SRIDEV SUMAN UTTARAKHAND UNIVERSITY, BADSHAHITHAUL, TEHRI, GARHWAL

SCHEME OF EXAMINATION AND COURSE OF STUDY IN BSC (MICROBIOLOGY)

FOR

B.Sc. I, II, III Years (Semester System)

(Effective from academic Session 2020-21)

SYLLABUS COMMITTEE

1- Dr. Prabhat Kumar Singh — Convener
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Syllabus and Scheme of Examination

for B.Sc. Microbiology

THREE YEAR FULL TIME PROGRAMME

Note: Syllabi applicable for students seeking admission in the B.Sc. Microbiology Course from the academic year 2020-2021

DEPARTMENT OF MICROBIOLOGY FACULTY OF INTERDISCIPLINARY AND APPLIED SCIENCES SRI DEV SUMAN UTTARAKHNAD UNIVERSITY BADSHAHITHAUL TEHRI GARHWAL

Introduction:

Program Duration: The B.Sc. Microbiology programme will be of three years duration. Each year will be called an academic year and will be divided into two semesters. Thus there will be a total of six semesters. Each semester will consist of sixteen weeks.

Design of Program: The teaching-learning will involve theory classes (Lectures) of one hour duration and practical classes. The curriculum will be delivered through various methods including chalk and talk, power point presentations, audio, video tools, E-learning/E-content, virtual labs, simulations, field trips/Industry visits, seminars (talks by experts), workshops, projects, models and class discussions. The assessment broadly will comprise of Internal Assessment (Continuous Evaluation) and End Semester Examination. Each theory paper will be of 100 marks with 20% marks for Internal Assessment and 80% for End Semester examination. The internal Assessment will be through MCQ, test, assignment, oral presentation, worksheets and short project. Each practical paper will be of 50 marks (In which 10 marks for internal and 40 marks for external).

Programme Structure:
The programme includes 04 theory papers and 02 practical in every semester. Project work will also carry in sixth semester. The number of students who will be allowed to opt for project work will vary from college to college depending upon the infrastructural facilities and may vary each year. The college shall announce the number of seats for project work well in advance and may select the students for the same based on merit. Project work will involve experimental work and the student will have to do this in the time after their regular theory and practical classes. The final evaluation of the project work will be through a committee involving internal and external examiners. In this regard guidelines provided by University of Delhi for executing and evaluation of project work will be final. Students will be asked their choice for Project work at the end of IV semester and all formalities of topic and mentor selection will be completed by this time.

Course Structure B.Sc. (Microbiology)

Semester	Subject	Marks
First	101 – Fundamental of Microbiology	80 +20
	102 Introduction to Microbial World (Bacteria, fungi & Protozoa)	80 +20
	103 Biochemistry	80 +20
	104 – Cell Biology	80 +20
	Practical- Paper 1 & 2	40 + 10
	Practical – paper 3 & 4	40 + 10
	Grand Total	500

Semester	Subject	Marks
Second	201 – Bacteriology	80 +20
	202 – Algae, Fungi & Plant Pathology	80 +20
	203 Molecular Biology	80 +20
	204 – Bioinformatics & Computer application	80 +20
	Practical - Paper 1 & 2	40 + 10
	Practical – Paper 3 & 4	40 + 10
	Grand Total	500

Semester	Subject	Marks
Third	301 – Virology	80 +20
	302 Instrumentation and Biotechniques	80 +20
	303 Environmental Microbiology	80 +20
	304 – Recombinant DNA Technology	80 +20
	Practical - Paper 1 & 2	40 + 10
	Practical – Paper 3 & 4	40 + 10
	Grand Total	500

Semester	Subject	Marks
Forth	401 Genetics and Genomics	80 +20
	402 Microbial Genetics and Molecular Biology	80 +20
	403 – Microbial Physiology and Metabolism	80 +20
	404 – Microbiology of Water & Air	80 +20
	Practical - Paper 1 & 2	40 + 10
	Practical – Paper 3 & 4	40 + 10
	Grand Total	500

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Semester	Subject	Marks
Fifth	501 – Medical Microbiology & Immunology	80 +20
	502 Industrial Microbiology	80 +20
	503 Microbial Biotechnology	80 +20
	504 Soil Microbiology	80 +20
	Practical - Paper 1 & 2	40 + 10
	Practical – Paper 3 & 4	40 + 10
	Grand Total	500

Semester	Subject	Marks
Sixth	601 Food and Dairy Microbiology	80 +20
	602 Microbial diagnosis in health clinics	80 +20
	603 Microbial Quality Control in Food and Pharmaceutical Industries	80 +20
	604 Project Work	80 +20
	Practical - Paper 1 & 2	40 + 10
	Practical - Paper 3	40 + 10
	Grand Total	500

B.Sc. Microbiology (First year) I Semester

Paper I: FUNDAMENTAL OF MICROBIOLOGY

UNIT I History of microbiology, scope and relevance of microbiology, Development of Microbiology as a discipline, Spontaneous generation vs. biogenesis, development of various Microbiological techniques, concept of fermentation, establishment of fields of medical Microbiology, immunology and environmental Microbiology with special reference to the work of following scientists : Anton von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Sergei N. Winogradsky, Alexander Fleming, Selman A. Waksman, Elie Metchnikoff, Norman Pace, Carl Woese and Ananda M. Chakraborty

UNIT II Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms, economic importance of Microorganisms

UNIT III Principle, types and application of microscopes, LAF cabinet, autoclave, oven, colony counter, spectrophotometer, pH meter, anaerobic chamber; Principle, and applications of electrophoresis, Polymerase chain Reaction, centrifuge, blotting Techniques, Chromatography & its types.

UNIT IV Isolation,cultivation and identification techniques for microorganisms, aerobic and anaerobic cultivation,biochemical methods for identification, culture media and its type, maintenance and preservation of pure cultures , Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation Chemical methods of microbial control: disinfectants, types and mode of action

UNIT V Study of Morphology of microbes by staining methods, Simple staining Leffer'spolychrome methylene blue & negative staining Gram's staining, Ziel neelson staining, Flurochrome staining, Leishman's staining, Giemsa's staining, special staining methods for granules, capsules, spores Flagella .

B.Sc. Microbiology (First year) I Semester

Paper II : INTRODUCTION TO MICROBIAL WORLD (BACTERIA, FUNGI & PROTOZOA)

UNIT I. Systems of classification: Basic idea about Hackel and Whittaker's kingdom concept and domain concept of Carl Woese, General characteristics and representative members of different groups: Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Archeobacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

UNIT II Viruses, Viroids, Prions Virusides General introduction with special reference to the structure of the following: TMV, poliovirus, T4 and λ phage, lytic and lysogenic cycles, one step multiplication curve

Bacteria A very precise account of typical eubacteria, chlamydiae & rickettsiae (obligate intracellular parasites), mycoplasma, and Archaebacteria (extremophiles) General character cyanobacteria.

UNIT III General characteristics of algae including occurrence (habitat), thallus organization, cell ultra structure, pigments, flagella, eyespot, food reserves (reserve foods) and reproduction in Chlorophyta and Xanthophyta. Economic Importance of algae

UNIT IV General characteristics of fungi including habit, habitat, nutritional requirements, thallus organization and aggregation, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism. Economic importance of fungi

UNIT V Flagellate protozoa : the Mastigophora, ameboid protozoa: the Rhizopoda, ciliate protozoa: the ciliophora. Protozoal disease: Malaria, Giardiasis, Trichomoniasis, Toxoplasmosis, Pneumocystis pneumonia and disease caused by Leishmania. importance of Protozoa.

B.Sc. Microbiology (First year) I Semester

Paper III : BIOCHEMISTRY

UNIT I Bioenergetics - First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, Enthalpy,and Entropy and mathematical relationship among them, 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.

UNIT II. Enzymes - Structure of enzyme: Apoenzyme and cofactors, coenzyme, Classification of enzymes, Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis and Induced Fit hypothesis. Significance of hyperbolic, double reciprocal plots of enzyme activity, enzyme kinetics Effect of pH and temperature on enzyme activity. Enzyme inhibition: competitive- sulfa drugs; non-competitive-heavy metal salts.

UNIT III Carbohydrates - Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Stereo-isomerism of monosaccharides, epimers, Mutarotation and anomers of glucose. Furanose and pyranose forms of glucose and fructose, muramic acid, N-acetyl neuraminic acid, Disaccharides; concept of reducing and non-reducing sugars, occurrence and maltose, lactose, and sucrose, Polysaccharides, storage polysaccharides, starch and glycogen. Structural Polysaccharides, cellulose, peptidoglycan and chitin.

UNIT IV Proteins - Functions of proteins, Primary structures of proteins: Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. (Titration curve of amino acid and its significance, classification, biochemical structure and notation of standard protein amino acids.) Ninhydrin reaction.Natural modifications of amino acids in proteins hydrolysine, cystine and hydroxyproline, Non protein amino acids: Gramicidin, beta-alanine, D-alanine and D- glutamic acid Oligopeptides: Structure and functions of naturally occurring glutathione and insulin and synthetic aspartame, Secondary structure of proteins: Peptide unit and its salient features.

UNIT V Lipids - Definition and major classes of storage and structural lipids. Storage lipids. Fatty acids structure and functions. Essential fatty acids. Triacyl glycerols structure, functions and properties. Saponification Structural lipids. Phosphoglycerides: Building blocks, General structure, functions and properties. Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids: building blocks, structure of sphingosine, ceramide. Special mention of sphingomyelins, cerebrosides and gangliosides Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers and bilayers

B.Sc. Microbiology (First year) I Semester

Paper IV : CELL BIOLOGY

Unit I An Overview of Cells: Overview of prokaryotic and eukaryotic cells, cell size and shape, Phages, Viriods, Mycoplasma and Escherichia coli. Chemical foundations: atomic bonds and molecular interactions, chemical building blocks of cells. Chemical equilibrium, equilibrium constants, dissociation constants, maintenance of pH and ionic balance.

Unit II Tools and techniques of Cell Biology : Microscopic-Principles of Light microscopy; Phase contrast microscopy; Confocal microscopy;Electron microscopy (EM)- scanning EM and scanning transmission EM (STEM); Fluorescence microscopy; Analytical-Flow cytometry- flurochromes, fluorescent probe and working principle; Spectrophotometry; Mass spectrometry; X-ray diffraction analysis. Separation-Sub-cellular fractionation- differential and density gradient centrifugation; Chromatographypaper, thin-layer, gel-filtration, ion-exchange, affinity and High-Performance Liquid Chromatography (HPLC).

Unit III . Composition of Cells Molecules of cell, cell membranes and cell Proteins.

The Nucleus :Nuclear Envelope- structure of nuclear pore complex, nuclear lamina, Transport across Nuclear Envelope, Chromatin: molecular organization, Nucleolus and rRNA Processing.

Protein Sorting and Transport The Endoplasmic reticulum, The Golgi Apparatus, Mechanism of Vesicular Transport, Lysosomes.

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

Unit V Cytoskelton and Cell Movement Structure and organization of actin filaments; the dynamics of actin assembly actin, myosin and cell movement; intermediate filaments; microtubules. Kinesin and Dynein powered movements, microtubule dynamics and motor proteins in mitosis.

B. Sc. Microbiology (First Year) II Semester

Paper 1: BACTERIOLOGY

UNIT I Cell organization The morphology and fine structure of bacteria. 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, Archaebacterial cell wall, Gram and acid fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids Endospore: Structure, formation, stages of sporulation.

UNIT II Growth and nutrition Definition; photoautotrophs, photohetrotrophs, chemoautotrophs, chemohetrotrophs; Nutritional categories among microorganisms Nutritional requirements in bacteria and nutritional categories; The requirements for carbon, nitrogen and sulphur, growth factors, the role oxygen, Continous cultures, their applications, chemostats and turbidostats. Reproduction in Bacteria Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate.

UNIT III B Bacterial Systematics Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaebacteria

UNIT IV Important archaeal groups According to Bergey's Manual of Systematic Bacteriology (Second Edition) Archaebacteria: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (Nanoarchaeum), Crenarchaeota (Sulfolobus, Thermoproteus) and Euryarchaeota [Methanogens (Methanobacterium, Methanocaldococcus), thermophiles (Thermococcus, Pyrococcus, Thermoplasma), and Halophiles (Halobacterium, Halococcus)]

UNIT V Important eubacterial groups Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups:

Gram Negative: • Alpha proteobacteria Rickettsia, Coxiella, Caulobacter, Rhizobium, Hyphomicrobium Agrobacterium.

• Beta proteobacteria Neisseria, Burkholderia, Thiobacillus

• Gamma proteobacteria Enterobacteriaceae family, Pseudomonas, Vibrio.

• Delta proteobacteria Bdellovibrio, Myxococcus

• Epsilon proteobacteria Helicobacter, Campylobacter Gram Positive:

• Low G+ C (Firmicutes) Mycoplasmas, Clostridium, Lactobacillus, Staphylococcus, Streptococcus, Bacillus. • High G+C (Actinobacteria) Arthrobacter, Corynebacterium, Mycobacterium, Streptomyces, Thermomonospora,

B. Sc. Microbiology (First Year) II Semester

Paper II: ALGAE, FUNGI & PLANT PATHOLOGY

UNIT I Classification of Algae Study of the following classes with reference to genera listed below (occurrence, thallus organization and life cycles): a) Chlorophyceae: Volvox, Coleochaete b) Charophyceae: Chara c) Diatoms: General features with reference to pinnate and centric diatoms d) Xanthophyceae: Vaucheria e) Phaeophyceae: Ectocarpus f) Rhodophyceae: Polysiphonia g) Cyanobacteria: Nostoc

UNIT II Cultivation of algae in laboratory. Application of algae in agriculture, biofertilizer, Industrial application of algae, medicinal importance, Nutritional value, environmental implications, algal blooms and eutrophication economic aspects of algae, algal biotechnology. Fossil records of algae.

UNIT III Classification of fungi Recent advances in fungal classification, General Characteristics, Ultrastructure. Habitat, fungal structure and thallus organization, wall structure, hyphal growth, Heterothallism, sexual and asexual reproductive structures. sex hormones in fungi, Evolutionary tendencies in lower fungi

UNIT IV Classification ,Nutrition and reproduction of Mycorrhiza , Economic importance of fungi with examples In Agriculture, Environment, Industry, Medicine, Food, Biodeterioration (of wood, paper, textile, leather), Mycotoxins Lichens: classification, physiology and importance.

UNIT V Concept of plant disease; signs and symptoms associated with microbial plant pathogens. Microbial enzymes, toxins,growth regulators and suppressor of plant defense in plant diseases, effects of pathogens on plant physiology, concept of passive and active resistance and mechanism in plants. Concepts of monocyclic& polycyclic disease, physical, chemical and biological control, integrated eco friendly approach of plant disease control.

B. Sc. Microbiology (First Year) II Semester

Paper III : MOLECULAR BIOLOGY

UNIT I. Nucleic Acids convey Genetic Information, DNA as the carrier of genetic information, Key experiments establishing-The Central Dogma, DNA Double helix, Genetic code, Direction of Protein Synthesis, Genomics.

UNIT II .The Structures of DNA and RNA Genetic Material , DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves. DNA topology - linking number, topoisomerases; Organization of DNA Prokaryotes, Viruses, Eukaryotes. RNA Structure Organelle DNA -- mitochondria and chloroplast DNA.

UNIT III Genome Structure, Chromatin and the Nucleosome Genome Sequence and Chromosome Diversity, Chromosome Duplication and Segregation, The Nucleosome Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin. Regulation of Chromatin Structure and Nucleosome Assembly. Organization of Chromosomes

UNIT IV The Replication of DNA (Prokaryotes and Eukaryotes) Chemistry of DNA synthesis, general principles - bidirectional replication, Semiconservative, Semi discontinuous, RNA priming, Various models of DNA replication including rolling circle, Dloop (mitochondrial), Θ (theta) mode of replication, replication of linear ds-DNA, replicating the 5'end of linear chromosome. Enzyme involved in DNA replication – DNA polymerases, DNA ligase, Primase, Telomerase and other accessory proteins

UNIT V. The Mutability and Repair of DNA Definitions, Mutation, muton, replicon, principles of mutation, Replication Errors, DNA Damage, different types of mutations, deletions, duplications, UV induced mutations, repair mechanisms against mutations and their importance

B. Sc. Microbiology (First Year) II Semester

Paper IV: BIOINFORMATICS & COMPUTER APPLICATION

UNIT 1 Introduction to Computer Fundamentals - RDBMS - Definition of relational database. Mode of data transfer (FTP, SFTP, SCP), advantage of encrypted data transfer.

UNIT 2 Introduction to Bioinformatics and Biological Databases - Biological databases - nucleic acid, genome, protein sequence and structure,gene expression databases, Database of metabolic pathways, Mode of data storage - File formats - FASTA, Genbank and Uniprot, Data submission & retrieval from NCBI, EMBL, DDBJ, Uniprot, PDB.

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

UNIT 4 Genome organization and analysis - Diversity of Genomes: Viral, prokaryotic & eukaryotic genomes. Genome, transcriptome, proteome, 2-D gel electrophoresis, MALDI-TOF spectrometery. Major features of completed genomes: *E.coli, S.cerevisiae, Human.*

UNIT 5 Protein Structure Predictions - Hierarchy of protein structure - primary, secondary and tertiary structures, modeling Structural Classes, Motifs, Folds and Domains. Protein structure prediction in presence and absence of structure template. Energy minimizations and evaluation by Ramachandran plot. Protein structure and rational drug design.

B. Sc. Microbiology (II Year) III Semester

Paper I :VIROLOGY

UNIT 1 Introduction Discovery of viruses, nature and definition of viruses, general properties of viruses. Concept of viroids, virusoids, satellite viruses and prions. Theories of viral origin. Structure of viruses: Capsid symmetry, enveloped and non-enveloped viruses.

UNIT II Isolation, purification and cultivation of viruses. Classification and nomenclature of different groups of viruses infecting microbes, plants and animals.

UNIT III Salient features of viral genome: Unusual bases (TMV, T4 phage), overlapping genes (ΦX174, Hepatitis B virus), alternate splicing (Picornavirus), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), ambisense genomes (arenavirus), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (influenza virus) and non segmented genomes (picornavirus), capping and tailing (TMV).

UNIT IV Bacteriophages Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda and P1 phage), concept of early and late proteins, regulation of transcription in lambda phage and applications of bacteriophages.

UNIT V Viral multiplication and replication strategies .Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses as per Baltimore classification. Assembly, maturation and release of virions. Concept of defective particles. Transmission of viruses. Oncogenic viruses Types of oncogenic DNA and RNA viruses. Concepts of oncogenes, protoncogenes and tumor suppressor genes. Prevention and control of viral diseases Antiviral compounds, interferons and viral vaccines. Applications of Virology Use of viral vectors in cloning and expression, Gene therapy and Phage display

B. Sc. Microbiology (IIYear) III Semester

Paper II: INSTRUMENTATION AND BIOTECHNIQUES

UNIT 1 Microscopy - Brightfield and darkfield microscopy, Fluorescence Microscopy, Phase contrast Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy) and Micrometry.

UNIT II Chromatography - Principles and applications of paper chromatography (including Descending and 2- D), Thin layer chromatography. Column packing and fraction collection. Gel filtration chromatography, ionexchange chromatography and affinity chromatography, GLC, HPLC.

UNIT III Electrophoresis - Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, 2D gel electrophoresis Isoelectric focusing, Zymogram preparation and Agarose gel electrophoresis.

UNIT IV Spectrophotometry - Principle and use of study of absorption spectra of biomolecules. Analysis of biomolecules using UV and visible range. Colorimetry and turbidometry. ,X-ray Crystallography, fluorescence; Hydrodynamic methods; Atomic absorption & Plasma emission spectroscopy

UNIT V Centrifugation - Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, differential centrifugation, density gradient centrifugation and ultracentrifugation.

B. Sc. Microbiology (II Year) III Semester

Paper III : ENVIRONMENTAL MICROBIOLOGY

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

UNIT II Microbial Interactions 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 III Biogeochemical Cycling Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction Phosphorus cycle: Phosphate immobilization and solubilisation Sulphur cycle: Microbes involved in sulphur cycle Other elemental cycles: Iron and manganes,

UNIT IV Waste Management 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 V Microbial Bioremediation Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inroganic (metals) matter, biosurfactants

B. Sc. Microbiology (II Year) III Semester

Paper IV: RECOMBINANT DNA TECHNOLOGY

UNIT I Introduction to basic biotechnology Milestones in genetic engineering and biotechnology Tools of recombinant DNA technology A. Hosts ,E. coli strains; Yeast (Saccharomyces cerevisiae, Pichia pastoris); Fungi (Penicillium, Aspergillus); Mammalian cell lines - names and genotypes B. Enzymes Restriction modification systems: Types I, II and III. Mode of action, nomenclature. Application of Type II restriction enzymes in genetic engineering. DNA modifying enzymes and their applications: Terminal deoxynucleotidyl transferase, kinases and phosphatases, DNA ligases and DNA polymerases, reverse transcriptases, bacteriophage RNA polymerases, exonuclease III, BAL31, mung bean nuclease, S1 nuclease C. Vectors Cloning Vectors- Definition and Properties. Plasmid vectors-pBR and pUC series, Bacteriophage lambda and M13 based vectors. Cosmids. Shuttle vectors. BACs, YACs, MACs. D. Mammalian Expression Vectors Vaccinia, Retroviral promoter based vectors

UNIT II Basic DNA Clon ing Simple cloning of DNA fragments, Vectors: Definition and properties. E. coli expression vectorslac, tac and T7 promoter based vectors. Yeast expression vectors - pET yeast vectors, YIp, YEp and YCp vectors. Baculovirus based vectors. Ti based vectors (Binary and Cointegrated vectors) and cloning using linkers and adaptors. Transformation of DNA by chemical method and electroporation Methods of gene delivery in plants and animals Microinjection, biolistic method (gene gun), liposome and viral-mediated delivery, Agrobacterium-mediated delivery.

UNIT III Methods of DNA, RNA and Protein analysis and DNA typing Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot and colony hybridizations. Chromosome walking and jumping. DNA fingerprinting by RFLP and RAPD. Gel retardation assays. DNA footprinting by DNase I, DNA microarray analysis. SDS-PAGE and Western blotting. Phage display. Polymerase chain reaction - enzymes used, primer design. Cloning PCR products. RT-PCR and principles of real time PCR. Ligation chain reaction.

UNIT IV Construction of Genomic and cDNA libraries Genomic and cDNA libraries: Preparation and uses. Screening of libraries by colony hybridization and colony, PCR DNA sequencing and synthesis Maxam-Gilbert's and Sanger's method. Automated sequencing. Human genome sequencing project

UNIT V Product of DNA technology Human protein replacements-insulin, hGH and Factor VIII. Human therapies - tPA, interferon, antisense molecules. Bt transgenics-rice, cotton, brinjal, Analysis of biological processes, DNA typing, gene therapy, commercial products.

B. Sc. Microbiology (II Year) IV Semester

Paper I : GENETICS AND GENOMICS

UNIT I Introduction to Genetics Definition: gene, genome, trait, genetic material, genetic maps, genotype, phenotype. Mendel's work on transmission of traits, Genetic Variation, Molecular basis of Genetic Information. Mitosis and Meiosis Interrelation between the cell structure and the genetics function, Mitosis, Meiosis (explaining Mendel's ratios).

UNIT II The structure of genetic material The nature of the genetic material, Discovery of DNA and RNA as genetic material, the chemical composition of DNA and RNA, Organization of DNA in chromosomes, Structural characteristics of bacterial and viral chromosomes, DNA replication in prokaryotes and Eukaryotes

UNIT III Mendelian Genetics and its Extension Principles of Inheritance, Chromosome theory of inheritance, Laws of Probability, Pedigree analysis, Incomplete and co dominance, Multiple alleles, Lethal alleles, Epitasis, Pleiotropy, Environmental effects on phenotypic expression, sex linked inheritance. Linkage and crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and coincidence, Somatic cell genetics – an alternative approach to gene mapping

UNIT IV Mutations Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy. Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations, Molecular basis of Mutations in relation to UV light and chemical mutagens, Detection of mutations: CLB method, Attached X method, DNA repair mechanisms.

UNIT V. Extra chromosomal Inheritance Chloroplast mutation/Variegation in Four o' clock plant and Chlymodomonas, Mitochondrial mutations in Neurospora and yeast, Maternal effects, Infective heredity- Kappa particles in Paramecium. Quantitative Genetics .Quantitative and multifactor inheritance, Transgressive variations, Heterosis.

B. Sc. Microbiology (II Year) IV Semester

Paper II: MICROBIAL GENETICS AND MOLECULAR BIOLOGY

UNIT I Genetic Material - DNA structure, Salient features of double helix, Types of DNA, denaturation and renaturation, topoisomerases; Organization of DNA Prokaryotes,Viruses, Eukaryotes. RNA Structure.

UNIT II Replication of DNA - Bidirectional and unidirectional replication, semi-conservative, semi- discontinuous replication. Mechanism of DNA replication: Enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends.

UNIT III Transcription - Transcription: Definition, promoter - concept and strength of promoter. Transcriptional Machinery and Mechanism of transcription. Translation - Genetic code, Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides.

UNIT IV Regulation of gene Expression - Principles of transcriptional regulation, regulation at initiation with examples from lac and trp operons. Mutations - Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Uses of mutations, DNA repair mechanisms.

UNIT V Mechanisms of Genetic Exchange - Transformation - Discovery, mechanism of natural competence. Conjugation - Discovery, mechanism, Hfr and F' strains. Transduction - Generalized transduction, specialized transduction.

B. Sc. Microbiology (II Year) IV Semester

Paper III: MICROBIAL PHYSIOLOGY & METABOLISM

UNIT I Enzymes as biocatalyst, enzymes classification, properties.Enzymes kinetics :MichaelisMenton equation for simple enzymes, Effects of pH and temperatures, on enzymes action, enzyme inhibition. Electron carriers, artificial electron donors, inhibitors uncouplers, energy bond and phosphorylation.

UNIT II Nutritional classification of microorganisms based on carbon, energy and electron sources .Microbial metabolism: anabolism and catabolism, energy production in aerobic, anaerobic process and photosynthesis,chemiosmotic hypothesis of ATP synthesis. Bacterial electron transport chain.Autotrophy, Heterotrophy, chemolithotrophy, fermentation.Transport of nutrients by active and passive transport.

UNIT III Phototrophic metabolism Historical account of photosynthesis, diversity of phototrophic bacteria, anoxygenic and oxygenic photosynthesis, photosynthetic pigments: action and absorption spectrum, type, structure and location, physiology of bacterial photosynthesis: light reactions, cyclic and non-cyclic photophosphorylation.

UNIT IV Respiratory metabolism – Glycolysis, EMP pathway, ED pathway, Glyoxallate pathway, Kreb's cycle-oxidative and substrate level phosphorylation.Reverse TCA cycle – Gluconeogenesis,fermentation and carbohydrates –homo and heterolacticfermentataions.

UNIT V Assimilation of nitrogen –dinitrogen, nitrate nitrogen,ammonia assimilation, synthesis of major amino acids,synthesis of Polysaccharides –peptidoglycan, biopolymers as cell components.

B. Sc. Microbiology (II Year) IV Semester

Paper IV: MICROBIOLOGY OF WATER & AIR

UNIT I Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests

UNIT II Water borne pathogens water borne diseases , methods of treatment Precipitation, chemical disinfection, filtration, high temperature, UV light

UNIT III Liquid Waste Management (Ch 12 Atlas and Bartha) Composition of sewage; strength of sewage (BOD and COD); Primary, secondary (aerobic – oxidation pond, trickling filter, rotating biological contractor/biodisc system, activated sludge process and anaerobic – septic tank, imhoff tank, anaerobic digestor) and tertiary sewage treatment

UNIT IV Aeromicrobiology Bioaerosols Air pollution: sources, types, effects of pollutants, control measures brief account of Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and preventive measures. Aeroallergy and Aeroallergens. Assessment of air quality and environment, significance in food and pharma industries and operation theatres, allergens

UNITV Air Sample Collection and Analysis Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi and their Identification characteristics . Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration

B.Sc. Microbiology (III Year) V Semester

Paper I: MEDICAL MICROBIOLOGY & IMMUNOLOGY

UNIT I Historical background of medical microbiology, Classification of medically important microorganisms, Disease cycle, transmission of pathogen and its routes. Infection and its type. Host parasite relationship, pathogenicity and virulence inn relation with bacteria, Virus fungi and parasites. Normal microflora of the human body ,Host-pathogen interaction Definitions of invasion, pathogen, parasite, pathogenicity, toxigenicity, virulence, carriers and their types, nosocomial infections, opportunistic infections, septicemia, septic shock

UNIT II Silent features of the diseases caused bacteria; Clostridium, Bacillus, Staphylococcus, streptococcus, E.coli, Klebsiella, Salmonella, Pseudomonas, Vibrio , Neisseria, Mycobacteria. Viral disease – Hepatitis, dengue fever, small pox, polio. Protozoan diseases- Malaria & Amoebiasis.

UNIT III Protein toxins – types and disease, early diagnosis and detection of disease by serological methods –RIA, ELISA, complement fixation, agglutination, chemotherapy types and action mechanism of anti microbial assay and drug resistance, vaccines interferons. Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis;

UNIT IV Immune responses and its types – innate (non specific) , acquired (cell mediated and humoral) immunity. Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes), Adjuvants, Structure, Types and Functions of antibodies, Immunoglobulin structures properties & functions Antigen – antibody reactions – ELISA, RIA, Agglutination &precipitate Complements structures and functions Major Histocompatability complex (MHC) Structure and functions. Autoimmunity and hypersensitivity reactions.

UNIT V Immunological Disorders and Tumor Immunity - Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice), SCID, DiGeorge syndrome, Chediak- Higashi syndrome, Leukocyte adhesion deficiency, CGD; Types of tumors, tumor Antigens, causes and therapy for cancers.

B. Sc. Microbiology (III Year) V Semester

Paper II : INDUSTRIAL MICROBIOLOGY

UNIT I Brief history and developments in industrial microbiology Isolation of industrially important microbial strains, strain improvement, preservation and maintenance of industrial microbes, scale-up. Criteria used for selection of micro -organisms for fermentation. Growth kinetics of industrially important microorganisms.

UNIT II Fermentation process: Batch, fed – batch and continuous fermentations; solid state and submerged fermentations. Components in a typical bioreactor and types. Maintenance of pH, temperature, dissolved oxygen aeration and agitation.

UNIT III Substrate for industrial fermentation ; Molasses, corn steep liquor, sulfite waste liquor, whey, yeast extract. Detection and assay of fermentation product. Down stream Processing, immobilization & its applications. Antifoams. Mycotoxins with reference to Aflatoxins. Microbial production of industrial products ; citric acid , ethanol ,acetone , penicillin, streptomycin , vitamin B12 , riboflavin , amylase, protease, lipase , single cell protein .

UNIT IV Enzyme immobilization Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase)

UNIT V Food as a substrate for micro organisms , microbial spoilage of different food – stuffs , principles and methods of food preservation . Microbiology of milk , dairy products and fermented foods . Food – borne diseases.

B.Sc. Microbiology (III year) V Semester

Paper III: MICROBIAL BIOTECHNOLOGY

UNIT I Microbial Biotechnology and its Applications Microbial biotechnology: Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental, and food technology Use of prokaryotic and eukaryotic microorganisms in biotechnological applications Genetically engineered microbes for industrial application: Bacteria and yeast

UNIT II Therapeutic and Industrial Biotechnology Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine) Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastics Microbial biosensors

UNIT III Applications of Microbes in Biotransformation Microbial based transformation of steroids and sterols Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute

UNIT IV Microbial Products and their Recovery Microbial product purification: filtration, ion exchange & affinity chromatography techniques Immobilization methods and their application: Whole cell immobilization).

UNIT V Microbes for Bio-energy and Environment No. of Hours: 12 Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture. Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents , drug resistance, therapeutics and host pathogen

B.Sc. Microbiology (III year) V Semester

Paper V: SOIL MICROBIOLOGY

UNIT I Soil as a habitat for microorganisms; Soil microbes – algae, bacteria, actinomycetes, fungi protozoa and nematodes, Microbial balance in soil. Molecular markers for ecological studies of soil micro organisms.

UNIT II Rhizosphere and rhizoplane micro organisms; reasons for increased microbial activity in rhizosphere. composition of root exudates factors affecting exudation, rhizosphere microorganisms, rhizosphere effect. Factors affecting microbial community in soil-soil moisture, organic and inorganic chemicals. soil organic matter.

UNIT III Organic matter decomposition; Organic matter dynamics in soil- microbial decomposition of cellulose, hemi cellulose, lignin. Factors affecting organic matter decomposition (litter quality, temperature, aeration, soil pH, inorganic chemicals, moisture); Pesticide degradation in soil, effects of pesticides on soil microflora, soil microbial biomass as an index of soil fertility.

UNIT IV Microbial interactions; negative interactions. Ammensalism, competition, parasitism and predation (mycoparasitism, mycophagy, namatophagy – predaceous fungi), commensalism positive interactions – mutualism, synergism, associative symbiosis, cyanobacterial bacterial (Rhizobium legume symbiosis), actinomycetes (actinorrhiza –Frankia non root legume symbiosis) and fungal symbiosis – types and significance of mycorrhuza. Concept of beneficial microorganisms.

UNIT-V Biogeochemical cycles: C, N, P ,S cycles. Nitrogen fixation- symbiotic and asymbiotic, significance of nitrogenase and nif genes, phosphate solubilization and its mechanism.

B.Sc. Microbiology (III year) VI Semester

Paper I: FOOD AND DAIRY MICROBIOLOGY

UNIT I Foods as a substrate for microorganisms Intrinsic and extrinsic factors that affect growth and survival of MICROBes in foods, natural flora and source of contamination of foods in general MICROBIAL spoilage of various foods Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned foods

UNIT II Principles and methods of food preservation Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins..

UNIT III Food borne infections and intoxications; Bacterial diseases with examples of infective and toxic types – Brucella, Bacillus clostridium, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio, fungi and viruses; Aflatoxins - structures and functions.

UNIT IV Food fermentations; bread, vinegar, fermented vegetables; prevention and spoilage of cereals, vegetables, fruits, meat and meat products fish and sea products. Foods produced by Microbes – Fermented foods, microbial cells as food (single cell proteins); Mushroom cultivation Industrial enzymes and their uses in food industry – amylases, proteases, cellulases; Oriental foods – Mycoprotein, Tempeh, soya sauce; Traditional foods.

UNIT V Food borne out breaks – laboratory testing procedures; Preventive measures – Sanitation in manufacture; Food control agencies and its regulations, HACCP, ISO standards. Cultural and rapid detection methods of food borne pathogens in foods and introduction to predictive microbiology

B.Sc. Microbiology (III year) VI Semester

Paper II : MICROBIAL DIAGNOSIS IN HEALTH CLINICS

UNIT 1 Importance of diagnosis of diseases Bacterial, Viral, Fungal and Protozoan Diseases of various human body systems, clinical samples for diagnosis of infectious disease.

UNIT II Collection of Clinical Samples How to collect clinical samples (oral cavity, throat, skin, Blood, CSF, urine and faeces) and precautions required. Method of transport of clinical samples to laboratory and storage.

UNIT III MICROSCOPIC examination and culture methods. Examination of sample by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsastained thin blood film for malaria. Preparation and use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, Mac Conkey agar, Distinct colony properties of various bacterial pathogens.

UNIT IV Serological and Molecular methods Serological Methods - Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes. Kits for rapid Detection of Pathogens Typhoid, Dengue and HIV, Swine flu.

UNIT V Testing for Antibiotic sensitivity in Bacteria Importance, Determination of resistance/sensitivity of bacteria using disc diffusion method, Kirby method Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method.

B.Sc. Microbiology (III year) VI Semester

Paper III

MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES

UNIT 1 Microbiological Laboratory and Safe Practices Good laboratory practices - Good laboratory practices, Good microbiological practices Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration

UNIT II Determining Microbes in Food / Pharmaceutical Samples Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products Molecular methods - Nucleic acid probes, PCR based detection,biosensors.

UNIT III Pathogenic Microorganisms of Importance in Food & Water Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay)

UNIT IV Water Potability No. of Hours: 5 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 and (c) Presence/absence tests

UNIT V HACCP for Food Safety and Microbial Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water

Paper IV: Project Work

Note: 1. Number of students who will be offered project work will vary from college to college depending upon the infrastructural facilities and may vary each year.

2. The college shall announce regarding the number of seats for project work well in advance and may select the students for the same based on merit.

3. Project work will involve experimental work and the student will have to do this in the time after their regular theory and practical classes.

4. The final evaluation of the project work will be through a committee involving internal and external examiners.

5. Guidelines provided by University Sri Dev Suman Uttrakhand University, Tehri Garhwal for executing and evaluation of project work will be final.

6. Students will be asked their choice for Project work at the end of IV semester and all formalities of topic and mentor selection will be completed by this time.

7. Project work will be offered in lieu of any one Discipline Specific Elective and will be evaluated for 100 Marks.