Maa Shakumbhari University, Saharanpur

Syllabus of the Subject
Microbiology

For First Three Year of Undergraduate (UG) Program

(As per guidelines of Common Minimum Syllabus by U.P. Government according to National Education Policy-2020 amended with GO-2090/70-3-2024-09(01) Dated: 02-09-2024)

Members, Board of Studies (Microbiology)

S. No.	Name	Designation	College/University	Signature
1.	Prof. Garima Jain	Dean Science	D.A.V. (P.G). College, Muzaffarnagar	
2.	Satyendra Kumar	Convener	D.A.V. (P.G). College, Muzaffarnagar	
3.	Prof. sandhya Jain	Member	D.A.V.(P.G.) College, Muzaffarnagar	
4.	Dr. Shekhar Chand	Member	S.D.P.G. College, Muzaffarnagar	
5.	Dr. Shalini Gupta	External Expert	S.V.P.G. & Tech University Modi Puram	
6.	Dr. Navneet	External Expert	Gurukul Kangari University Haridwar	

Semester-wise Titles of Papers

Year	Sem.	Course Code	Paper Title	Theory/ Practical	Credits
Certificate course					
1st	I		GENERAL MRICOBIOLOGY	Theory	4
			Principles of Microbiology Lab.	Practical	2
			Mycology, Phycology and Virology	Theory	4
			Mycology, Phycology and Virology Lab.	Practical	2
			Minor Elective (Other faculty)	Theory	6
			Vocational Skill Development course	Theory	3
			Co-curricular Course	Theory	2
		Total Credits:23			
	II		Cell Biology	Theory	4
			Cell Biology Lab	Practical	2
			Instrumentation and technique	Theory	4
			Instrumentation and technique Lab.	Practical	2
			Vocational Skill Development course	Theory	3
			Co-curricular Course	Theory	2
		Total Credits:17			
First Year Total credits: 40					

Year	Sem.	Course Code	Paper Title	Theory/ Practical	Credits
Diploma					
2nd	III		Microbial Genetics & Molecular Biology	Theory	4
			Microbial Genetics & Molecular Biology Lab.	Practical	2
			Biostatistics and Bioinformatics	Theory	4
			Biostatistics and Bioinformatics Lab	Practical	2
			Minor Elective (Other Faculty)	Theory	6
			Vocational Skill Development course	Theory	3
			Co-curricular Course	Theory	2
		Total Credits:23			
	IV		Biochemistry	Theory	4
			Biochemistry Lab.	Practical	2
			Microbial physiology and metabolism	Theory	4
			Microbial physiology and metabolism Lab	Practical	2
			Co-curricular Course	Theory	2
			Research Project		3
		Total Credits:17			
Second Year Total credits: 40					

Year	Sem.	Course Code	Paper Title	Theory/ Practical	Credits
Degree in Bachelor of Science					
3rd	V		Immunology	Theory	4
			Immunology Lab	Theory	4
			Recombinant DNA Technology	Practical	2
			Recombinant DNA Technology lab	Theory	4
			Enzyme technology	Theory	4
			Enzyme technology Lab	Practical	2
			Medical Microbiology		
			Medical Microbiology lab		
		Total Credits:20			
	VI		Industrial microbiology	Theory	4
			Industrial microbiology lab	Theory	4
			Food microbiology	Practical	2
			Food microbiology lab	Theory	4
			Biosafety and intellectual property Right	Theory	4
			Biosafety and intellectual property Right Lab.	Practical	2
			Environment Microbiology		
			Environment Microbiology LAB		
		Total Credits:20			
Third Year Total credits: 40					

SEMESTER – I

PAPER I – General Microbiology

Programme/Class:	Year: First	Semester: First
Subject: MICROBIOLOGY		
Course Code:	Course Title: General Microbiology	

Course Outcomes:

The student at the completion of the course will be able to:

- To understand the history, relevance of microbiology and classification of microbes.
- To learn and understand the microbial diversity in the living world.
- To gain knowledge of various (physical and chemical) methods of control of microorganisms and safety measures to be followed while handling microbes.
- To demonstrate and understanding of bacterial, fungal, cyanobacterial, algal, viral and rickettsial classification, culturing, reproduction and significance.
- To learn different methods of staining of microbes.
- To understand, learn and gain skill of isolation, culturing and maintenance of pure culture.
- To enable the students to get sufficient knowledge in principles and applications of bio-instruments.
- To help students gain knowledge about antibiotics and other chemotherapeutic agents.

Credits: 4	Core: Compulsory
Max. Marks: 25+75	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): L-T-P: 4-0-0

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction, history, and scope of Microbiology** History, scope, branches of microbiology and relevance of microbiology; Contribution of Antony Van Leeuwenhoek, Edward Jenner, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Ivanowsky, Waksman, Subba Rao, Sambhunath De; development of various microbiological techniques and golden era of microbiology. Position of microorganisms in the living world	8
II	5 kingdom classification of Whittaker and 3 kingdom classification of Carl Woese, comparison of the 3 domain of microorganisms- bacteria, archaea, eukarya; Bergey's manual and introduction to classification of bacteria.	10
III	**Bacterial morphology** Ultrastructure of bacterial cell, cell wall, plasma membrane, capsule, flagella, nucleoid, and reserve material. Differences between archaebacterial and eubacterial cell. General features of Rickettsia, Chlamydia, Mollicutes, Actinomycetes and Cynobacteria.	

IV	**The viruses** General properties and structure of animal viruses: Influenza, HIV; plant viruses: TMV; bacterial viruses: Lambda Phage and T4 bacteriophage; general features of Prions and Viroid's. **Fungi** General characteristics, classification & reproduction of Saccharomyces, Aspergllus. **Protozoa** General characteristics, classification & reproduction of Giardia, Entamoeba	
V	Sterilization techniques and control of microorganisms Definitions of terms- sterilization and disinfection; Sterilization by Physical methods- Use of moist heat- heat under pressure, autoclave, boiling, pasteurization, fractional sterilization, tantalization; Use of dry heat- hot air oven, incineration;	7
VI	Filtration- Seitz filter, membrane filter, HEPA filter; Radiation- Ionizing and non- ionizing; Chemical methods- Alcohols, aldehydes, phenols, halogens, metallic salts, ethylene oxide.	
VII	Isolation, cultivation and preservation of microorganisms Culture media and its types; Methods for enumeration & isolation of microorganisms using pour plate, spread plate technique, and streak plate; Isolation of anaerobic microorganisms; Maintenance and preservation of pure culture	8
VIII	Stains and staining techniques Staining techniques, principles, procedures and applications of Simple staining, negative staining; Differential staining- Gram's staining, acid fast staining, Leishman's staining, Giemsa's staining, Ziehl Neelsen staining; Structural staining- cell wall, capsule, endospore and flagella staining.	7

Recommended Books:

1. Alexopoulas C.J. and Mims C.W., Introductory Mycology, New Age International, New Delhi.
2. Aneja K.R., Experiments in Microbiology, plant pathology, Tissue culture and Mushroom cultivation, New Age International, New Delhi.
3. Atlas R.M., Microbiology- Fundamentals and applications, Macmillan Publishing Company, New York.
4. Benson Harold J., Microbiological Applications, WCB Mcgraw-Hill, New York.
5. Bold H.C. and Wynne M.J., Introduction to Algae, Prentice Hall of India Private Limited, New Delhi.
6. Baveja C.P., Textbook of microbiology APC 6th edition.
7. Dubey R.C.. and Maheshwari D.K., Textbook of microbiology, S Chand Publications.
8. Pelczar M.J., Chan E.C.S and Kreig N.R., Microbiology, Mcgraw-Hill Book Company, New York.
9. Prescott Lansing M., Harley John P. and Klein Donald A., Microbiology, WCB Mcgraw- Hill, New York.
10. Stanier R.Y., Ingraham J.L., General Microbiology, Prentice Hall of India Private Limited, New Delhi.

Principles of Microbiology-Lab

- Microscopic examination of bacteria, actinomycetes, algae, fungi and protozoa;Differential staining methods;
- Study of shape and arrangement of bacterial cells;
- Preparation of microbiological media;
- Sterilization: principles & operations;
- Sterlization of heat sensitive material by membrane filtration
- Preparation of specific media for isolation of bacteria, actinomycetes and fungi from natural sources;
- Sampling and quantification of microorganisms in air, soil and water;
- Study of common fungi, algae and protozoan using temporary / permanent mount
- Isolation of thermophiles from compost.

SEMESTER - I

PEPER – II: Mycology, Phycology & Virology

Programme/Class:	Year: First	Semester: First
Subject:		
Course Code:	Course Title: Mycology, Phycology & Virology	

Course Outcomes:

After completion of the course students will be able to understand:

- Understand about the Introduction of algae and Fungi.
- Know about the life cycle of representative genera.
- To understand the importance of algae in food chains, oxygen production , carbon cycling and their role in ecosystem.
- Students will be able to understand the principles and schemes used to classify algae and fungi
- Students will be able to understand the beneficial roles fungi play in biotechnology , food production and the environment, as well as the negative impact of some fungi on humans.

Credits:	Core:
Max. Marks:	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**

Unit	Topics	Total No. of Lectures/ Hours (60)
I	Introduction of algae: Occurrence and distribution, thallus structure, characteristics, nutrition, classification and reproduction.	
II	Algae as pollution indicators, eutrophication agent and role in bioremediation, algae in global warming and environmental sustainability, cyanobacteria and selected microalgae in agriculture as biofertilizer, importance of algae in production of algal pigments, biofuels, hydrogen production, important bioactive molecule.	
III	Introduction of fungi: Occurrence and distribution, somatic structure, hyphal growth, nutrition, heterothallism, sex hormones in fungi, Classification of fungi. Reproduction in fungi: asexual, sexual and parasexual.	
IV	Lichens and Mycorrhiza: Occurrence, Structure, Types and Importance. Fungi as insect symbionts, fungi as biocontrol agents. Fungi in Industry: Production of alcohol and organic acids. Fungi in Medicine: Types of metabolites used in medicine and production of antibiotics.	

V	Fungi in Agriculture and Forestry. Fungi as biopesticides: mycofungicides, weedicides, and insecticides. Fungi as human and animal parasites (medical mycology) Fungi as food: Mushrooms: Types of mushrooms, biology and growth of mushrooms, nutritional and medicinal value of edible mushrooms; Fungal protein (Yeast and Fusarium).	
VI	Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroid's, virusoids, satellite viruses and Prions. Viral taxonomy: Classification and nomenclature of different groups of viruses	
VII	Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage	
VIII	Modes of viral transmission: Persistent, non-persistent, vertical and horizontal Salient features of viral Nucleic acid: Virus types; TMV, Influenza virus, Hepatitis and HIV VIRUS.	

Recommended Books:

1. Alexopoulos, C.J. and C.W. Mims 1979. Introduction to Mycology (3rd Ed.) Wiley Eastern Ltd., New Del
2. Charlile M. & Watkinson S.C. The Fungi, Publisher: Academic Press.
3. E.Moore –Landeekeer: Fundamentals of the fungi, Publisher: Prentice Hall.
4. L. Barsanti, Paolo Gualtieri: Algae: anatomy, biochemistry, and biotechnology
5. Ayhan Demirbas, M. Fatih Demirbas: Algae Energy: Algae as a New Source of Biodiesel (2010)
6. Linda E. Graham, James Graham, James M. Graham: Algae (2009)
7. Burnett J.H., Publisher: Edward, Arnold Crane Russak: Fundamentals of Mycology.

Practicals

1. Study of the structure of important animal viruses (rhabdo, influenza, paramyxo hepatitis B and retroviruses) using electron micrographs
2. Study of the structure of important plant viruses (caulimo, Gemini, tobacco ring spot, cucumber mosaic and alpha-alpha mosaic viruses) using electron micrographs
3. Study of the structure of important bacterial viruses (ϕX 174, T4, λ) using electron micrograph.
4. Study of vegetative and reproductive structures of Nostoc, Chlamydomonas (electron micrographs), Volvox, Oedogonium,Coleochaete, Chara, Vaucheria, Ectocarpus, Fucus and Polysiphonia,Procholoron, Diatoms through electron micrographs, temporary preparations and permanent slides (based on availability of materials).
5. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, asocarps & basidiocarps).
6. Rhizopus: study of asexual stage from temporary mounts and sexual structures through permanent slides.
7. Aspergillus and Penicillium: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
8. Agaricus: Specimens of button stage and full grown mushroom; sectioning of gills of Agaricus, and fairy rings are to be shown.
9. Albugo: Study of symptoms of plants infected with Albugo; asexual phase study throughsection/ temporary mounts and sexual structures through permanent slides.

SEMESTER –II

PAPER – I

Programme/Class:	**Year:** First	**Semester:** Second
Subject:		
Course Code:	**Course Title: CELL BIOLOGY**	

Course Outcomes:

- Upon completing a cell biology course, students should be able to understand cell structure and function, including organelles, cell division, and cell signaling, and apply this knowledge to analyze biological processes and experimental data.
- Students will understand key cellular processes like cell division (mitosis and meiosis), cell signaling, and energy production
- Students will develop practical skills in cell biology, including techniques like microscopy, cell culture, and molecular biology.

Credits:	**Core:**
Max. Marks:	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**

Unit	Topics	Total No. of Lectures/ Hours (60)
I	Structure and organization of Cell Cell Organization – Eukaryotic (Plant and animal cells) and prokaryotic Plasma membrane: Structure and transport of small molecules.	
II	Cell Wall: Eukaryotic cell wall, Extra cellular matrix and cell matrix interactions, Cell-Cell Interactions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata (only structural aspects)	
III	Cell Organelles: Mitochondria, chloroplasts and peroxisomes, ER, Golgi Complex and Lysosome	
IV	Nucleus: Nuclear envelope, nuclear pore complex and nuclear lamina Chromatin – Molecular organization Nucleolus	

V	Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules	
VI	Cell Signaling Signaling molecules and their receptors Function of cell surface receptors, Pathways of intra-cellular receptors – Cyclic AMP pathway, cyclic GMP and MAP kinase pathway	
VII	Cell Cycle, Cell Death and Cell Renewal Eukaryotic cell cycle and its regulation, Mitosis and Meiosis.	
VIII	Development of cancer, causes and types Programmed cell death Stem cells Embryonic stem cell, induced pluripotent stem cells.	

1. **Recommended Books:** Hardin J, Bertoni G and Kleinsmith LJ. (2010). Becker's World of the Cell. 8th edition. Pearson.
2. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
3. De Robertis, EDP and De Robertis EMF. (2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.

Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

SEMESTER –2 **CREDITS: 2**

CELL BIOLOGY (PRACTICAL)

1. Study a representative plant and animal cell by microscopy.
2. Study of the structure of cell organelles through electron micrographs
3. Cytochemical staining of DNA – Feulgen
4. Demonstration of the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B
5. Study of polyploidy in Onion root tip by colchicine treatment.
6. Identification and study of cancer cells by photomicrographs.
7. Study of different stages of Mitosis.
8. Study of different stages of Meiosis.

SEMESTER – II

PAPER – II: Instrumentation and Techniques

Programme/Class:	Year: First	Semester: Second
Subject:		
Course Code:	Course Title: Instrumentation and Techniques	

Course Outcomes:

Upon successful completion of the course, the student will:

- Be familiar with different types of techniques currently used in laboratories
- Be able to carry out the analysis of the data from CD and Fluorescence experiments to monitor the stability of the protein under different environmental conditions
- Be able to design a multi-step purification protocol for a target protein.
- Be able to perform chromatographic methods of separation.
- Be able to understand and correctly interpret the migration of protein molecule on PAGE under native and SDS conditions

Credits:	Core:
Max. Marks:	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Basics of microscopy**: image formation, magnification, resolution, biological applications and instrumentation of various kinds of microscopy.	
II	**Types of Microscopy**: Optical Microscopy, Fluorescence, Confocal microscopy. Dark field Microscopy. Electron Microscopy (TEM, SEM).	
III	Differential centrifugation and purification by density gradient centrifugation, TLC, ultracentrifugation, flow cytometry,	
IV	**Spectrophotometry**: Different types of spectroscopy: NMR, absorption spectroscopy, fluorescence spectroscopy, phosphorescence, Infrared and Raman spectroscopy, Optical Rotatory Dispersion (ORD), Circular Dichroism (CD).	
V	Isolation and purification of microbial protein, Electrophoretic separation of protein. Determination of molecular weight of protein using PAGE/ gel filtration method, Polyacrylamide gel electrophoresis (PAGE), native and SDS, PAGE, 2D,PAGE, capillary electrophoresis, IEF.	
VI	Chromatographic methods of separation, Principles and applications of Paper, Thin layer chromatography, Gas, Liquid chromatography, HPLC and FPLC; PCR & its types.	
VII	Autoradiography, applications of radiotracer in microbiology, X-RAY Diffraction.	
VIII	**Biotechniques**: Measurement of pH, Preparation of buffer and solutions, Different types culture media, and staining method.	

Recommended Books:

1. Clark JM. 1977. Experimental Biochemistry. 2nd Ed. WH Freeman. Sawhney SK & Singh R. 2000. Introductory Practical Biochemistry. 2nd Ed. Narosa.
2. Willard M, Merritt LL & Dean JA.1981. Instrumental Methods of Analysis. 4th Ed. Van Nostrand.
3. William BL & Wilson K. 1975. Principles and Techniques of Practical Biochemistry. Edward Arnold.
4. Wilson K, Walker J & Walker JM. 2005. Principles and Techniques of Practical Biochemistry. Cambridge Univ. Press.
5. Kolowick NP & Kaplan NP. Methods in Enzymology. Academic Press (Series).
6. Zlummer DT. 1998. An Introduction to Practical Biochemistry. 3rd Ed. Tata McGraw Hill.
7. Rickwood D. (Ed.). 1984. Practical Approaches in Biochemistry. 2nd Ed. IRL Press, Washington DC.
8. Wilson K & Goulding KH. 1992. A Biologist"s Guide to Principles and Techniques of Practical Biochemistry. 3rd Ed. Cambridge Univ. Press.
9. Wilson K & Walker J. 2000. Principles and Techniques of Practical Biochemistry. 5th Ed. Cambridge Univ. Press. 30

SEMESTER – III

PAPER – I: MICROBIAL GENETICS AND MOLECULAR BIOLOGY

Programme/Class: BSC	Year: First	Semester: Third
Subject:		
Course Code:	Course Title: MICROBIAL GENETICS AND MOLECULAR BIOLOGY	

Course Outcomes:

- After completing a course in Microbial Genetics and Molecular Biology, students should be able to understand the principles of microbial genetics, molecular biology, and their applications in various fields, including biotechnology and medicine.
- Comprehend principles of genetic analysis in microbes.
- Will learn about gene regulation and expression in microorganisms.
- Will be able to understand the molecular mechanisms of microbial metabolism.

Credits: 4	Core: MICROBIAL GENETICS AND MOLECULAR BIOLOGY
Max. Marks: 75+ 25 = 100	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): L-T-P:

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Fundamentals of Genetics:** Mendelian Inheritance, alleles, concept of genes, Muton, Recon, Cistron, One gene one enzyme hypothesis, Extrachromosomal inheritance.	
II	**Prokaryotic Information pathways** Mutations, Bacteriophage genetics, Restriction-modification systems, Recombination Molecular applications- Synthetic biology	
III	**Microbial genetic response** Genetics of Quorum sensing, Stress shock, Bacterial mobility, Two component regulation, Genetics of bacterial defense system	
IV	**Genetic Exchange** Bacterial transopons, Transformation, Conjugation, Transduction, Yeast genetics, Neuropora genetics	
V	**Structures of DNA and RNA** **DNA Structure**: Watson and Crick- Model, Organization of DNA in Prokaryotes, Viruses, Eukaryotes, plasmid. **Structure of RNA**, Types of RNA, Genetical and non genetical RNA, iRNA, mi RNA, si RNA.	

VI	**DNA replication and repair** DNA replication in Prokaryotes and Eukaryotes, Mechanism of DNA replication: Enzymes and proteins involved in DNA replication Mismatch and excision repair	
VII	**Transcription in Prokaryotes and Eukaryotes** Transcription: Definition, difference from replication, promoter - concept and strength of promoter RNA Polymerase and the transcription unit Transcription in Eukaryotes: RNA polymerases, general Transcription factors, Post-Transcriptional Processing **Translational machinery** Mechanisms of initiation, elongation and termination of polypeptides in both prokaryotes and eukaryotes, Inhibitors of protein synthesis in prokaryotes and eukaryote, Post translational modification	
VIII	**Regulation of gene Expression in Prokaryotes and Eukaryotes** Principles of transcriptional regulation, regulation at initiation with examples from lac and trp operons,	

1. **Recommended Books Genetics:** Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed., Benjamin Cummings
2. U.N.Streips, and R.E. Yasbin, 2014. Modern microbial genetcs, John Wiley and sons
3. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning
4. V.A.Saunders, 2012. Microbial genetics applied to biotechnology:principles and techniquesof gene transfer and manipulation. Springer Science & Business Media
5. Watson JD, Baker TA, Bell SP et al. (2008) Molecular Biology of the Gene, 6th Ed., Benjamin Cummings
6. Maloy SR, Cronan JE and Friefelder D(2004) Microbial Genetics 2nd EDITION., Jones and Barlett Publishers

Recommended Books Molecular Biology:

1. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Lab. Press, Pearson Publication
2. Becker WM, Kleinsmith LJ, Hardin J and Bertoni GP (2009) The World of the Cell, 7th edition, Pearson Benjamin Cummings Publishing, San Francisco
3. De Robertis EDP and De Robertis EMF (2006) Cell and Molecular Biology, 8th edition. Lippincott Williams and Wilkins, Philadelphia
4. Karp G (2010) Cell and Molecular Biology: Concepts and Experiments, 6th edition, John Wiley & Sons. Inc.
5. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.
6. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning
7. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India

MICROBIAL GENETICS (PRACTICAL)

1. Preparation of Master and Replica Plates
2. Study the effect of chemical (HNO_2) and physical (UV) mutagens on bacterial cells
3. Study survival curve of bacteria after exposure to ultraviolet (UV) light
4. Isolation of Plasmid DNA from *E.coli*
5. Study different conformations of plasmid DNA through Agaraose gel electrophoresis.
6. Demonstration of Bacterial Conjugation
7. Demonstration of bacterial transformation and transduction

MOLECULAR BIOLOGY (PRACTICAL)

1. Study of different types of DNA and RNA using micrographs and model / schematic representations
2. Study of semi-conservative replication of DNA through micrographs / schematic representations
3. Isolation of genomic DNA from *E. coli*
4. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A_{260} measurement)
5. Estimation of RNA using colorimeter (orcinol reagent) or UV spectrophotometer (A_{260} measurement)
6. Resolution and visualization of DNA by Agarose Gel Electrophoresis.
7. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).

SEMESTER - III

PAPER - II

Programme/Class:	Year: First	Semester: Third
Subject:		
Course code:	Course Title: Biostatistics and Bioinformatics	

Unit	Topics:	
I	Biostatistics – Basic concepts. Fundamentals of measurement. Qualitative & Quantitative Variables. Histogram and Pie chart.	Total No. of Lectures (60)
II	Collection, Classification, Tabulation & Presentation of data, Mean, Median, Mode, Dispersion, Standard Deviation, merits & demerits.	
III	Chi-square test & 't' test. Analysis of variance, Correlation Analysis. Types and measures of Correlation. Regression Analysis. Regression of Y on X and X on Y.	
IV	Statistical methods: Scope of statistics: utility and misuse. Principles of statistical analysis of biological data	
V	Introduction to Computer Fundamentals RDBMS - Definition of relational database Mode of data transfer (FTP, SFTP, SCP), advantage of encrypted data transfer	
VI	Introduction to Biological data bases and its types Primary & Secondary Databases. Sequence Databases (European Molecular Biology Laboratory, Gene bank). DNA Data Base of Japan (DDBJ), SWISS-PORT, Protein Information Resource, TREMBL, Protein Family/Domain Databases (Prosite. Pfam & Prints	
VII	Submitting sequence to Database and information retrieval through ENTREZ. Collecting & Storing Sequences, Local alignment, Global Alignment, BLAST (BLASTP, BLASTN, BLASTX, TBLASTN, TBLASTX).Multiple sequence alignment (Clustal w algorithm	
VII	Genome organization and analysis Diversity of Genomes: Viral, prokaryotic & eukaryotic genomes No. of Hours: 10 Genome, transcriptome, proteome, 2-D gel electrophoresis, Maldi Toff spectroscopy Major features of completed genomes: E.coli, S.cerevisiae, Arabidopsis, Human	

Recommended Books:

1) Bioinformatics for geneticists: Wiley (2003)
2) Lesk: Bioinformatics, Oxford (2003, Indian ed)
3) Westhead et al: Bioinformatics Instant Notes, Viva Books (2003, Indian ed)
4) Jerrold H. Zarr: Biostastistical Analysis (Fourth edition), Pearson Education Inc., Delhi
5) W.W.Daniel and C.L.Cross: Biostatistics(Tenth edition), Wiley
6) John E. Havel, Raymond, E. Hampton and Scott J Meiners: Introductory Biological Statistics (Fourth edition)
7) Satguru Prasad: Elements of Biostatistics
8) Pranab Kumar Banerjee: Introduction to Biostatistics

Practicals

1. Introduction to different operating systems - UNIX, LINUX and Windows
2. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB
3. Sequence retrieval using BLAST
4. Sequence alignment & phylogenetic analysis using clustalW & phylip
5. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool
6. Protein structure prediction: primary structure analysis, secondary structure prediction using psipred, homology modeling using Swissmodel. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK)
7. Prediction of different features of a functional gene Word Problems based on Differential Equations 2. Mean, Median, Mode from grouped and ungrouped Data set 3. Standard Deviation and Coefficient of Variation 4. Skewness and Kurtosis 5. Curve fitting 6. Correlation 7. Regression 8. Finding area under the curve using normal probability 9. Testing of Hypothesis- Normal Distribution, t-test and Chi-Square-test 10. Confidence Interval

Programme/Class: B.Sc.	Year: Second	Semester: Fourth
Subject: Microbiology Paper I		
Course code:	**Course Title: Biochemistry**	
Course outcome: Biochemistry is regarded as the mother of all biological sciences disciplines as it unveils the chemical basis of life an all the living organisms from micro-organisms to plants and animals. Keeping in pace with the developing trends in various areas of biochemistry the subject course contains fundamental as well as latest and upcoming developments in the field of biochemistry.		
Credits:4	**Core Compulsory**	
Max. Marks: (25+75)	**Min. Passing Marks: 40**	

Unit	Topics:
I	Structure of atoms, molecules and chemical bonds Composition, structure and function of biomolecules carbohydrates, lipids, proteins.
II	Conformation of proteins (Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds) nucleic acids and vitamins.
III	Principles of biophysical chemistry pH, buffer, Reaction of kinetics, thermodynamics, colligative properties.
IV	Enzymes, classification, enzyme kinetics, mechanism of enzyme catalysis, enzyme regulation, isozymes, coenzymes, Abzymes, ribozymes, Enzyme Inhibitors.
V	Bioenergetics, high energy rich biomolecules, phosphoryl transfer reactions, oxidation reduction reactions, Coupled reaction standard free energy change.
VI	Carbohydrate metabolism: glycolysis, pyruvate oxidation, TCA cycle, PPP pathway, oxidative phosphorylation, gluconeogenesis, glycogenolysis, glycogenesis
VII	Lipid metabolism beta oxidation of fatty acid, steroid synthesis, cholesterol synthesis, fatty acid synthesis (SFA, UFA). Protein metabolism (catabolism of carbon skeleton, nitrogen skeleton, urea cycle.)
VIII	Nucleic acid metabolism (Synthesis of purines and pyrimidines nucleotides and its catabolism) Enzyme technology: engineering, immobilization, physical, adsorption, entrapment, covalent modifications.

Recommended Books:

- Nelson et al: Lehninger Principles of Biochemistry (3rd Ed.), MacMillan Worth, 2000
- Berg et al.: Biochemistry (5th Ed.), Freeman, 2002
- J.L.Jain: Fundamental of Biochemistry
- Mathews et al.: Biochemistry (3rd Ed.), Pearson, 2004 (37)
- Zubay et al: Principles in Biochemistry (2nd Ed.), WCB, 1995
- Murray et.al: Harper's Illustrated biochemistry : McGraw Hill (2003) Elliott and Elliott
- Lubert Stryer: Biochemistry
- Voet & Voet. Biochemistry Vols I &2: Wiley (2004)

BIOCHEMISTRY (PRACTICALS)

1. Properties of water, Concept of pH and buffers, preparation of buffers and Numerical problems to explain the concepts
2. Numerical problems on calculations of Standard Free Energy Change and Equilibrium constant
3. Standard Free Energy Change of coupled reactions
4. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non reducing sugars
5. Qualitative/Quantitative tests for lipids and proteins
6. Study of protein secondary and tertiary structures with the help of models
7. Study of enzyme kinetics – calculation of V_{max}, Km, Kcat values
8. Study effect of temperature, pH and Heavy metals on enzyme activity
9. Estimation of any one vitamin

SEMESTER - IV

PAPER – II: MICROBIAL PHYSIOLOGY AND METABOLISM

Programme/Class:	Year: Second	Semester: Fourth
Subject:		
Course Code:	Course Title: MICROBIAL PHYSIOLOGY AND METABOLISM	

Course Outcomes:

- After completion of course the students will understand the fundamental principles of microbial physiology, including growth, metabolism, and environmental adaptations, and be able to apply this knowledge to various fields like biotechnology and healthcare.
- Students will learn about the key metabolic pathways involved in energy production, carbon and nitrogen assimilation, and biosynthesis of essential biomolecules.

Credits:	Core:
Max. Marks:	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**

Unit	Topics	Total No. of Lectures/ Hours ( )
I	**Microbial Growth and Effect of Environment on Microbial Growth** Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate, synchronous growth, diauxic growth curve	
II	Microbial growth in response to environment, nutrition and energy -Temperature (psychrophiles, mesophiles, thermophiles, extremophiles, thermodurics, psychrotrophs), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative anaerobe), barophilic.	
III	Microbial growth in response to nutrition and energy – Autotroph/ Phototroph, heterotrophy, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, photolithoautotroph, Photoorganoheterotroph.	
IV	**Nutrient uptake and Transport** Passive and facilitated diffusion Primary and secondary active transport, concept of uniport, symport and antiport Group translocation Iron uptake	
V	**Chemoheterotrophic Metabolism - Aerobic respiration** Concept of aerobic respiration, anaerobic respiration and fermentation Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway TCA cycle Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors	
VI	**Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation** Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction) Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways	

VII	**Chemolithotrophic and Phototrophic Metabolism** Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction) Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic vs. oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria	
VIII	**Nitrogen Metabolism** - an overview Introduction to biological nitrogen fixation Ammonia assimilation Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification , denitrification.	

Recommended Books:

1. Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.
2. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons
3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
4. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag
5. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
6. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

MICROBIAL PHYSIOLOGY AND METABOLISM (PRACTICAL)

1. Study and plot the growth curve of E. coli by tubidiometric 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 on growth of E. coli
4. Effect of pH on growth of E. coli
5. Demonstration of alcoholic fermentation
6. Demonstration of the thermal death time and decimal reduction time of E. coli.

SEMESTER – V

PAPER - I: IMMUNOLOGY

Programme/Class: B.Sc.	**Year:** Third	**Semester:** V
Subject:		
Course Code:	**Course Title: IMMUNOLOGY**	

- **Course Outcomes:** Students will be able to describe the cells, tissues, and organs of the immune system, including the roles of different immune cells (like lymphocytes, macrophages, and dendritic cells) and molecules (like antibodies, cytokines, and chemokines).
- Students will be able to explain the mechanisms of hypersensitivity reactions (allergies) and autoimmune diseases (where the immune system attacks the body's own tissues).
- Students will be familiar with common immunological techniques used in research and diagnosis, such as ELISA, flow cytometry, and serology.

Credits:	**Core:**
Max. Marks:	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**

Unit	Topics	Total No. of Lectures/ Hours ( )
I	**Introduction** 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	
II	**Immune Cells and Organs** Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT	
III	**Antigens and antibodies** Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes); T-dependent and T-independent antigens; Adjuvants Structure, Types, Functions and Properties of antibodies, Monoclonal and Chimeric antibodies	
IV	**Major Histocompatibility Complex** class I & class IIMHC antigens, antigen processing	
V	**Complement System** Components of the Complement system; Activation pathways (Classical, Alternative and Lectin pathways); Biological consequences of complement Activation	4
VI	**Immune techniques** - Blood grouping, Antigen Antibody reactions :agglutination, precipitation, immune electrophoresis, Coomb's test, ELISA, RIA.	
VII	**Vaccines and vaccination** adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, tumor vaccines, principles of vaccination, passive & active immunization, immunization programs & role of WHO in immunization programs.	

VIII	Immunological Disorders and Tumor Immunity No. of Hours: 10 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.	

IMMUNOLOGY (PRACTICAL)

1. Identification of human blood groups.
2. Perform Total Leukocyte Count of the given blood sample.
3. Perform Differential Leukocyte Count of the given blood sample.
4. Separate serum from the blood sample (demonstration).
5. Perform immunodiffusion by Ouchterlony method.
6. Perform DOT ELISA.
7. Perform immunoelectrophoresis.

Recommended Books:

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology.11th edition Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway'sImmunobiology. 7th edition Garland Science Publishers, New York.
5. PeakmanM, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

SEMESTER – V

PAPER – II: RECOMBINANT DNA TECHNOLOGY

Programme/Class: B.Sc.	Year: III	Semester: V
Subject: Microbiology		
Course Code:	Course Title: RECOMBINANT DNA TECHNOLOGY	

Course Outcomes:

- After completion of course the students will be able to demonstrate a strong understanding of the principles and applications of genetic engineering, including proficiency in designing and conducting experiments involving genetic manipulation, and be able to apply these skills in various fields like biotechnology, medicine, and agriculture.
- The students will be familiar with various techniques used in RDT, such as DNA cloning, gene editing, and PCR
- Will be able to design cloning experiments using vectors.
- Understand the techniques used in functional genomics, such as microarrays, NGST, mRNA expression, and miRNA expression.

Credits:	Core:
Max. Marks:	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): L-T-P:

Unit	Topics	Total No. of Lectures/ Hours (6 0)
I	**Introduction to Genetic Engineering –** Milestones in genetic engineering and biotechnology	
II	**Molecular cloning -Tools of RDT** Cloning tools -Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering	
III	**Vectors in RDT** Plasmid vectors: pBR and pUC series, 2micron plasmid and yeast plasmid, Ti plasmid, Bacteriophage lambda and M13 based vectors Cosmids, phagemids, BACs, YACs, HAC. Use of linkers and adaptors	
IV	**STRATEGIES OF MOLECULAR CLONING** Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors, Baculovirus based vectors, mammalian SV40-based expression vectors	
V	**Techniques used in RDT** Transformation of DNA: Chemical method, Electroporation, Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, *Agrobacterium* - mediated delivery. DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE and Western blotting	

VI	**Amplification and DNA Sequencing** DNA sequencing-Maxam Gilbert, Sanger dioxy method and automated DNA sequencing, Overview of Next Generation Sequencing Technologies	
VII	**Construction and Screening of Genomic and cDNA libraries** Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping. DNA sequencing-Maxam Gilbert, Sanger dioxy method and automated DNA sequencing, Overview of Next Generation Sequencing Technologies	
VIII	**Applications of Recombinant DNA Technology** Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic -cotton, brinjal, Gene therapy, recombinant vaccines, protein engineering and site directed mutagensis	

Recommended Books: 1.Brown TA. (2010). Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.

1. Clark DP and Pazdernik NJ. (2009). Biotechnology: Applying the Genetic Revolution. Elsevier Academic Press, USA
2. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
3. Sambrook J and Russell D. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press
4. Wiley JM, Sherwood LM and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. McGraw Hill Higher Education
5. Brown TA. (2007). Genomes-3. Garland Science Publishers

Primrose SB and Twyman RM. (2008). Genomics: Applications in human biology. Blackwell Publishing, Oxford, U.

SEMESTER –4

RECOMBINANT DNA TECHNOLOGY (PRACTICAL)

1. Preparation of competent cells for transformation
2. Demonstration of Bacterial Transformation and calculation of transformation efficiency.
3. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis
4. Ligation of DNA fragments
5. Cloning of DNA insert and Blue white screening of recombinants.
6. Interpretation of sequencing gel electropherograms
7. Designing of primers for DNA amplification
8. Amplification of DNA by PCR
9. Demonstration of Southern blotting

SEMESTER – V

PAPER – III

Programme/Class: B.Sc.	Year: III	Semester: V
Subject: Microbiology		
Course Code:	Course Title: Enzyme Technology	

- **Course Outcomes:** After completion of course students shall be able to have a comprehensive understanding of enzymes, their mechanisms, applications, and biotechnological significance, enabling them to analyze, design, and apply enzyme-based solutions in various fields.
- They will understand enzyme kinetics, mechanisms of enzyme action, and factors influencing enzyme activity (e.g., pH, temperature, inhibitors).
- Students will gain an appreciation for the diverse applications of enzymes in various industries, including food, pharmaceuticals, and biotechnology.

Credits:	Core:
Max. Marks:	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to Enzymes** General introduction and historic background- General Terminology, Enzyme units-Katal and IU. Enzyme activity- chemical nature of enzymes.	
II	**Nomenclature and Classification of Enzymes** Protein nature of enzymes and Non protein enzymes- Ribozymes and DNAzymes. Metalloenzymes and metal activated enzymes. Coenzymes and Cofactors- Prosthetic group, coenzymes involved in different metabolic pathways. Classification of coenzymes. Isozymes, Abzymes, Synzyme	
III	**Enzyme Catalysis** Lock and key, Induced fit and Transition state Hypotheses. Mechanism of enzyme catalysis- Acid- base catalysis, covalent catalysis, Metal ion catalysis, Proximity and orientation effects etc. Proenzymes (Zymogens).	
IV	**Enzyme Inhibition** Reversible Inhibition- Competitive, Non Competitive, Uncompetitive, Mixed, Substrate, Allosteric and Product Inhibition. Irreversible Inhibition- Suicide inhibition.	
V	**Enzyme Regulation** Feedback Regulation, Allosteric Regulation, Reversible Covalent Modification and Proteolytic Activation. Organisation of enzymes in the cell.	

VI	**Enzyme Kinetics** Factors affecting the enzyme activity- Concentration, pH and temperature. Kinetics of a single- substrate enzyme catalysed reaction, Michealis-Menten Equation, Km, Vmax, L.B Plot, Turnover number, Kcat. Kinetics of Enzyme Inhibition. Kinetics Allosteric enzymes.	
VII	**Industrial uses of Enzymes (Applied Enzymology)** Industrial Enzymes- Thermophilic enzymes, amylases, lipases, proteolytic enzymes in meat and leather industry, enzymes used in various fermentation processes, cellulose degrading enzymes, Metal degrading enzymes.	
VIII	**Clinical uses of Enzymes** Clinical enzymes- Enzymes as thrombolytic agents, Anti-inflamatory agents, strptokinasae, asparaginase, Biosensors. Enzyme Engineering and site directed mutagenesis, Designer enzymes. Lead Compound, Structure based drug design,	

Recommended Books:

1. Fundamentals of Enzymology : Nicholas Price & Lewis Stevens
2. Enzymes : Biochemistry, Biotechnology and Clinical Chemistry- Trevor Palmer
3. Biochemistry text books by Stryer, Voet and Lehninger (Relevant Chapters)
4. Proteins by Gary Walsh
5. Internet/ Journal Resources

SEMESTER – V

PAPER – IV: Medical Microbiology

Programme/Class: B.Sc.	Year: Third	Semester: Fifth
Subject: Microbiology		
Course Code:	Course Title: Medical Microbiology	

Course Outcomes:

Students after completion of course will be able to

- Understand the fundamentals of Medical Microbiology and key principles of it.
- Will gain the knowledge of most common medically important organism and the infections they cause.
- Will learn the different approaches, techniques and tools used to identify pathogens and control them.
- Will be able to apply Diagnostic approaches for microbial pathogens
- Know about important bacterial and viral disease.

Credits:	Core:
Max. Marks:	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to medical microbiology** History and scope of medical microbiology, normal microflora of human body and its importance, Early discovery of pathogenic microorganisms, normal microbial flora of the human body and their importance.	
II	**Host Pathogen Interaction** Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Transmission of infection, Pathophysiologic effects of LPS	
III	**Sample collection, transport and diagnosis** Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests,Complement fixation, PCR, DNA probes).	
IV	**Bacterial diseases** List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control Respiratory Diseases: Streptococcus pyogenes, Haemophilus influenzae, Mycobacterium tuberculosis Gastrointestinal Diseases: Escherichia coli, Salmonella typhi, Vibrio cholerae, Helicobacter pylori Others: Staphylococcus aureus, Bacillus anthracis, Clostridium tetani, Treponema pallidum, Clostridium difficie	
V	**Viral diseases** - List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza with brief description of swine flu, Ebola, Chikungunya, Japanese Encephalitis	

VI	**Protozoan diseases** - List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control Malaria, Kala-azar Unit 6 Fungal diseases Brief description of each of the following types of mycoses and one representative disease to be studied with respect to transmission, symptoms and prevention Cutaneous mycoses: Tinea pedis (Athlete's foot) Systemic mycoses: Histoplasmosis Opportunistic mycoses: Candidiasis	
VII	**Therapeutics of microbial diseases** Mechanism of action of various chemotherapeutic agents: Treatment using antibiotics: beta lactam antibiotics(penicillin, cephalosporins), quinolones, polypeptides and aminoglycosides. Principle of drug resistance. Concept of DOTS	
VIII	**Prevention Of Microbial Diseases** General preventive measures, importance of personal hygiene, Environmental sanitation and methods to prevent the spread of infectious agents transmitted by direct contact, food, water and insect vectors, vaccines: importance, types, vaccines available against microbial diseases	

Recommended Books:

1. Ananthanarayanan R. and C.K. Jayaram Panicker Orient Longman Text of Microbiology, 1997.
2. Mackie and McCartney Medical Microbiology Vol.1: Microbial Infection.
   Vol.2: Practical Medical Microbiology Churchill Livingstone, 1996.
3. Shanson D.C., Wright PSG, Microbiology in Clinical Practice., 1982.
4. Baron EJ, Peterson LR and Finegold SM Mosby, Bailey and Scott's Diagnostic Microbiology, 1990.
5. Smith, C.G.C. "Epidemiology and Infections' (1976): Medowfief Press Ltd., Shildon, England.

SEMESTER – V

Medical Microbiology (Practical)

1. Identify bacteria (any three of E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
2. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
3. Study of bacterial flora of skin by swab method
4. Perform antibacterial sensitivity by Kirby-Bauer method
5. Determination of minimal inhibitory concentration (MIC) of an antibiotic.
6. Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ring worms)
7. Study of various stages of malarial parasite in RBCs using permanent mounts.

SEMESTER – VI
PAPER – I: Industrial Microbiology

Programme/Class: B.Sc.	Year: Third	Semester: six
Subject: Microbiology		
Course Code:	Course Title: Industrial Microbiology	

Course Outcomes:

- Learning of different fermentation techniques, bioreactor design,inoculum development for industrial fermentations, Microbial growth and product formation kinetics, media formulation and sterilization, isolation, preservation and improvement of industrially important micro-organisms.
- Understanding of industrial production and purification of organic acids, alcohols, wine and vinegar with help of different microbes.
- Understanding of industrial production and purification of antibiotics, enzymes, amino acids and steroids.
- Understanding of different pathways followed in or by the microbes involved in production of these bio-chemicals. Method of manipulating these pathways to get desired yield.
- Understanding of application of these bio-molecules in benefit of mankind

Credits:	Core:
Max. Marks:	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**

Unit	Topics	Total No. of Lectures/ Hours (60)
I	Historical developments of industrial microbiology - Definition and scope of Industrial Microbiology Contributions of various scientists to Industrial Microbiology- a) Louis Pasteur b) Antony Van Leeuwenhoeck c) Alexander Fleming d) Selman Waksman	
II	Introduction to Industrially important products a) Pharmaceutical products – i) Vitamins – Vit B12 ii) Antibiotics– Penicillin b) Agricultural products – i) Biofertilizers – Azotobacter ii) Biopesticides – Bacillus thuringiensis. c) Food products – i) Fermented milk products – Curd ii) Pickles – Sauerkraut d) Other Industrial products – i) Enzymes – Amylase ii) Organic acid -Citric acid	
III	Microbial substrate- Media formulation, Optimization of media; Cell growth kinetics: Kinetics of substrate utilization, biomass production and product formation in batch, fed batch and continuous cultivations; Kinetics of death of microorganisms	
IV	Concepts of Fermentation 1. Fermentation – Definition 2. Primary and secondary metabolites 3. Types of fermentation a) Batch and continuous fermentations b) Dual and multiple fermentation c) Solid state and liquid state fermentation Fermentation media	
V	Components of Fermentation media- 1. Basic components a) water b) Sources of: carbon, nitrogen, minerals 2. Special ingredients – a) growth factors b) buffers c) precursors, inhibitors, inducers, d) antifoam agents e) redox potential 3. Types of media used- a) synthetic, semisynthetic b) crude	

VI	Use of Wastes a) Industrial waste i) Molasses ii) Corn steep liquor iii) SWL b) Agricultural wastes i)Wheat bran ii) Rice husk	
VII	A. Screening of industrially important microorganisms 1. Primary Screening of a) Antibiotic producers b) Organic acid producers c)Amylase producers 2. Secondary screening	
VIII	Study of Industrially Important Microorganisms 1. General characteristics and industrial importance of : a) Bacteria including actinomycetes b) Fungi (yeasts and molds) c) Algae	

Recommended Books:

1. Stanbury P. F., A. Whitaker, S. J. Hall. Principles of Fermentation Technology Publisher: Butterworth-Heinemann
2. Shuler M.L. and F. Kargi: Bioprocess Engineering Basic Concepts by Publisher Prentice Hall.
3. Vogel H.C., C.L. Todaro, C.C. Todaro: Fermentation and Biochemical Engineering Handbook: Principles, Process
   Design, and Equipment by Publisher: Noyes Data Corporation/ Noyes Publications.
4. W. Crueger and A.Crueger: Biotechnology. A Textbook of Industrial Microbiology, Publisher : Sinauer Associates.
5. Prescott and Dunn's Industrial Microbiology. Publisher: Gerald Reed: Books.
6. Casida L. E. J. R: Industrial Microbiology by Publisher: New Age (1968)
7. Shukla P. and Pletschke, Brett I. (Eds.) (2013) Advances in Enzyme Biotechnology, Springer-Verlag Berlin Heidelberg. ISBN 978-81-322-1094-8 (ebook); ISBN 978-81-322- 1093-1 (Softcover)

SEMESTER – VI
Industrial Microbiology (Practical)

Introduction to Industrial Microbial Techniques

1. Biosafety in Microbiology Laboratory-
   a) Aseptic techniques: i)Table disinfection ii)Hand wash, iii) Use of aprons
   b) Proper disposal of used material
   c) Cleaning and sterilization of glass wares
2. Studying parts of Light compound microscope and its use and care.
3. Study of the principle and applications of instruments used in the microbiology laboratory:
   a) Biological safety cabinets b) Autoclave c) Incubator
   d) Hot air oven e) Seitz filter
   f) Colony counter and bacteriological filter assembly. g) Centrifuge
   h) pH meter i) Spectrophotometer j) Distillation

Unit Unit II/ Credit II Preparation of Media for the Study of Microorganism in Fermentation 15

1. Preparation of liquid and solid culture media and their sterilization.
   a) Preparation of - agar plates, buts and slants.
2. Preparation of media suitable for the growth of:
   a) Bacteria – i. Nutrient broth ii. Nutrient agar iii. Soil extract agar
   b) Molds – i. Potato Dextrose Agar ii. Czapek Dox agar
   c) Yeasts – i. Glucose Yeast Extract Agar ii. Sabouraud's agar
   d) Actinomycetes – i. Glycerol Asparagine Agar
3. Sterilization of culture medium using Autoclave and assessment for sterility.
4. Sterilization of glassware using Hot Air Oven and assessment for sterility

SEMESTER - VI
PAPER – II: Food Microbiology

Programme/Class: B.Sc.	Year: Third	Semester: six
Subject: Microbiology		
Course Code:	Course Title: Food Microbiology	

Course Outcomes: After completion of course the student will be able to-

- Understand the principles of microorganisms during various food-processing and preservation steps.
- Comprehend the interactions between microorganisms and the food environment, and factors¬influencing their growth and survival.
- Understand the significance and activities of microorganisms in food.
- Recognize the characteristics of food-borne, waterborne and spoilage microorganisms, and¬methods for their isolation, detection and identification.
- Analyze the importance of microbiological quality control programme"s in food production. Discuss the microbiology of different types of food commodities.
- Describe the rationale for the use of standard methods and procedures for the microbiological analysis of food.

Credits:	Core:
Max. Marks:	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**

Unit	Topics	Total No. of Lectures/ Hours ( )
I	Food and Microorganisms- Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general.	
II	Microbial spoilage of various foods - Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods	
III	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	
IV	Fermented foods - Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.	
V	Food borne infections and intoxications-Bacterial and nonbacterial infection with examples of infective and toxic types, Brucella, Bacillus, Clostridium, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio, Yersinia enterocolitica, Listeria monocytogenes and Campylobacter jejuni Fungal born infections and intoxications fungi (Aspergillus, Penicillium). Viruses born infections and intoxications viruses (Hepatitis, Poliomylitis) and nematodes and emerging food-borne pathogens	

VI	Food fermentation- Production methods of bread, cheese, fermented vegetables and dairy products, vinegar, wine, oriental fermented foods on industrial scale, microbes as a single cell protein (quron and pruteen), Mushrooms: nutritive values of mushrooms, Edible and poisonous Mushrooms.	
VII	Microbial biomass-: Single cell proteins and myco-proteins; use of microbial enzymes in food. Fermented foods and traditional fungal foods (Shoya, miso, tempe etc.) fermented vegetable, meat and milk products. Indian fermented foods.	
VIII	Quality assurance: Microbiological quality standards of food , food quality monitoring, biosensors and immune assays. Government regulatory practices and policies. FDA, EPA, HACCP, ISI, NABL.	

Recommended Books:

1. Adams, M. R. and Moss, M. O. (2005) Food Microbiology (Second edition).Royal Society of Chemistry Publication, Cambridge.
2. Jay, J.M. (2008) Modern Food Microbiology (Sixth Edition).Aspen Publishers, Inc.Gaithersburg, Maryland.
3. Ray, B. (2005) Fundamental food microbiology (Third edition). CRC Press, New York, Washington D.C.
4. Frazier, W. C. and Westhoff, D. C. (2007) Food Microbiology. Tata McGraw Hill Publishing Company Ltd. New Delhi.
5. George J Banwart. 1989. Basic Food Microbiology. AVI publication.
6. Peppler HJ & Perlman D.1979. Microbial Technology. 2nd Ed. Academic Press.

SEMESTER - VI

PAPER – II: Food Microbiology(Practical)

1. Microbial fermentation for the production and estimation of amylase
2. Microbial fermentation for the production and estimation of citric acid
3. Microbial fermentation for the production and estimation of ethanol
4. Determination of the microbiological quality of milk sample by MBRT

SEMESTER – VI

PAPER – III: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS

Programme/Class: B.Sc.	**Year:** Third	**Semester:** six
Subject: Microbiology		
Course Code:	**Course Title: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS**	
Course Outcomes: The student at the completion of the course will be able to:		
Credits:		**Core:**
Max. Marks:		**Min. Passing marks:** as per rules
Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:**		

Unit	Topics	Total No. of Lectures/ Hours (6 0)
I	**Biosafety:** Introduction; biosafety issues in biotechnology; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms	
II	**Biosafety Guidelines:** Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture;	
III	AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions.	
IV	**Overview and Introduction of Intellectual Property** Introduction and the need for intellectual property right (IPR) - Kinds of Intellectual Property Rights: Patent, Copyright, Trade Mark, Design, Geographical Indication, Plant Varieties and Layout Design – Genetic Resources and Traditional Knowledge – Trade Secret - IPR in India	
V	**Patents and Drafting** Patents - Elements of Patentability: Novelty, Non Obviousness (Inventive Steps), Industrial Application - Non - Patentable Subject Matter - Registration Procedure, Rights and Duties of Patentee, Assignment and licence , Restoration of lapsed Patents, Surrender and Revocation of Patents, Infringement, Remedies & Penalties	
VI	**Copyrights in IPR** Nature of Copyright - Subject matter of copyright: original literary, dramatic, musical, artistic works; cinematograph films and sound recordings - Registration Procedure, Term of protection, Ownership of copyright, Assignment and licence of copyright - Infringement, Remedies & Penalties	
VII	**Industrial Designs Registrations:** Classification, Protection and Enforcement of Industrial Designs in Indian. Registration and protection of design in India and abroad.	
VIII	**Geographical Indications**:Concept of Geographical Indications and GI registration in India; Global scenario of GI. Protection of Traditional Knowledge and development of balanced benefit sharing models	

SEMESTER – VI

BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (PRACTICAL)

1. Study of components and design of a BSL-III laboratory
2. Filing applications for approval from biosafety committee
3. Filing primary applications for patents
4. Study of steps of a patenting process
5. A case study

Recommended Books

1. Rimmer, M. (2008). *Intellectual property and biotechnology: biological inventions*. Edward Elgar Publishing.
2. Singh, H. B., Jha, A., &Keswani, C. (Eds.). (2016). *Intellectual property issues in biotechnology*. CABI.
3. Nithyananda, K V. (2019). Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning India Private Limited.
4. Neeraj, P., &Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHI learning Private Limited.

E-resources:

1. Subramanian, N., &Sundararaman, M. (2018). Intellectual Property Rights – An Overview. Retrieved from http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf
2. World Intellectual Property Organisation. (2004). WIPO Intellectual property Handbook. Retrieved from https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf

Reference Journal: 1. Journal of Intellectual Property Rights (JIPR): NISCAIR
http://nopr.niscair.res.in/handle/123456789/45 (Case Studies)

Useful Websites:

1. Cell for IPR Promotion and Management (http://cipam.gov.in/)
2. World Intellectual Property Organisation (https://www.wipo.int/about-ip/en/)
3. Office of the Controller General of Patents, Designs & Trademarks (http://www.ipindia.nic.in/)

SEMESTER - VI

PAPER – IV: Environmental Microbiology

Programme/Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Microbiology		
Course Code:	Course Title: Environmental Microbiology	

Course Outcomes:

On the completion of the course students should be able to:

- Understand on soil characteristics and biogeochemical cycling
- Know the microbial analysis of drinking water and aeromicrobiology
- Know on the different aspects of waste management and sewage Treatment systems
- Acquire knowledge on bioremediation and microbial leaching
- Know the biosafety and environmental monitoring regulations

Credits:	Core:
Max. Marks:	Min. Passing marks: as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): L-T-P:

Unit	Topics	Total No. of Lectures/ Hours (60)
I	Soil characteristics & Biogeochemical cycling Physio-chemical properties of soil - Rhizosphere and rhizoplane organisms. Mineralization and immobilization.	
II	Biogeochemical cycling: Carbon cycling, nitrogen cycling, phosphorus cycling and sulphur cycling. Ecological groups based on oxygen requirement, nutrition, temperature, habitat (soil, water & air	
III	Microbial analysis of drinking water & Aeromicrobiology Microbial analysis of drinking water: Tests for coliforms (presumptive, confirmed and completed tests). Purification of water: Sedimentation, Filtration (slow and rapid sand filters) and Disinfection	
IV	Aeromicrobiology - Phylloplane microflora (morphological, physiological characters: nutrition, radiation, relative humidity and temperature) – Air Pollution – aerosol, droplet nuclei and infectious dust. Examination of air microflora	
V	. Waste management & Sewage Treatment Waste management - Utilization of solid and liquid waste pollutants for production of Single-Cell protein. Nature of sewage and its composition. Physical, chemical and biological properties of sewage (BOD, COD etc).	
VI	Sewage systems and types. Sewage Treatment: Single Dwelling Unit, municipal sewage treatment - primary, secondary and tertiary treatments (Trickling filters, activated sludge process, Oxidation lagoons and Imhoff tank).	
VII	Bioremediation & Microbial leaching Polluted heterogeneous environment. Indicator organisms for pollution and abatement of pollution. Bioremediation – Types and uses - Microbes and Environmental clean up - Genetically Engineered microbes for Bioremediation. Microbial leaching: In situ & Ex situ methods -copper and uranium mining.	

VIII	Biosafety & Environmental monitoring Environmental regulations - Biohazards - Types of hazardous emission - Biosafety measures - Biomonitority of waste water toxics - Monitoring of Genetically Engineered Microbes in the Environment	

SEMESTER - VI

Environmental Microbiology (Practical)

1. Analysis of soil - pH, moisture content, water holding capacity, percolation, capillary action.
2. Isolation of microbes (bacteria & fungi) from soil (28°C & 45°C).
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Assessment of microbiological quality of water.
5. Determination of BOD of waste water sample.
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.
7. Isolation of Rhizobium from root nodules

Recommended Books-

1. Mara, D and Horan, N 2003. The Handbook of Water and Waste Water Microbiology. Academic. Press, California.
2. Clesceri, L.S., Greenberk, A.E. and Eaton, A.D.1998. Standard Methods for Examination of Water and Waste Water, 20th Edition, American Public Health Association.
3. Raina M. Maier, Ian L. Pepper and Charles P. Gerba. 2000. Environmental Microbiology. Academic Press. New York. pp: 394-399;491-538.
4. Patel, A.H. 1996. Industrial Microbiology, Macmillan India Ltd., New Delhi.
5. Subba Rao, N. S. 1995. Soil Microbiology, IV Ed. Oxford & IBH Publishing Co. Pvt. Ltd.New Delhi. pp: 11-49; 292-301.
6. Subba Rao, N.S. 1995. Biofertilizers in Agriculture and Forestory.3rd Ed., Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi.
7. Salle, A.J. 1992. Fundamental Principles of Bacteriology, VII Ed., McGraw Hill Publishing Co. Ltd., New York. pp: 649-709;794-843.
8. Kumar, H.D. 1991. Biotechnology, II Ed., East – West Press Private Ltd., New Delhi.
9. Pelczar.M.J. and Reid 1986 " Microbiology". V Ed., Tata McGraw Hill Co., New Delhi.pp:593-617.
10. Brock, T.D, Smith, D.W. and Madigan M.T 1984, Biology of Microorganisms. IV Ed., Prentice Hall Int. Inc., London.
11. Campbell, R. 1983. Microbial Ecology, II Ed., Blackwell Scientific Publishers, London.
12. Alexander, M. 1971. Microbial ecology, John Wiley & Sons Inc., New Yor