
5.	Finding area under the curve using normal probability	(4)
6.	Testing of Hypothesis- Normal Distribution, t-test and Chi-Square-test	(4)
7.	Confidence Interval	(4)
8.	Search of nucleic acid sequence database (GenBank), alignment and construction of phylogenetic tree	(4)
9.	Deducing 3D structure of proteins using primary sequence.	(2)
Pedagogy:	Lectures, seminars, assignments and practicals.	
References/ Readings	**(Latest Edition)**	
	1. Rastogi S.C., Mendiratta N. and Rastogi P. Bioinformatics: methods and applications, genomics, proteomics and drug discovery, Prentice Hall India Publication	
	2. Batschelet E: Introduction to Mathematics for Life Scientists, Springer Verlag, Narosa Publishing House, New Delhi	
	3. Pradeep and Sinha Preeti. Foundations of Computing, BPB	

	Publications	
	4. Danial W Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.	
	5. Primrose and Twyman. Principles of Genome Analysis & Genomics. Blackwell	
Learning Outcomes	Students will be able to understand the different tools for data analysis and apply the appropriate tool for data processing	

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure – Semester VI
Course Code: MIC 108
Title of the Course: IMMUNOLOGY
Number of Credits: 6 credits = 4 (Theory) + 2 (Practical)
Effective from Academic Year: 2019-20

Prerequisites	Basic knowledge of human anatomy and physiology.	
Objective :	To study the components of human immune system. To understand human defense mechanisms.	
Content:	**THEORY (4 Credits)**	**(60)**
1.	**Introduction of Immunology**	(5)
1.1	Concept of Innate and Adaptive immunity	
1.2	Contributions of following scientists to the development of field of immunology: Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter and Susumu Tonegawa.	
2.	**Immune Cells and Organs**	(8)
2.1	Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell	
2.2	Structure, Functions and Properties of Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT.	
3.	**Antigens and Antibodies**	(10)
3.1	Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes); T-dependent and T-independent antigens; Adjuvants	
3.2	Antibodies: Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic); Monoclonal and Chimeric antibodies.	
4.	**Major Histocompatibility Complex**	(6)
4.1	Structure and Functions of MHC I & II molecules	
4.2	Antigen processing and presentation. (Cytosolic and Endocytic pathways).	
5.	**Complement System**	(5)
5.1	Components of the Complement system; Activation pathways (Classical, Alternative and Lectin pathways)	
5.2	Biological consequences of complement Activation.	
6.	**Generation of Immune Response**	(10)

6.1	Primary and Secondary Immune Response	
6.2	Generation of Humoral Immune Response (Plasma and Memory cells)	
6.3	Generation of Cell Mediated Immune Response (Self MHC restriction, T cell activation, Co- stimulatory signals)	
6.4	Killing Mechanisms by CTL and NK cells	
6.5	Introduction to tolerance.	
7.	**Immunological Disorders and Tumor Immunity**	(6)
7.1	Types of Autoimmunity (Rheumatoid arthritis) and Hypersensitivity (I-V).	
8.	**Immunological Techniques**	(5)
8.1	Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA,Western blotting, Immunofluoresence, Immunoelectron microscopy.	
9.	**Immunohaematology**	(5)
9.1	ABO blood group system, haemolytic disease of newborn.	
	PRACTICALS (2 Credits)	**(60)**
1.	Identification of human blood groups.	(4)
2.	Total Leukocyte Count of a blood sample.	(6)
3.	Total RBC count of a blood sample.	(4)
4.	Differential Leukocyte Count (Leishman/Giemsa) of a blood sample.	(6)
5.	Preparation of serum and plasma from blood.	(10)
6.	Immunodiffusion by Ouchterlony method.	(20)
7.	VDRL test and WIDAL test (qualitative).	(10)
Pedagogy:	Lectures, seminars, assignments and practicals.	
References/ Readings	**(Latest Edition)**	
	1. Delves P, Martin S, Burton D, Roitt IM. Roitt's Essential Immunology. Wiley-Blackwell Scientific Publication, Oxford.	
	2. Goldsby RA, Kindt TJ, Osborne BA. Kuby's Immunology. W.H. Freeman and Company, New York.	
	3. Murphy K, Travers P, Walport M. Janeway'sImmunobiology. Garland Science Publishers, New York.	
	4. Peakman M, and Vergani D. Basic and Clinical Immunology. Churchill Livingstone Publishers, Edinberg.	
	5. Richard C and Geiffrey S. Immunology. Wiley Blackwell Publication.	
Learning Outcomes	Students will gain hands on experience of haematology and immunotechniques	

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure – Semester VI
Course Code: MIC 109
Title of the Course: Agricultural Microbiology
Number of Credits: 6 credits = 4 (Theory) + 2 (Practical)
Effective from Academic Year: 2019-20

Prerequisites	Basic knowledge of microbiology of soil, biotic and abiotic factors	

	affecting plant growth.	
Objective:	To understand the plant microbe interactions in the soil and mechanisms involved in improving crop productivity	
Content:	**THEORY (4 Credits)**	**(60)**
1	**Soil as microenvironment**	(8)
1.1	Organic matter decomposition – humus formation Rhizosphere and endophytic microflora and their role	
1.2	R:S ratio,Microbivory, Microbial associations in phytosphere: rhizosphere – phyllosphere – spermosphere.	
1.3	Degradation of cellulose, hemicelluloses, lignin and pectin in soils	
2	**Plant Microbe Interaction**	(15)
2.1	**Plant diseases**	
	Mode of entry of pathogens, disease symptoms	
2.1.1	**Bacterial diseases**	
	Crown gall, Citrus cancer, Black rot	
2.1.2	**Viral diseases, viriods**	
	TMV, Tomato leaf curl, Potato spindle tuber	
2.1.3	**Fungal diseases**	
	Late blight of potato - *Phytophthorainfestans*, Loose smut of wheat - *Ustilagonuda,* Rice blight - *Magnaporthagriseae,* Wilt - *Fusarium*	
2.1.4	**Control of plant diseases** Principles and practices, cultural practices, chemical methods, biological methods and genetic engineering for disease resistant plants.	
2.2	**Beneficial associations**	
	Rhizobium (Nitrogenase,Nodulation, Hydrogenase)	
	Azolla	
	Frankia(infection process, nodulation)	
	Mycorrhiza(Types- ecto/endo, mechanism of symbiosis)	
Unit 3	**Phytostimulation and Bioinsecticides**	(15)
3.1	Plant Growth Promoting Bacteria (PGPB)	
3.1.1	Microorganisms in soil, Root exudation, Effect of PGPB on plants, Root microbiome, PGPB :Direct (Nitrogen fixation, Psolubilisation, IAA producers, ammonia producers,ethylene(ACC deaminase) and indirect (Siderophores, HCN)	
3.2	Biopesticides -Introduction, types (bacterial- *Bacillus thuringiensis*, viral -NPV, fungal -*Trichoderma, Metarhizium*), mode of action,genes involved, factors influencing their action and target pests.	
4	**Biofertilizers**	(16)
4.1	Biofertilizers – definition, importance	
4.1.1	Types i) Nitrogen fixing – *Azotobacter, Rhizobium*, Azolla, Frankia, Cyanobacteria and *Azospirillum*. ii) Phosphate solubilizing Microorganisms. iii) Vesicular Arbuscular Mycorrhiza (VAM)	
4.1.2	Biochemistry of symbiotic and non- symbiotic nitrogen fixation,Phosphate solubilisation and Potassium mobilization	
4.1.3	Application methods	
	Steps in mass production of bacterial biofertilizers,quality guidelines	

	for biofertilizers. Methods of preparation and application – liquid and carrier based, Mass production of blue green algae, Azolla and mycorrhiza. Plant response to biofertilizers.	
Unit 5	**Genetically Modified Crops**	06
	Definition, Advantages, social and environmental aspects, Bt crops, Golden rice, salinity tolerance, cold temperature	
	PRACTICALS (2 Credits)	**(60)**
1.	Study of soil profile	(6)
2.	Study of microflora of different types of soils	(10)
3.	Isolation of plant growth promoting bacteria:	(24)
	(a) nitrogen fixers - symbiotic and non-symbiotic) (b) PSB's and KSB (c) IAA producers (d) siderophores producers	
4.	Formulation of biofertilizers	(6)
5.	Effect of biofertilizers on seedlings of *Vignaradiata*.	(6)
6.	Visit to ICAR/ ELA –Old Goa for study of plant pathogens and genetically modified crops.	(8)
Pedagogy:	Lectures/tutorials/assignments	
References/ Readings	**(Latest edition)**	
	1. Agrios GN. Plant Pathology. Academic press, San Diego,	
	2.Singh RS. Plant Diseases Management. Oxford & IBH, New Delhi.	
	3. Glick BR, Pasternak JJ, and Patten CL Molecular Biotechnology ASMPress	
	4. Atlas RM and Bartha R. Microbial Ecology: Fundamentals & Applications. Benjamin/Cummings Science Publishing, USA	
	5. Maier RM, Pepper IL and Gerba CP. Environmental Microbiology. Academic Press	
	6. Barton LL & Northup DE Microbial Ecology. Wiley Blackwell, USA	
	7. Campbell RE. Microbial Ecology. Blackwell Scientific Publication, Oxford, England.	
	8. Coyne MS. Soil Microbiology: An Exploratory Approach. Delmar ThomsonLearning.	
	9. Altman A Agriculture Biotechnology, Marcel decker Inc.	
	10. Mahendra K. Rai Hand Book of Microbial Biofertilizers, The Haworth Press, Inc.New York	
	11. Reddy, S.M. *etal*.Bioinoculants for Sustainable Agriculture and Forestry,Scientific Publishers	
	12. Saleem F and Shakoori AR. Development of Bioinsecticide, Lap Lambert Academic Publishing.	
	13. Rangaswamy G. Diseases of crop plants in India	
	14.Glick B.R. Beneficial Plant Bacterial Interactions, Springer.	
Outcome	1.The students will be able to identify the types of plant diseases affecting crops 2. They will be able to isolate PGPB and formulate bioinoculant	

	preparation.	

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Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester VI
Course Code: MIC 110
Title of the Course: GENETIC ENGINEERING
Number of Credits: 6 credits = 4 (Theory) + 2 (Practical)
Effective from Academic Year: 2019-20

Prerequisites	Students should have knowledge of microbial genes and genetics.	
Objective	To familiarize the students with tools and techniques in genetic engineering.	
Content	**THEORY (4 Credits)**	**(60)**
1	**Introduction to genetic engineering** Milestones in genetic engineering	(20)
1.1	**Tools and strategies:** Restriction endonucleases: Type I, II, III. Mode of action, nomenclature and applications of Type II restriction enzymes in genetic engineering. Restriction and modification.	
1.2	**DNA modifying enzymes and their applications:** DNA polymerases, Klenow fragment, kinases and phosphatases, terminal deoxynucleotidyl transferase, DNA ligases, S1 nuclease, and RNAase H. Use of linkers and adapters. Synthesis of cDNA, sticky end and blunt end cloning.	
1.3	**Cloning and Expression vectors:** Plasmids, pBR and pUC series, Ti plasmid based vector; Bacteriophage, lambda and M13 based vectors; cosmids; phagemids, Bacterial Artificial Chromosomes (BACs); Yeast Artificial Chromosomes (YACs). Shuttle vectors, Expression vectors (Fusion and Pure proteins), *E. coli* lac promoter based vector, Yeast Episomal Plasmids (YEPs), Mammalian vector (SV40).	
2	**Methods in molecular cloning**	(25)
2.1	**DNA, RNA and Protein Analysis** - agarose gel electrophoresis, PAGE - 1D/2D gel analysis, concept of nucleic acid probes, Northern, Southern, Western and Immuno-blotting techniques and protein sequencing.	
2.2	**DNA amplification and DNA sequencing -** PCR, Sanger's method, Maxam and Gilbert's method, Shot gun sequencing.	
2.3	**Transformation, Transduction and Screening** Chemical methods, electroporation, shotgun method, virus mediated gene delivery; *Agrobacterium* mediated gene delivery, selection methods of transformed bacterial cells (antibiotic resistance markers and Blue white screening). Colony hybridization and Plaque hybridization. Chromosome walking and chromosome jumping.	
3	**Applications of recombinant DNA technology**	**(15)**
3.1	**Products of rDNA technology:** Human therapeutic significance – insulin, antisense molecules. Gene therapy, RNAi, recombinant vaccines. Agricultural significance – Bt transgenic: cotton, brinjal.	
	PRACTICALS (2 Credits)	**(60)**
1.	Restriction enzyme digestion of DNA and analysis by agarose gel electrophoresis.	(5)
2.	Ligation of DNA fragments and analysis by agarose gel electrophoresis.	(5)

3.	Interpretation of sequencing gel electropherograms and sequence analysis.	(5)
4.	Native PAGE.	(5)
5.	Demonstration of Immuno-blotting technique	(10)
6.	Demonstration of PCR	(10)
7.	Demonstration of Gel-Doc	(5)
8.	Screening of transformed cells (blue-white screening method)	(15)
Pedagogy:	Lectures, seminars, assignments and practicals.	
References/ Readings	**(Latest Edition)**	
	1. Sambrook J and Russell D. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.	
	2. Freifelder D. Microbial Genetics. Jones and Bartlett Publishers.	
	3. Gardner EJ, Simmons MJ, Snustad DP. Principles of Genetics. Wiley India.	
	4. Stryer L. Biochemistry. W H Freeman and Company.	
	5. Krebs JE, Goldstein ES, Kilpatrick ST. Lewin's Genes. Jones and Bartlett Publishers.	
	6. Glick BR, Pasternak JJ, and Patten CL. Molecular Biotechnology ASM Press.	
	7. Dubey RC, A Textbook of Biotechnology. S. Chand & Co. Ltd.	
	8. Mathur SK, Purohit SS, Biotechnology. Fundamentals and Applications. Agro Botanica.	
	9. Brown TA. Gene Cloning and DNA Analysis: An Introduction. Wiley Publication.	
Learning Outcome:	Students will be able to handle microorganisms for isolation and amplification of DNA and transform host cells.	

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester VI
Course Code: MID 104
Title of the Course: CELL BIOLOGY
Number of Credits: 4 credits = 3 (Theory) + 1 (Practical)
Effective from Academic Year: 2019-20

Prerequisites	Students are expected to have a basic knowledge of prokaryotic and eukaryotic cells.	
Objective:	To study the types and functioning of different organelles in cells	
Content:	**THEORY (4 Credits)**	**(60)**
1.	Cell to cell interactions.	(10)
1.1	Eukaryotic cell membrane, Extra cellular matrix and cell matrix interactions, cell surface protrusions, Types of cellular junctions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata.	
2.	Protein Sorting and Transport	(10)
2.1	Ribosomes, Endoplasmic Reticulum – targeting and insertion of proteins in the ER, protein folding, processing and quality control in ER, smooth ER, export of proteins and lipids. Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus.	
3.	Cell Signalling	(10)

3.1	Cyclic GMP and MAP kinase pathway, chemotaxis and phototaxis, quorum sensing: CFTR, Calmodulin.	
4.	Cell Cycle	(5)
4.1	Regulation of eukaryotic cell cycle, mitosis and meiosis. Cell death and apoptosis.	
5.	Development of cancer, causes and types	(10)
5.1	Introduction to cancer, Oncogenes, Tumor suppressor genes, Properties and development of cancer cells (activation of cell division), Symptoms, Causes, Risk factors, Classification (benign and malignant), Different types (Carcinoma, Sarcoma, Leukemia, Lymphoma and Myeloma), Stages of cancer (Histological classification).	
	PRACTICALS (1 Credit)	**(30)**
1.	Study of stages of mitosis.	(2)
2.	Study of stages of meiosis.	(2)
3.	Study of gap junctions through electron micrographs.	(2)
4.	Identification and study of cancer cells by photomicrographs.	(4)
5.	Demonstration of quorum sensing (Swarming by *Proteus*).	(8)
6.	Demonstration of positive and negative chemotaxis (Effect of attractants and repellants on *E.coli*).	(8)
7.	Demonstration of apoptosis and necrosis	(4)
Pedagogy:	Lectures, seminars, assignments and practicals.	
References/ Readings	**(Latest Edition)**	
	1. Hardin J, Bertoni G and Kleinsmith LJ. Becker's World of the Cell. Pearson.	
	2. Karp G. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Inc.	
	3. De Robertis, EDP and De Robertis EMF. Cell and Molecular Biology. Lipincott Williams and Wilkins, Philadelphia.	
	4. Cooper, G.M. and Hausman, R.E. The Cell: A Molecular Approach. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.	
	5. Lodish H., Berk A., Kaiser C., Krieger M., Scott M., Bretscher A., Ploegh H., Matsudaira P., Molecular cell biology .W H Francis and company, New York.	
	6. Alberts B., Johnson A., Lewis J., Raff M., Roberts K., Walter P., Molecular Biology of The Cell Garland science,Taylor and Francis group.	
	7. Adler J.Chemotaxis in Bacteria .Annual Reviews of Biochemistry. 44:341-356.	
Learning Outcomes	Students will gain knowledge of functioning of different part of cells and understand differences between normal and diseased cells.	

Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester VI
Course Code: MID 105
Title of the Course: VIROLOGY
Number of Credits: 4 credits = 3 (Theory) + 1 (Practical)
Effective from Academic Year: 2019-20

Prerequisites	Basic understanding of human physiology and genetics	
Objective:	To study bacteriophages and understand the classification of viruses along with their role in cancers in humans	
Content:	**THEORY (3 Credits)**	**(45)**
1.	**Nature and Properties of Viruses**	(15)
1.1	Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and Prions.	
1.2	Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses, Isolation, purification and cultivation of viruses.	
1.3	Viral taxonomy: Molecular classification and nomenclature of different groups of viruses.	
2.	**Bacteriophages**	(14)
2.1	Diversity, Classification of bacteriophage on the basis of structure, one step multiplication curve	
2.2	Lytic and lysogenic phages (lambda phage) concept of early and late proteins	
2.3	Regulation of transcription in lambda phage.	
3.	**Viruses and Cancer**	(8)
3.1	Introduction to oncogenic viruses	
3.2	Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes	
4.	**Prevention & control of viral diseases**	(8)
4.1	Antiviral compounds and their mode of action	
4.2	Interferon and their mode of action	
4.3	General principles of viral vaccination	
	PRACTICALS (1 Credit)	**(30)**
1.	Study of the structure of important animal viruses (rhabdo, influenza, hepatitis B and retroviruses) using electron micrographs	(6)
2.	Study of the structure of important plant viruses (caulimo, Gemini, tobacco mosaic virus) using electron micrographs	(6)
3.	Study of the structure of important bacterial viruses (T4, λ) using electron micrograph.	(6)
4.	Determination of phage titre from water/sewage sample.	(8)
5.	Study of cytopathic effects of viruses using photographs	(4)
Pedagogy:	Lectures, seminars, assignments and practicals.	
References/ Readings	**(Latest Edition)**	
	1.Dimmock, NJ, Easton, AL, Leppard, KN. Introduction to Modern Virology. Blackwell Publishing Ltd.	
	2. Carter J and Saunders V. Virology: Principles and Applications. John Wiley and Sons.	
	3. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM. Principles of Virology, Molecular biology, Pathogenesis and Control. ASM press Washington DC.	
	4. Levy JA, Conrat HF, Owens RA. Virology. Prentice Hall publication,	

	NewJersey.	
	5. Wagner EK, Hewlett MJ. Basic Virology. Blackwell Publishing.	
Learning Outcomes	1. Students will learn to differentiate between types of viruses and their role in disease and cancer. 2.Ability to isolate and cultivate bacteriophages	

Programme : B.Sc. Microbiology (HONS)
Course Code: MID 106
Title of the Course: Haematology and Clinical Biochemistry
Number of Credits: 3+1 = 4
Effective from Academic Year: 2019-20

Prerequisites	Basic knowledge of microbiology, human anatomy and physiology	
Objective:	To understand the significance of blood and the disorders associated with metabolism and physiology.	
Content:	**Theory (3 credits)**	**(45)**
Unit 1	**Haematology**	(10)
1.1	Overview of blood circulatory system of humans, Blood, plasma, serum - definition, Blood components and their functions, Buffering system – role of proteins, carbonate system and other ions in buffering, deviations in pH and their impact, Haematopoiesis-erythropoiesis, leukopoiesis and thrombopoeisis.	
1.2	Structure and function of erythrocytes, Hemoglobin- structure, function, synthesis, metabolism of iron, abnormal erythrocytes and haemoglobins, types of Hbs and its derivatives (carboxy Hb and met Hb, sickle cell Hb).	
1.3	Structure and function of different types of leucocytes.	
1.4	Structure and function of thrombocytes.	
Unit 2	**Blood counts**	(8)
2.1	Collection of blood - methods, skin puncture and venipuncture; type and use of Anticoagulants, handling and processing of blood samples, disposal of samples.	
2.2	Determination of hemoglobin- significance, principle and method.	
2.3	Blood cell counts – RBC count and Total leucocyte count by Haemocytometer, differential leucocyte count, total platelet count , determination of haematocrit –micro haematocrit and macro haematocrit method, Erythrocyte sedimentation rate (ESR) - Westergren's and Wintrobe's method. Overview of automated methods of blood analysis.	
Unit 3	**Hemostasis and coagulation**	(04)
3.1	Mechanism of blood coagulation – intrinsic and extrinsic pathways, routine coagulation tests – bleeding time, clotting time.	
Unit 4	**Hematological diseases**	(10)
4.1	Anaemia - Introduction and etiological classification, types of anaemias – iron deficiency, aplastic anaemia, megalobastic anaemia, sideroblastic anaemia, pernicious anaemia.	
4.2	Thalassemia – alpha and beta – underlying causes, clinical	

	features, diagnosis and treatment	
4.3	Leukemia - introduction, types of leukemia - Acute myelogenous leukemia (AML), Chronic lymphocytic leukemia (CLL), Acute lymphoblastic leukemia (ALL).	
Unit 5	**Immunohaematology**	(03)
5.1	Blood groups – Introduction and history of blood grouping, classification of different types of blood groups, ABO and sub groups, antigen (structure and composition) and antibodies (definition and role of natural Abs). ABO blood grouping techniques, Inheritance of the ABO blood groups, Rh blood group – definition, structure, importance, incomplete antibodies. Other blood group systems and their significance, Cross matching.	
5.2	Blood transfusion- collection of blood from donor, Blood transfusion reactions. Blood banks and their role.	
Unit 6	**Clinical Biochemistry**	(10)
6.1	Carbohydrate metabolism: Clinical aspects of Regulation of Blood sugar and Diabetes, Diabetic profile test.	
6.2	Protein metabolism: starvation, and protein energy malnutrition, blood urea.	
6.3	Lipid metabolism: Clinical aspects of lipid profile- HDL, LDL, VLDL, cholesterol, triglycerides. Atherosclerosis.	
	PRACTICALS (1 Credit)	(30)
1.	Total RBC count by Haemocytometer	
2.	Total WBC count by Haemocytometer	
3.	Differential leucocyte count	
4.	Determination of Packed cell volume by Macro- hematocrit method	
5.	Determination of ESR by Westergren/Wintrobe method	
6	Determination of platelet count	
7	Screening for sickle cell anemia	
8	Determination of bleeding time	
9	Determination of blood clotting time	
10	Qualitative test for ABO grouping by slide method	
11	Determination of Rho (D) typing by slide method	
12	Cross matching by saline tube method	
13	Fasting and post prandial blood sugar determination using glucometer	
14	Total serum protein determination	
15	Determination of serum total cholesterol	
16	Visit to Clinical/Pathology Laboratory	
Pedagogy:	Lectures/tutorials/assignments/videos	
References/ Readings (Latest edition)	1. Godkar, P. B. and Godkar, D. P., Textbook of Medical Lab Technology, Bhalani Publishing House, India.	
	2. Maheshwari, N., Clinical Pathology, Hematology and Blood Banking (for DMLT students), Jaypee Brothers Medical	

	Publishers.	
	3. Kabra, M. P. and Kabra, A., Practical Human Anatomy and Physiology, Pharmamedix India Publication Pvt. Ltd.	
	4. Deb, A. C., Fundamentals of Biochemistry, New Central Book Agency, Kolkata.	
	5. Sood, R., Textbook of Medical Laboratory Technology, Jaypee Brothers Medical Publishers.	
	6. Chatterjee, M.N. and Shinde, R., Textbook of Medical Biochemistry, JP Medical Limited.	
	7. Bain, B., Bates, I., Laffan, M. and Lewis, S., Dacie and Lewis Practical Haematology, Churchill Livingstone.	
	8. Makroo, R. N., Compendium of Transfusion Medicine, Career Publication.	
Outcome	1. Students will be able to appreciate the significance of blood and its components. 2. Students will be able to handle and process the blood samples for various analyses. 3. Students will be able to detect and diagnose haematological and metabolic disorders.	

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Programme: B.Sc. (Microbiology) (HONS.) CBCS Structure - Semester VI
Course Code: MIP
Title of the Course: PROJECT
Number of Credits: 4 credits
Effective from Academic Year: 2019-20

Prerequisites	Knowledge of various techniques in Microbiology and Laboratory training obtained during B.Sc. practical.
Objective:	Planning and execution of various research related practicals independently or as a group.
Content:	
1.	Identification of research problem in Microbiology.
2.	Review of literature associated with project.
3.	Listing the various objectives.
4.	Planning and conducting experiments related to project work.
5	Collection and analysis of data for preparation of project report.
6.	Final preparation of project report to be submitted as dissertation in partial fulfillment of B.Sc. Programme.
Pedagogy:	Students individually / as a group of five will conduct practical/ survey and prepare project report at the end of Semester VI.
References / Readings	As required for review of literature and methodology for compilation of project report.
Learning Outcomes	Ability to apply the tools and techniques of Microbiology in conducting research. Enhanced capacity to analyze observations and results & prepare

	project report.