



**PSG College of Arts & Science**  
*An Epitome of Quality Learning*

Since 1947

# **B.Sc. MICROBIOLOGY**

**2017 - 2020**

**B.Sc. Microbiology**  
**Scheme of Examinations**  
*(For students admitted from 2016-17 & onwards)*

CODE NO.	SUBJECT	EXAM DURATION (Hrs)	Max. Marks			Credit points
			CA	CE	Total	
<b>First Semester</b>						
<b>Part –I</b>						
14LAU01	Tamil – I OR Hindi – I OR French-I	3	25	75	100	3
<b>Part –II</b>						
14EU01	Communicative English - I- Interpersonal Communication	3	25	75	100	3
<b>Part –III</b>						
14MBU01	Fundamentals of Microbiology	3	25	75	100	3
14MBU02	Principles of Microbiological methods	3	25	75	100	3
14MBU03	Biochemistry(Allied-BC)	3	25	75	100	4
14MBU04	Biochemistry Practicals (Allied-BC)	3	40	60	100	1
	Microbiology Practicals-I	-	-	-	-	-
<b>Second Semester</b>						
<b>Part –I</b>						
14LAU02	Tamil – II OR Hindi – II OR French-II	3	25	75	100	3
<b>Part –II</b>						
14EU02	Communicative English II– Academic Communication	3	25	75	100	3
<b>Part –III</b>						
14MBU05	Microbial Diversity and Taxonomy	3	25	75	100	3
16MBU06	Cell Biology and Microbial Genetics	3	25	75	100	3
14MBU07	Introduction to Windows and Web designing(Allied-CS)	3	25	75	100	4
14MBU08	Microbiology Practicals-I	6	40	60	100	3
14MBU09	Introduction to Windows and Web designing practicals (Allied-CS)	3	40	60	100	1
<b>Part –IV</b>						
14VEU01	Value Education	--	100	--	100	2

Cont ...

CODE NO.	SUBJECT	EXAM DURATION (Hrs)	Max. Marks			Credit points
			CA	CE	Total	
<b>Third Semester</b>						
<b>Part –I</b>						
14LAU03	Tamil – III OR Hindi – III OR French-III	3	25	75	100	3
<b>Part –II</b>						
14EU03	Communicative English III- English for Career	3	25	75	100	3
<b>Part –III</b>						
14MBU10	Microbial Physiology and Metabolic Regulation	3	25	75	100	3
14MBU11	Molecular Biology	3	25	75	100	3
14MBU12	Computer Applications in Biology-Biological databases	-	100	-	100	3
14MBU13	Chemistry for Microbiology(Allied-CH)	3	25	75	100	5
	Microbiology Practicals-II	-	-	-	-	-
<b>Part –IV</b>						
14ESU01	Environmental Studies	--	100	--	100	2
<b>Fourth Semester</b>						
<b>Part –I</b>						
14LAU04	Tamil – IV OR Hindi – IV OR French-IV	3	25	75	100	3
<b>Part –II</b>						
14EU04	Communicative English- IV English Through Literature and Newspapers	3	25	75	100	3
<b>Part –III</b>						
14MBU14	Bioinstrumentation	3	25	75	100	3
14MBU15	Soil and Agricultural Microbiology	3	25	75	100	3
14MBU16	Mathematics(Allied-MA)	3	25	75	100	5
14MBU17	Microbiology Practicals-II	9	40	60	100	3
<b>Part –IV</b>						
14SBU01	<b>Skill Based Subject :</b> Information Security	--	100	--	100	2
Two weeks training in summer vacation in clinical laboratory/ industry						

CODE NO.	SUBJECT	EXAM DURATION (Hrs)	Max. Marks			Credit points
			CA	CE	Total	
<b>Fifth Semester</b>						
<b>Part –III</b>						
14MBU18	Principles of Genetic Engineering	3	25	75	100	4
14MBU19	Immunology	3	25	75	100	4
16MBU20	Medical Microbiology	3	25	75	100	4
14MBU21	Food Microbiology	3	25	75	100	4
14MBU22A	<b><u>Core Elective –I</u></b> Antimicrobials and Chemotherapy	3	25	75	100	4
14MBU22B	OR Principles of Good Laboratory Practices					
14MBU23	Internship and Viva Voce	----	40	60	100	5
	Microbiology Practicals-III	--	--	--	--	--
<b>Part –IV</b>						
14NME01	<b><u>Non-Major Elective (1) :</u></b> EDC	--	100	--	100	2
14NME02	<b><u>Non-Major Elective (2) :</u></b> General Awareness (On-line Test)	1½	--	100	100	2
<b>Sixth Semester</b>						
<b>Part –III</b>						
14MBU24	Applied Biotechnology	3	25	75	100	4
14MBU25	Industrial Microbiology	3	25	75	100	4
14MBU26	Microbial Ecology	3	25	75	100	3
14MBU27	Virology	3	25	75	100	3
14MBU28A	<b><u>Core Elective - II</u></b> Biostatistics and Research Methodology	3	25	75	100	4
14MBU28B	OR Quality Control in Clinical and Industrial Microbiology Laboratories					
14MBU29	Microbiology Practicals-III	9	40	60	100	6
<b>Total Credits</b>						<b>136</b>

PART-V			Credits
1.	<b>Extension Activity :</b> NSS / NCC / Sports / Department Activity	I – VI semesters	2
2.	<b>Competence Enhancement :</b> Add-on Course / Women’s Studies / Extra paper/ Certificate or Diploma in Yoga for Youth Empowerment (offered by World Community Service Centre)	I – VI semesters	2
<b>Grand Total</b>			<b>140</b>

**EDC Offered by the Department**

**EDC: 14EDCMBU**

Microbes in Daily Life (Cluster - IV)



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**Objectives**

Fundamentals of Microbiology deals with

- The early developments of Microbiology.
- Basic concepts of different groups of microorganism and its salient features.
- Classification of different groups of microbes and its reproductive strategies.
- Economic importance of the microorganisms.

**Unit – I****(10 Hrs)**

**Basic concepts in Microbiology:** History and scope of Microbiology-Spontaneous generation theory- disproval of spontaneous generation theory -Germ theory of diseases. Contributions of Antonie van Leeuwenhoek-Louis Pasteur- Joseph Lister - Edward Jenner – Robert Koch – Paul Ehrlich- Elie Metchnikoff- Alexander Flemming – Shibasaburo Kitasato and Emil von Behring – Selman.A.Waksman.

**Unit – II****(12 Hrs)**

**Prokaryotic cell:** structure, size, shape arrangement. Cell organization – Plasma membrane-fluid mosaic model, Cytoplasmic matrix, Ribosomes and Inclusion bodies, Nucleoid – Prokaryotic cell wall – Gram Positive and Gram negative cell wall-cell wall and osmotic protection, Capsules, Slime layers and S layers, Pili and Fimbriae. Flagella and motility.

**Unit – III****(10 Hrs)**

**Algae:** Morphology– ultra structure of the algal cell-Distribution - algal nutrition – algal thallus structure - Sexual reproduction – Asexual Reproduction – Algal importance- Algae as food, algae as SCP, Algae as primary producers – Commercial products derived from algae.

**Unit – IV****(10 Hrs)**

**Fungi:** Distribution – Fungal divisions: Characteristics of Ascomycetes, Basidiomycetes, Deuteromycetes, Zygomycetes – Cell structure – metabolism and nutrition - Fungi – economic and agricultural importance - Fungal reproduction: Various asexual modes of reproduction – Life Cycle of *Rhizopus stolonifer* (sexual and asexual reproduction).

**Unit V****(08 Hrs)**

**Protozoa:** Distribution–importance–Morphology – nutrition – locomotion -classification – Representative types—Reproduction: Asexual reproduction- Binary fission. Sexual reproduction- conjugation observed in *Paramecium caudatum*.

**Text Book:**

1. Jeffrey C.Pommerville, Alcamo's Fundamentals of Microbiology, 8<sup>th</sup> edition. Blackwell Publications.

**Reference:**

1. Prescott L.M ; J.P Heavy and D.A. Klein 1993 Microbiology 7<sup>th</sup> edition Wm C- Brown Publishers.
2. Michael J. Pelczar, Chan, ECS and Kreig, R, Microbiology, 5<sup>th</sup> edition (Tata Mc Graw Hill Education ,1998), New Delhi.
3. Ketchum, Microbiology, John Willey & Sons, 1998
4. Roger Y. Stanier, Edward A. Adelberg, John L. Ingraham General Microbiology. 5<sup>th</sup> edition. Macmillan Education. London.
5. Jacquelyn G. Black, Microbiology, Principles and Exploration 7<sup>th</sup> edition. Prentice Hall international Inc.
6. [Michael T. Madigan](#), [John M. Martinko](#), [Kelly Bender](#), [Daniel P Buckley](#), [David A.Stahl](#). Brock Biology of Microorganisms, 13<sup>th</sup> edition, Prentice hall International, Inc.



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**Objectives:**

Principles of Microbiology give an idea about

- Various types of microscopes.
- Staining techniques for identification of microbes.
- Cultivation techniques for microbes.
- The effect of physical and chemical agents on microbial growth inhibition.

**Unit – I**

(12 Hrs)

**Microscopy:** Development of microscopy – Principles of microscopy- light microscopy – dark field, phase contrast and fluorescent microscopy – electron microscopy, scanning and transmission electron microscopy – Preparation of specimen for light and electron microscopy.

**Unit – II**

(08 Hrs)

**Microbial morphology:** Size and cell number measurement, wet mount – hanging drop. Staining techniques: Dyes, stains, simple, differential- Gram staining and Acid fast staining, capsular, flagellar, nuclear and cytoplasmic staining techniques.

**Unit – III**

(10 Hrs)

**Sterilization Principles:** Physical agents – Principles and Applications of heat killing, dry heat, moist heat, Pasteurization, Tyndallisation, Radiation, UV rays, X-rays, Sonic and ultrasonic waves, filtration, osmotic pressure.

**Unit – IV**

(10 Hrs)

**Chemical agents:** Potency of chemical agents – mechanism of action of chemical agents - soaps and detergents, acid and alkali, Heavy metals, Halogens, alcohols, aldehydes, gases, phenol, oxidizing agents, alkylating agents and dyes.

**Unit – V**

(10 Hrs)

**Culture techniques:** Media preparation – Culture media- types of media – Methods of obtaining pure culture: streak plate, spread plate and pour plate. Preservation of microbial culture – Cultivation of anaerobic microorganisms.

**Text Book:**

1. Jeffrey C.Pommerville, Alcamo's Fundamentals of Microbiology, 8<sup>th</sup> edition. Blackwell Publications.

**References :**

1. Prescott, L.M. J.P. Harley and D.A. Klein 1993, Microbiology 2<sup>nd</sup> edition, WMC. Brown Publishers.
2. Jacquelyn G. Black, Microbiology, Principles and Exploration 7<sup>th</sup> edition. Prentice Hall international Inc.
3. [Anthony Joseph Salle](#), 1994: Fundamental Principles of Bacteriology. 7<sup>th</sup> edition. Tata McGraw Hill Publishing Company Ltd.

Hrs

**Objectives**

- To understand basic concepts in biochemistry and in enzyme
- To understand the interactions of various biomolecules

**Unit I**

Early history of biochemistry: chemical elements in biomolecules, biological macromolecules. Biochemistry of water: water as biological solvent, properties, hydrogen bonding, solubility and cellular reactions of water. pH and buffer system of biological fluid. Laws of thermodynamics (outline without derivation). Osmosis.

**Unit II**

Carbohydrates: Simple Sugars, reducing and non-reducing sugars. Classification - monosaccharides, disaccharides and polysaccharides – Structure and properties of Glucose, Fructose, Maltose, Lactose and Sucrose. Mutarotation and inversion. Homopolysaccharides and heteropolysaccharides. Glycoproteins and N-Glycosidic and O- Glycosidic bond(Elementary level).

**Unit III**

Lipids: Biological functions; Structure, properties and chemical reactions of fatty acids. Classification into fatty acids, glycerol lipids, essential and non-essential fatty acids. Sterols – Cholesterol – structure and functions. Phospholipids and Glycolipids – structure and functions. Structure of model membrane, lipid bilayer and membrane protein diffusion, ion channels, active transport. Water soluble and fat soluble vitamins – sources, biological functions and deficiency manifestation (Elementary level).

**Unit IV**

Proteins and Amino acids: Protein content of cells, Composition and biological functions of proteins. Amino acids; Zwitter ion nature; properties and reactions of aminoacids. Peptides; Primary, Secondary, tertiary and quaternary structures of proteins. Protein malnutrition. Hormones – Steroid and peptide hormones; Insulin, Cortisol, Vasopressin, T<sub>3</sub>,T<sub>4</sub> & TSH.

**Unit V**

Enzymes and their properties. Specificity of enzyme action, co-enzymes. Active sites. Classification of enzymes. Enzyme inhibition – feedback inhibition, end product inhibition. Michaelis and Menton equation, V<sub>max</sub> and Michaelis constant. Allosteric enzymes. Mechanism of action of enzymes. Competitive and non-competitive and uncompetitive inhibition. Multienzyme systems. Clinical Biochemistry- marker enzymes of liver and heart diseases; ALT, AST, ALP, ACP & CPK.

**REFERENCES**

1. Boyer, R 2002. Concepts in Biochemistry, 2<sup>nd</sup> edition, Brooks/Cole.
2. Berg.J.M., Tymoczko.J.I.,and Stryer L., 2002, Biochemistry, 5<sup>th</sup> edition, W H Freeman & Co.
3. Voet & Voet, 1995, Biochemistry, 2<sup>nd</sup> edition, John Wiley & Sons Inc.,
4. Jain J L., 2005, Fundamentals of Biochemistry, 1<sup>st</sup> multicolor edition, S Chand & company Ltd.,

5. Nelson, D.L & Cox, M.M (2006) “ Lehninger Proinciples of Biochemistry”, W.H. Freeman and Company, New York.

**14MBU04**

**BIOCHEMISTRY Allied PRACTICALS**

**2 Hrs/week**

1. Analysis of carbohydrates
  - a. Glucose
  - b. Fructose
  - c. Xylose
  - d. Lactose
  - e. Sucrose
2. Identification of given sugar.
3. Analysis of amino acids.
  - a. Tyrosine
  - b. Metionine
  - c. Arginine
  - d. Tryptophan
  - e. Cysteine
4. Identification of given amino acid.
5. Estimation of protein by Biuret method (Demo)
6. Estimation of Glycine by formal titration.
7. Estimation of ascorbic acid.

**CA components for practicals:**

Experiment	<b>15 marks</b>
Record	<b>5 marks</b>
Test (2)	<b>20 marks</b> (each test for 10 marks)

**CE components for practicals:**

- |               |                 |
|---------------|-----------------|
| 1. Record     | <b>10 marks</b> |
| 2. Experiment | <b>50 marks</b> |

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**60 marks**  
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**Objectives:**

Microbial Diversity and Taxonomy imposes

- a broader idea about the positional classification of different groups of microorganisms stating their characteristics in detail.
- Gives an overview about the diversity of bacteria, archae and viral classification

**Unit:I****(11 Hrs)**

**Microbial Taxonomy:** Microbial kingdoms-Taxonomic ranks-classification systems-Five kingdom concept-major characteristics used in Taxonomy-Morphological characteristics, physiological and metabolic characteristics, serological characteristics-Molecular characteristics-Phylogenetic studies-Phenetic classification.

**Unit:II****(10 Hrs)**

**Photosynthetic Bacteria:** Anoxygenic photosynthetic bacteria: Purple 's' bacteria- purple non-'s'- bacteria- Green 's' and Green non-'s' bacteria- oxygenic photosynthetic bacteria: Cyanobacteria. Classification of Cyanobacteria- Cyanobacterial structure-function. Importance of cyanobacteria. General characteristic features of photosynthetic bacteria.

**Unit:III****(10 Hrs)**

**Bacterial Diversity:** Gram positive filamentous rods: Actinomycetes-classification-Facultatively anaerobic gram negative rods: characteristic features of Enterobacteriaceae, Vibrionaceae and Pasteurellaceae family members. Gram negative rods: Spirochetes, Rickettsias. Gram negative cocci: Chlamydias. Cell wall less bacteria – Mycoplasmas. Endospore forming rods and cocci.

**Unit:IV****(08 Hrs)**

**Archael Diversity:** General Characteristics: unique phenotypic features of cellwall, cytoplasmic membrane, ribosomes, nucleic acid. Taxonomic groups of Archae (Extremophilic organisms): Thermophilic archaea – Halophilic archaea –Methanogenic archaea - Cell wall less archaea – Archael Sulphate Reducers.

**Unit:V****(09 Hrs)**

**Viral Classification:** Characteristics and structural Properties of viruses- Capsid, Nucleic acid, viral envelopes and enzymes. Classification of animal viruses-DNA viruses and RNA viruses. Classification of Plant viruses- DNA viruses and RNA viruses. Bacteriophage - structure and classification.

**Text Book:**

1. Ronald M. Atlas, 1995. Principles of Microbiology, 2<sup>nd</sup> Edition, WCB McGraw Hill.

**References:**

1. Jeffrey C. Pommerville, Alcamo's Fundamentals of Microbiology, 8<sup>th</sup> edition. Blackwell Publications.
2. Prescott L.M; J.P Heavy and D.A. Klein 1993 Microbiology 7<sup>th</sup> edition Wm C-Brown Publishers.
3. Jacquelyn G. Black, Microbiology, Principles and Exploration 7<sup>th</sup> edition. Prentice Hall international Inc.
4. [Michael T. Madigan](#), [John M. Martinko](#), [Kelly Bender](#), [Daniel P Buckley](#), [David A. Stahl](#) Brock Biology of Microorganisms, 13<sup>th</sup> edition, Prentice hall International, Inc.

- Schlegel, General Microbiology, low price editions Cambridge University Press, Cambridge.



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(For students admitted from 2016-17 & onwards)

**Objectives:**

Cell Biology includes

- the detail study of all the organelles present within the cell,
- its functions and involvement of these organelles in the proper life span of the organism.

Genetics is

- the science of heredity and variation in living organisms,
- learning about genes and their functions,
- mutations and repair and
- various gene transfer mechanisms with applications of genetics.

**Unit – I**

**(10 Hrs)**

**Concepts of Cell Biology:** Definition of Cell Biology-History- Cell theory-Eukaryotic cell organelles - Structure and Function - Nucleus, Mitochondria, Microtubules, Lysosomes.

**Unit – II**

**(10 Hrs)**

**Eukaryotic cell cycle and regulation:** Mitosis and meiosis. Cell Programmed death (Apoptosis). Cell adhesion – CAM- Cadherin, Ca<sup>2+</sup> dependent and independent molecule, Selectins. Basics of Eukaryotic cell to cell signaling.

**Unit – III**

**(10 Hrs)**

**Genetic Material:** DNA as the genetic material – Griffith's experiment – Extra chromosomal inheritance: Plasmids–types of plasmids. Applications. Transposons–Simple and composite transposon – transposition process. Applications.

**Unit – IV**

**(10 Hrs)**

**Gene Mutation and Repair:** Mutation & types of mutations – Physical & chemical mutagenesis- Ames test-Toxicity testing. DNA damage and repair: Excision repair, Photo reactivation, Recombinational repair and SOS repair.

**Unit – V**

**(10 Hrs)**

**Genetic recombination at molecular level:** Role of Rec A. Transformation – competence, DNA uptake and mechanism of transformation. Transduction: Generalized and specialized transduction. Conjugation- F<sup>+</sup>, Hfr, F' transfer.

**Text Book:**

1. E.D.P De Robertis, Francisco A, Saez and E. M. F. De Robertis, Cell Biology 6<sup>th</sup> Edition, Publications – Info; Philadelphia: Saunders.

**Reference :**

1. Alberts, B., D. Bray, J.Lewis, M.Raff, K.Roberts and J.D.Wawton. 1989. Molecular Biology of the Cell. 2<sup>nd</sup> edition, Garland Publishing, New York.
2. Freifelder. D. 1995. Microbial Genetics, Narosa Publishing House, New Delhi.
3. Lewin B. 2002. Genes VIII. Oxford.
4. Ajoy Paul. Cell and Molecular Biology. Books and Allied (P) Ltd Publishers. 1<sup>st</sup> Edition.
5. Robert H. Tamarin, Principles of Genetics, Tata Mc Graw Hill Company. 7<sup>th</sup> Edition.

6. Benjamin Lewin. Genes IX, Oxford University Press. John Wiley & Sons Inc.



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**INTRODUCTION TO WINDOWS AND WEB DESIGNING (Theory)****Total Hours: 40****UNIT – I: (INTRODUCTION TO WINDOWS & WORD) (8 Hours)**

Word Basics – Editing with word – Copying and Moving Text – Adding pictures in Documents – Formatting with word- Formatting Paragraphs – Sections - Creating Form Letters – Inserting header and Foot notes – Tables – Spell Checking – Grammar Checking – Sorting Fields.

**UNIT – II: (POWER POINT) (7 Hours)**

Basics of Power point – Creating and Editing Slides – Formatting Slides – Templates – Coloring Texts and Objects – Heading Slides – Using Clip Art Gallery – Slide Transitions.

**UNIT –III: (EXCEL) (9 Hours)**

Introduction –Definition of Electronic Worksheet –Advantages of using a Spreadsheet – Getting started with Excel – Understanding Operators – Entering information, numbers, formula – Function – Editing the contents of a cell – Working with rows and columns – Formatting – Range – copying a range – Working with tables – Working with Graphs - Data Form – Sorting – Printing Worksheet – Creating Charts.

**UNIT – IV: (INTERNET BASICS) (7 Hours)**

What is Internet? Resources of Internet – Internet Services – H/W and S/W requirements of Internet – Internet Addressing System – Internet Service Providers – Domains and Sub domains – Top Level Domains – Web browsers and Web Servers.

**UNIT – V: (HTML) (9 Hours)**

HTML: Introduction - Structure of HTML Document – HTML Basic Tags – Using Basic Tags – Creating Links – Creating Lists – Creating Tables – Creating Images – Inserting Images into Web pages – Adding sound to a HTML document.

Back ground Animations: Background color – Background Images – Background Video – Looping HTML. Forms: What is a form? - Form Controls – Creating a Form and Adding Controls Creating Frames.

**Textbook**

1. R.K. Taxali, “PC SOFTWARE for Windows made simple”, TMH, 2010.
2. Steven Holzner, ”HTML Black Book”, Dreamtech Press, New Delhi, 2002.

**Objectives:**

Practical Paper I deals with

- Basic Microbial Laboratory Skills.
  - Handling of Instruments and Laboratory safety measures are included in practicals.
  - Principles of Microbiology.
  - Methods for Microbiology.
1. Laboratory precautions and safety and Glassware cleaning.
  2. Microscopy: Use of Bright field microscope-demonstration
  3. Sterilization principles and methods: Dry heat, moist heat and filtration methods.
  4. Staining techniques: Preparation of Stains
  5. Smear preparation: Heat fixation. Simple staining procedure.
  6. Differential staining procedure: Gram's staining
  7. Endospore staining.
  8. Capsular Staining: Positive staining and Negative staining.
  9. Determination of motility: Hanging drop method
  10. Micrometry: measuring the size of a microorganism.
  11. Media preparation: Liquid medium, Solid medium : Agar slants,&Agar plates, Agar deeps
  12. Preparation of Selective media –EMB agar, Differential media- MacConkey agar.
  13. Pure culture technique: Serial dilution – Pour plate method.
  14. Spread plate method
  15. Streak plate method –single line, Quadrant, T-streak, Continuous
  16. Cultural characteristics of microorganisms.
  17. Anaerobic culture techniques – Wright's Tube method
  18. Identification of organisms from permanent slides – *Aspergillus*, *Penicillium*, *Entamoeba*.

**INTRODUCTION TO WINDOWS AND WEB DESIGNING PRACTICALS****MS-WORD**

1. Prepare an invitation for your college function (use Word Art and Clip Art).
2. Prepare an invitation for national workshop in 3 columns.
3. Prepare your resume and use tables wherever needed.
4. Create a mail merge document for an interview call letter.

**MS-EXCEL**

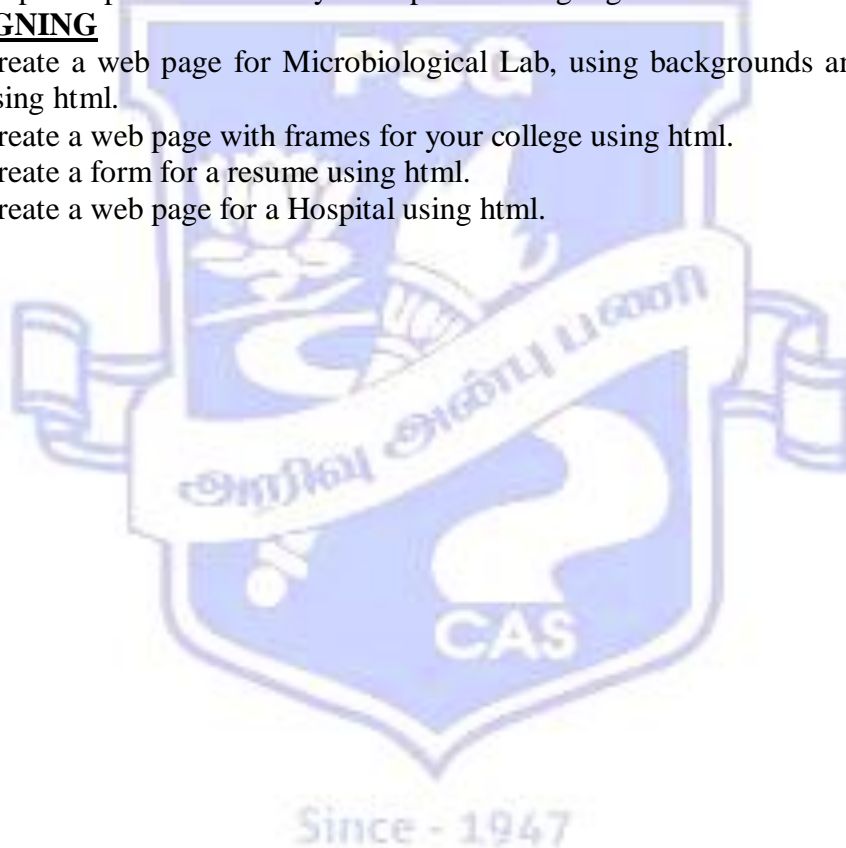
5. Prepare a statement of marks for a class and calculate the total, percentage and result using formula.

**MS-POWERPOINT**

6. Prepare a presentation for your department highlights in auto mode.

**WEB DESIGNING**

7. Create a web page for Microbiological Lab, using backgrounds and image links using html.
8. Create a web page with frames for your college using html.
9. Create a form for a resume using html.
10. Create a web page for a Hospital using html.



## 14MBU10 MICROBIAL PHYSIOLOGY AND METABOLIC REGULATION

### Objectives:

III Semester

Microbial Physiology & Metabolic Regulation describes in detail about

- The various transport systems available for different organisms for their nutritional uptake
- Giving a broader edge to the students about the process of Growth cycle, Morphogenesis, Endospore formation, Photosynthesis.
- The pathways for utilization of nutrients incorporated by the organism to gain their living,
- About proteins and enzymes, their structural and functional role.

### Unit – I

(8 Hrs)

**Growth and regulation:** Nutritional requirements – macro and micronutrients – growth factors. Transport of nutrients across the membrane – diffusion, active and passive transport, Group translocation. Growth curve – growth determinations – batch, continuous and synchronous culture.

### Unit – II

(7 Hrs)

**Cell differentiation:** morphogenesis – development of dormant and resting structures. Sporulation in *Bacillus*. – Endospore formation – stages of Endospore formation, germination and regulation.

### Unit – III

(9 Hrs)

**Respiratory metabolism:** Carbohydrate metabolism – Embden – Mayerhoff pathway - the HMP pathway — the Tricarboxylic acid cyclic. Aerobic respiration – Substrate level phosphorylation – Oxidative phosphorylation – lipid catabolism – beta oxidation.

### Unit – IV

(7 Hrs)

**Biosynthesis of molecules :** Synthesis of fatty acids. Biosynthesis of nucleotides – purines and pyrimidines. Biosynthesis of aminoacids – glutamate family. Biosynthesis of bacterial cell wall.

### Unit – V

(7 Hrs)

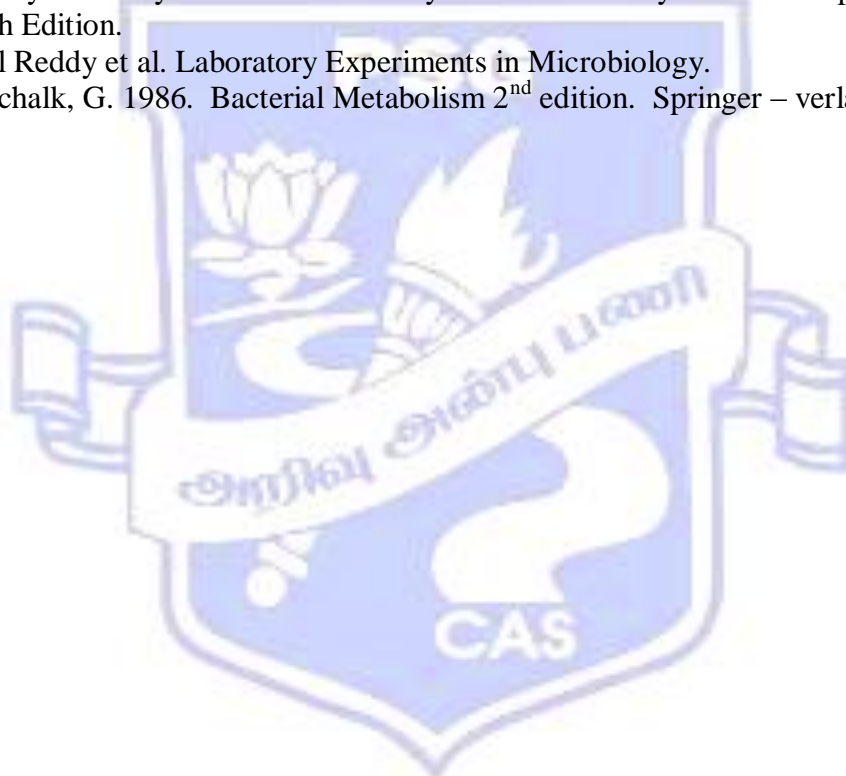
Photosynthesis: Oxygenic and Anoxygenic photosynthesis and Calvin Benson cycle – Methanogenesis –pathways. Anaerobic respiration – sulfur compounds – nitrate and carbon dioxide as electron acceptors. Fermentation – alcoholic, propionic, lactic and mixed acid and solvent producing fermentations

### Text Book:

1. White, D. 1995. The physiology and Biochemistry of prokaryotes. Oxford University press. New York.

### References:

1. Doelle, H.W. 1975. Bacterial Metabolism 2<sup>nd</sup> edition. Academic press.
2. Gottschalk, G. 1986. Bacterial metabolism 2<sup>nd</sup> edition. Springer – verlag. New York.
3. Moat, A.G. and J.W. Foster. 1995. Microbial physiology, ed. Wiley – Liss. New York.
4. Rose A.H. 1976. Chemical Microbiology- An introduction to Microbial Physiology . 3<sup>rd</sup> ed. Plenum.
5. Caldwell, D.R. 1995 Microbial Physiology and Metabolism, Wm. C. Brown Publishers, U.S.A.
6. David L. Nelson and Michael M. Cox. 2008. Lehninger Principles of Biochemistry by W.H. Freeman and Company. Fifth Edition.
7. Doelle, H.W. 1975. Bacterial Metabolism 2<sup>nd</sup> edition. Academic press.
8. Geoffrey L. Zubay. 2008. Biochemistry. Addison-Wesley educational publishers Inc., Fourth Edition.
9. Gopal Reddy et al. Laboratory Experiments in Microbiology.
10. Gottschalk, G. 1986. Bacterial Metabolism 2<sup>nd</sup> edition. Springer – verlag. New York.



Since - 1947

**Objectives:**

Molecular Biology gives

- the basic idea about the central dogma of the organism
- describing mechanisms of central dogma
- involving various control factors.

**Unit – I****(8 Hrs)**

**Nucleic acids:** structure of double helix DNA. Different forms of DNA – A DNA, B DNA, Z DNA. Prokaryotic DNA replication – Semi-conservative mode of DNA replication – Meselson and Stahl's experiment. – enzymology of DNA replication.

**Unit – II****(7 Hrs)**

**Gene expression (Prokaryotes):** Transcription process – RNA polymerase - structure and function. Initiation of transcription – promoters. Elongation, termination – Rho-dependant and Rho-independent process. Post transcriptional modifications of r-RNA and t-RNA. Inhibitors of transcription.

**Unit – III****(8 Hrs)**

**Genetic code & Translation (Prokaryotes):** Features of genetic code – Translation in prokaryotes – structure of ribosomes – aminoacid activation, charging of t-RNA – Initiation of protein synthesis. Elongation and termination. Post translational modifications. Inhibitors of translation.

**Unit – IV****(7 Hrs)**

**Prokaryotic gene regulation:** Operon concept – lac operon: Positive and negative control of gene expression, trp operon– tryptophan's role in negative control, attenuator control.

**Unit – V****(7 Hrs)**

**Eukaryotic genome organization:** Interaction with histones – Exon, Intron concepts – promoters and enhancers. Mechanism of m-RNA splicing . Hormonal control of gene expression.

**Text Book:**

1. Freifelder, D and Malacinski, G M. 1996. Essential of Molecular Biology. 2<sup>nd</sup> edition Panima Publishing Co.

**REFERENCE:**

1. Lewin, B, 2000, Genes VII, Oxford University Press, Oxford, New York.
2. Weaver, R.F. 1999; Molecular Biology, WCB McGraw- Hill.
3. Lodish H, Berk A, Zipursky L, Matsudaira P, Baltimore D and Darnell J, 2000. Molecular Cell Biology, 4<sup>th</sup> Edition, WH Freeman & Co, New York.

**Objectives**

The goal of this paper is

- To introduce the main principles of bioinformatics
- To learn the databases and their location
- Significance and retrieval of databases
- Applications of databases

**Unit I****(7 Hours)**

**Introduction to Bioinformatics:** Basics of bioinformatics. Classification of biological databases. Biological data format. Applications of bioinformatics in various fields.

**Unit II****(8 Hours)**

**Introduction to databases:** Introduction to single letter code of aminoacids, symbols used in nucleotides and proteins. Data retrieval – Entrez and SRS. NCBI and PubMed.

**Unit III****(8 Hours)**

**Biological Databanks:** Biological databases – Genomic resources; DNA sequence databases. Protein data bases - Primary sequence and Secondary sequence databases.

**Unit IV****(7 Hours)**

**Specialized databases:** Structure databases; Protein structure and gene structure databases. DNA sequences. Specialized databases.

**Unit V****(7 Hours)**

**Data Retrieval Methods:** Data retrieval tools and methods. Fasta and Blast versions. cDNA libraries and EST's. Applications of data retrieval in bioinformatics.

**Text Books:**

1. Teresa. K. Attwood and David. J, Parry Smith. Introduction to Bioinformatics.
2. Shanmugavel.P. 2005. Principles of Bioinformatics. Pointer Publishers, Jaipur, India.
3. S.C. Rastogi, Namita Mendrata, Parag Rastogi. Bioinformatics – concepts, skills, Applications.
4. Mani.K & Vijayaraj. N (2002). Bioinformatics for beginners. Ist Edition. Kalaikathir Achagam, Coimbatore.

**Reference Books:**

1. Andrequas.D. Baxevanis, B.F. Francis Quелlette. Bioinformatics : A Practical guide to analysis of genes and proteins. John Wiley and Sons. New York (1998)

14MBU13

## Chemistry for Microbiology (50 Hrs) Semester III

### Objectives

- To learn the basic applications of chemistry in Industries.

### Unit I

(10 Hrs)

#### Purification and separation techniques

Concentration Terms -Mass percentage, volume percentage, normality, molarity, molality, mole fraction, and ppm.

Extraction of organic compounds- methods of purification of solids- crystallization, fractional crystallization, sublimation methods of purification of liquids- Distillation, fractional distillation, steam distillation, distillation under reduced pressure, counter current distribution.

Green chemistry – an elementary idea, green synthesis (any two example). Nano chemistry – an elementary idea.

### Unit II

#### Organic Chemistry

(10 Hrs)

Chemotherapy-introduction- -analgesics-antibiotics-tranquillizers- sulpha drugs anaesthetics-antiseptics definition, types and examples.

Vitamins-occurrence of fat and water soluble vitamins, functions and deficiency diseases, structural representations of vitamins A, D, E, K, B complex and ascorbic acid (synthesis and structural elucidation are not expected)

3D structure of molecules – conformational analysis of ethane, n-butane and cyclohexane.

### Unit III

#### Fertilizers & Insecticides

(10 Hrs)

Plant nutrients, need for fertilizers, classification of fertilizers, natural & artificial fertilizers, natural organic, natural inorganic fertilizers. Manufacture of ammonium nitrate, urea.

Phosphate fertilizers-manufacture of triple super phosphate.

Potassium fertilizers.

Insecticides- classification according to mode of action. Inorganic insecticides- Lead arsenate, calcium arsenate. Natural plant insecticides- nicotine, rotenone, allethrin.

### Unit – IV

#### Perfumes, polymers & detergents

(10 Hrs)

Perfumes and flavoring industry – composition and manufacturing process of essential oils. Isolation and production of semi synthetic chemicals. Perfume formulation(example). Natural fruit concentrate – preparation of vanilla, Cocoa and monosodium glutamate.

Polymers – nomenclature and types of polymerization. Plastics- thermoplastics and thermosetting plastics. Preparation, properties and biological applications of nitrocellulose, Teflon and poly urethane, polyethylene.

Detergents: Classification: ionic and non ionic amphoteric detergents. Manufacture of detergents. Enzymes in detergent industry.

## Unit V

(10 Hrs)

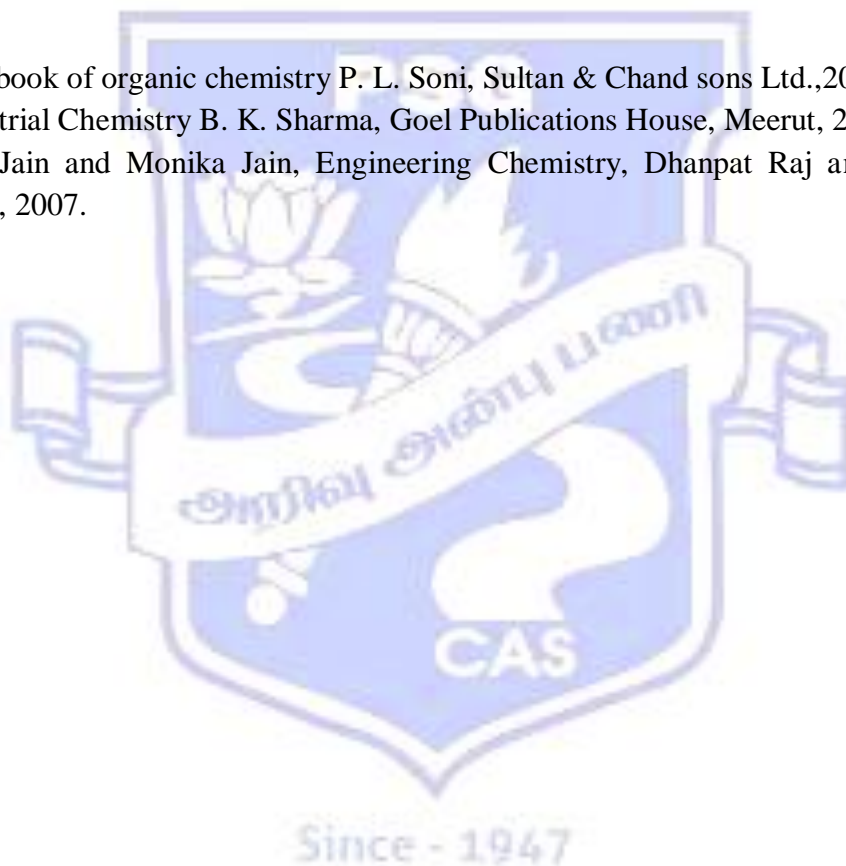
### Leather and adhesives

Leather industry – leather forms and types. Leather manufacturing process – preservation and disinfection of skins. Preparation of hides, lining, bating, tanning and finishing. Enzymes involved in leather industry. Preparation and conditioning.

Adhesives- animal glue, other protein adhesives starch adhesives, synthetic resin adhesive. Rubber based adhesives, silicate adhesives.

### References

1. Text book of organic chemistry P. L. Soni, Sultan & Chand sons Ltd.,2000.
2. Industrial Chemistry B. K. Sharma, Goel Publications House, Meerut, 2000.
3. P.C. Jain and Monika Jain, Engineering Chemistry, Dhanpat Raj and Sons, New Delhi, 2007.



**Objectives:**

Bioinstrumentation deals with

- the methods available for the separation of biomolecules
- instrumentation requirements for the same and
- their various applications.

**Unit – I****(7 Hrs)**

**Colorimetry & Spectrophotometry:** Basic principles – Beer & Lambert's law – UV – visible spectrophotometry – Instrumentation – pH meter. Biosensor – Electrochemical biosensors.

**Unit – II****(7 Hrs)**

**Principles & Instrumentation of Centrifugation:** Different types of centrifuges: Principle and mechanism of ultracentrifugation. Analytical centrifugation and Preparative centrifugation: Differential centrifugation, Density gradient centrifugation.

**Unit – III****(8 Hrs)**

**Chromatography:** Adsorption chromatography – Paper & thin layer chromatography, column chromatography. Partition chromatography: Gas – liquid chromatography – Gel permeation chromatography – Ion-Exchange chromatography – Affinity chromatography – HPLC.

**Unit – IV****(8 Hrs)**

**Electrophoresis:** Factors affecting Gel electrophoresis – Agarose gel electrophoresis – SDS polyacrylamide gel electrophoresis – Immuno electrophoresis.

**Unit – V****(7 Hrs)**

**Radioisotopes:** Radioactive decay – Geiger-Muller counter – Solid & Liquid scintillation counter – Application of radioisotopes in biology.

**Text Book:**

1. Upadyay, Biochemistry

**REFERENCES :**

1. Jayaraman, J. 1999. Laboratory manual in Biochemistry. New age International Publishers.
2. Plummer, T.D. 1988. An Introduction to Practical Biochemistry. 3<sup>rd</sup> edition. Tata McGraw- Hill Publishing Company Limited, New Delhi.
3. Wilson, K and J. Walker. 1994 : Practical Biochemistry. 4<sup>th</sup> edition, low price editions Cambridge University Press, Cambridge.

**14MBU15 SOIL AND AGRICULTURAL MICROBIOLOGY IV Semester**

**Objectives:**

Soil & Agricultural Microbiology tells about

- The distribution of the various major groups of organisms found in the soil environment.
- Positive and Negative interactions among these group of organisms.
- Agricultural importance of microorganisms and their role in mediating biogeochemical cycles.
- Microbes involved in the production of biofertilizer and insecticides.

**Unit:I (10 Hrs)**

**Population dynamics of various soil microorganisms:** Bacteria, Algae, Fungi, Actinomycetes, Protozoans in soil: Distribution and abundance- Environmental influences-function and activity, significance in soil transformations. Autochthonous, Allochthonous and Zymogenous microflora.

**Unit:II (10 Hrs)**

**Microbial associations:** Positive Interactions: Co-operation, Neutralism, Commensalism, Synergism, and Mutualism. Negative Interactions: Competition, Ammensalism, Predation, and Parasitism with suitable examples.

**Unit:III (10 Hrs)**

**Biogeochemical cycles:** Beneficial association of microorganisms in decomposition of organic matter. Mineral transformations and ecological interrelationships of microbes in mediating biogeochemical cycles: Carbon cycle- Phosphorous cycle- Sulphur cycle and Nitrogen cycle.

**Unit-IV (11 Hrs)**

**Nitrogen fixation:** Mechanism of non-symbiotic nitrogen fixation- non-symbiotic nitrogen fixers- Root nodule bacteria-nodulation process- Nif genes. *Rhizobium*, *Azotobacter* and *Azospirillum* as Biofertilizer- Blue green algae as Biofertilizer- Various methods of mass production of Biofertilizers. Advantages and disadvantages of Biofertilizer.

**Unit-V (09 Hrs)**

**Microbial insecticide:** Bacterial insecticides: Various bacteria used as insecticides. Various Protozoans and nematodes used as insecticides. Bacterial, fungal, viral biopesticides and their mass production- Advantages and disadvantages of Microbial insectides- Symbiotic association between microbes and insects.

**Text Book:**

1. Ronald M. Atlas, Richard Bartha. Microbial Ecology: Fundamentals and applications 4<sup>th</sup> Edition. Benjamin Cummings Publication.
2. Martin Alexander. 1997. Introduction to Soil Microbiology, 2<sup>nd</sup> edition. John Wiley & Sons, Newyork.
3. Mark S. Coyne. Soil Microbiology: an exploratory approach. Deimar Publishers, 2001.

## REFERENCES:

1. Subbha Rao N.S. Soil Microorganisms and Plant growth. 4<sup>th</sup> edition. Science Publishers, Incorporated, 1999.
2. Sadasivam Kannaiyan. 2002 Biotechnology of Biofertilizers. Narosa publishing house, New Delhi.
3. Subbha Rao N.S. 1993. Biofertilizers in Agriculture and Forestry. 3<sup>rd</sup> edition. Oxford and IBH publishing Co., New Delhi.
4. Subbha Rao NS. 2004. Soil Microbiology. 4<sup>th</sup> edition. Oxford and IBH publishing Co., New Delhi.
5. Mishra RR.2004. Soil Microbiology. 1<sup>st</sup> edition. CBS publishers and Distributors.
6. Rangaswami G and Bagyaraj D G. 2002. Agricultural Microbiology. 2<sup>nd</sup> edition. Prentice Hall of India, New Delhi.



**Unit I (Sections: 3.4.- 3.5)**

**Matrices:** Characteristic Equation – Eigen Values and Eigen Vectors of a Square Matrix – Cayley-Hamilton Theorem – Applications.

**Unit II (Sections 3.1 to 3.5.1)****10hrs**

**Trigonometry:** Expansions of  $\sin n\theta$ -  $\cos n\theta$ -  $\tan n\theta$  in Terms of Powers of Functions of  $\theta$  (Formation of Equations Excluded). Expansions of  $\sin^n\theta$  - $\cos^n\theta$  in Terms of Functions of Multiples of  $\theta$  – Expansions of  $\sin \theta$  and  $\cos \theta$  is a Series of Ascending Powers of  $\theta$  (Evolutions of Limits Expansions)

**Unit III(Sections 1.1 to 1.11- 2.1to 2.10)****9hrs**

**Three-Dimensional Geometry:** Co-ordinate of 3-D – Distance Between Points- Point Dividing a Line in the Ratio  $m : n$ - Centroid of a Triangle (Results of Bookwork Without Proof) Angle Between Two Straight Lines in Space – Direction Cosines – Direction Ratios – Coordinate Plane – Standard Equation – Angle Between Planes – Length of Perpendicular From a Point to the Plane – The Equation of Plane Passing Through the Line of Inter Sections of Two Given Planes.

**Unit IV (Sections 5.1 to 5.6- 6.1 to 6.4- 8.1 to 8.4)****9hrs**

Difference Table – InterSections – Newton's Forward Interpolation Formula - Newton's Backward Interpolation Formula – Construction of Polynomials - Newtons Divided Difference Formula – Lagrange 's Interpolation Formula for Unequal Intervals.

**Unit V (Sections 9.1 to 9.8- 9.10 to 9.12)****8hrs**

Numerical Differentiation: Newton's Forward and Backward Formula for the Derivatives – Newton's Divided Difference Formula to Compute the Derivatives – Numerical Integration – the Trapezoidal Rule – Simpson's 1/3 Rule.

**Text Book:**

1. S. Narayanan and T.K. Manicavachagam Pillay and others, "Ancillary Mathematics" Volume I 2012 .
2. S. Narayanan and T.K. Manicavachagam Pillay, "Trigonometry", 2007.
3. T.Natarajan and T.K. Manicavachagam Pillay, "Analytical Geometry of 3D", 2012.
4. Dr.M.K.Venkataraman, "Numerical Methods in Science and Engineering" , 2013.

**Objectives:**

Practical II includes practicals on

- understanding the Growth requirements.
  - parameters for growth and Biochemical characteristics
  - aiding identification of microorganisms by various biochemical tests.
1. Enumeration of Bacteria from soil- serial dilution and spread plate method.
  2. Enumeration of Fungi from soil- serial dilution and spread plate method.
  3. Enumeration of Actinomycetes from soil – serial dilution and spread plate method.
  4. Measurement of bacterial growth- Turbidity method.
  5. Effect of environmental factors on bacterial growth: pH
  6. Effect of environmental factors on bacterial growth: Temperature.

Physiological and biochemical characteristics of bacteria:

**Bio-oxidations :**

7. Carbohydrate fermentation
8. Mixed acid fermentation
9. Butanediol fermentation
10. Oxidase test
11. Nitrate Reduction

**Hydrolysis :**

12. Starch hydrolysis
13. Casein hydrolysis
14. Urea hydrolysis
15. Gelatin liquefaction

**Miscellaneous Tests :**

16. H<sub>2</sub>S production
17. Citrate Utilization
18. Indole production
19. TSI agar test
20. Isolation of Rhizobium from root nodules.
21. Paper Chromatography.

**Objectives:**

Fundamentals of Molecular Cloning details

- the process of recombinant DNA technology
- as isolation of the gene of interest,
- insertion of the gene into a vector,
- transformation of cells of organism to be modified and
- tests to isolate genetically modified organism.

**Unit – I****(11 Hrs)**

**Enzymes in molecular cloning:** Restriction enzymes – Types and nomenclature – classification. Restriction and modification – types of termini liberated by types II – uses of restriction enzymes. Joining of DNA molecules : DNA ligases – mechanism of action – *E.coli*, T<sub>4</sub> DNA ligase, methods of joining DNA fragments with vectors – linkers, adaptors, homopolymer tailing.

**Unit – II****(11 Hrs)**

**Vectors in Cloning:** General characteristics. Cloning and expression. Types of vectors - Plasmids,(pBR 322, pUC, Ti, Ri). Bacteriophage vectors  $\lambda$  - Cosmids, Phasmids, Phagemids, invitro packaging of bacteriophage  $\lambda$  DNA, - and M13. Expression vectors.

**Unit – III****(8 Hrs)**

**Prokaryotic hosts:** *E.coli* and *Bacillus* species. Eukaryotic hosts: Yeast-yeast vectors, shuttle vectors. Animal cells-Vectors - Baculo viral vectors and animal transfer methods. Cloning strategies – transformation techniques and transfection.

**Unit – IV****(10 Hrs)**

**Synthesis of c DNA:** Cloning c DNA in plasmid vectors. Chemical synthesis of DNA. Genomic DNA library and cDNA libraries construction – Screening of recombinants: Genetic detection, Immunological detection, DNA Hybridisation.

**Unit – V****(10 Hrs)**

**Methods for genetic engineering:** Blotting techniques – Southern, Northern and Western. Principles of DNA sequencing – Sanger's method and Maxim and Gilbert's method. PCR methods and applications.

**Text Book:**

1. Old, R.M. and S.B. Primrose. 2002. 6<sup>th</sup> Edition. Principles of Gene Manipulation. Blackwell Scientific Publication. London.

**References :**

1. Glick Pasternak. Principles of Genetic Engineering. WMC Publishers.
2. James Watson, Tania Baker, Stephen Bell, Alexander Gann, Michael Levine & Richard Losick , Molecular Biology of the Gene. 6th Edition; CSHL Press.
3. Joseph Sambrook & David Russell. 2001. Molecular Cloning: A laboratory manual, 3rd edition; CSHL press.
4. Maheshwari. D. K., R.C.Dubey, R.Saravanamuthu, 2010, Industrial Exploitation of Microorganisms, I. K. International Publishing house Pvt Ltd, New Delhi.
5. Nicholl, D.S,T., 1994: An introduction to Genetic engineering, Cambridge University Press.
6. Old, R.W., Primrose S.B., 1993. Principles of Gene Manipulation, An Introduction to Genetic Engineering, Blackwell Science Publications.
7. Satyanarayana .U, 2005, Biotechnology, 1st edition published by books and allied (p) Ltd. Kolkata.

8. Winnacker, E.C. 1987. From Genes to Clones, Introduction to Gene technology VCH, Weinheim.



Since - 1947

**Objectives:**

Immunology explains

- The working of immune system and immune molecules.
- Deals with the response of immune system to antigenic substances.
- Mechanisms of immune response and autoimmune disorders.
- Explains about hypersensitivity reactions and types of vaccines.
- Briefs about Immuno diagnosis, Cancer immunology, and Transplantation immunology.

**Unit – I****(10 Hrs)**

**Introduction and History of Immunology:** Immunity-Innate and acquired immunity. Cells and organs of Immune system – T cells, B-cells, Antigen Processing Cells, lymphocytes, macrophages, mast cells, NK cells. Immunological responses - Primary and secondary immune responses.

**Unit – II****(11 Hrs)**

**Antigens & Antibodies:** Antigens - Properties, types, antigenicity, haptens, adjuvants, Antibodies – structure, function & biological properties, type of immunoglobins- Ig G, Ig A, Ig M, Ig D, Ig E. Complement system – Classical and Alternative pathways.

**Unit – III****(10 Hrs)**

**Immunity Types & Vaccines:** Antigen presentation, Humoral and cell mediated immunity, role of Interleukins; Monoclonal antibodies – Applications of monoclonal antibodies - Vaccines: Active and Passive immunization- Designing vaccines for active immunization- Whole organism vaccines: Attenuated vaccines, Inactivated vaccines. Common immunizations – schedule.

**Unit – IV****(11 Hrs)**

**Antigen- Antibody reactions:** Precipitation reactions- Radial Immunodiffusion, Double immunodiffusion, Immunoelectrophoresis. Agglutination reactions- Hemagglutination, Bacterial agglutination, Passive agglutination. Diagnostic assay based on antigen antibody reaction: RIA, ELISA, Immunofluorescence, Complement fixation test. Applications of these methods in diagnosis of microbial pathogens.

**Unit – V****(8 Hrs)**

**Hypersensitivity reactions:** Introduction, types-Anaphylactic (Type-I), Antibody mediated cytotoxic (type-II), immune complex mediated (type-III), TDTH mediated (Type-IV). Autoimmunity: Introduction, mechanism, autoimmune diseases. Transplantation-transplantation antigens, tissue typing, Immunologic basis of graft rejection.

**Text Book:**

1. Owen, Judith A; Punt, Jenni; Stranford, Sharon A; Jones, Patricia P; Kuby, Janis. Immunology. 7<sup>th</sup> Edition. W. H Freeman & Co, Newyork.

**References :**

1. Shetty, Nandini 2005 Immunology: Introductory text book, 2<sup>nd</sup> edition. New age International limited.
2. Roitt's Essential Immunology, April, 2011. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, 12<sup>th</sup> edition, Wiley-Blackwell Publication.

3. Tizard, R.I. 1983. Immunology: An Introduction. Saunders college Publishing, Philadelphia.



Since - 1947

**Objectives:**

Medical Microbiology deals with

- The study of medical important microbes which are capable of causing diseases in human beings.
- Deals with the morphology, pathogenicity and clinical features of various bacteria, fungi, viruses and protozoans.
- Briefs on diagnosis of clinical infections and its treatment measures.
- Explains the collection and processing of various clinical specimens.

**Unit – I****(17 Hrs)**

**Bacteriology:** Morphology, pathogenicity, clinical features, laboratory diagnosis and treatment of *Staphylococcus* species, *Streptococcus* species, *Escherichia coli*, *Klebsiella* species, *Proteus* species, *Salmonella* species, *Shigella* species, *Vibrio cholera*, *Mycobacterium tuberculosis*.

**Unit – II****(10 Hrs)**

**Mycology:** Classification of Medically important Fungi, Superficial Mycoses – Dermatophytic infections: clinical features of various dermatophytic infections, Subcutaneous infection – Mycetoma. Systemic mycosis- *Histoplasma capsulatum* (histoplasmosis), *Coccidioides immitis* (coccidioidomycosis), *Blastomyces dermatitidis* (Blastomycosis), Opportunistic mycosis – Candidiasis, Cryptococcosis, Aspergillosis.

**Unit – III****(12 Hrs)**

**Viral infections:** Morphology, pathogenicity, clinical features, Laboratory diagnosis and treatment of Herpes simplex virus, Hepatitis – B, Rabies, Polio, Influenza, Measles, AIDS.

**Unit – IV****(13 Hrs)**

**Parasitology:** Morphology, life cycle, pathogenicity and laboratory diagnosis of *Entamoeba histolytica*, *Plasmodium vivax*, *Ancylostoma duodenale*, *Ascaris lumbricoides*, *Wuchereria bancrofti*.

**Unit – V****(10 Hrs)**

**Examination of Clinical Specimens:** Microbiological processing of urine, blood, faeces, cerebrospinal fluid, throat swabs, sputum, pus and wound exudates.

**Text Book:**

1. [David Greenwood](#), [Richard C.B. Slack](#), [John F. Medical Microbiology - a Guide to Microbial Infections .1992. 14<sup>th</sup> edition. Peutherer](#) SPCK Publishing.

**References:**

1. Anantha Narayanan, R and C.K. Jayaram Paniker, 2005: Textbook of Microbiology. 7<sup>th</sup> edition. Orient Longman private limited.
2. Jawetz., E., J.L. Melnie and E.A., Adelberg. 2001. Medical Microbiology. Tata McGraw publishing house, New Delhi.
3. Patric R Murray.1990. Medical Microbiology. Mosby Publications.
4. CK Jayaram Panicker. 2004. Text book of Medical Parasitology, JP brothers medical publishers, New Delhi.
5. Chakraborty, P. 1995. A textbook of Microbiology, New Central Book Agency Pvt. Ltd, Calcutta.
6. Arora Medical Parasitology. 2009. 2<sup>nd</sup> Edition. CBS Publishers and distributors.
7. Subash Chandra Parija, Text book of Medical Parasitology, protozoology and helminthology, 2<sup>nd</sup> edition. All India Publishers and Distributors.

**Objectives:**

Food Microbiology explains about

- food borne pathogens,
- fermentation,
- food quality & safety,
- food processing & packaging, Food laws, Food technology,
- product development,

**Unit – I****(10 Hrs)**

**Importance of studying food microbiology:** Food as a substrate for microorganisms – Important Microorganisms in food (mold, bacteria, yeast) - Factors affecting the growth of microorganisms in food- intrinsic & extrinsic factors.

**Unit – II****(11 Hrs)**

**Principles of food preservation:** Applications of food preservation, Asepsis, Use of Temperature-Low, High: Pasteurization & Canning, Drying. Natural and Chemical preservatives.

**Unit – III****(10 Hrs)**

**Fermented and microbial foods:** Microbial activity in foods - Fermented vegetable – Sauer Kraut - Fermented dairy product – cheese. Oriental fermented foods. Basic concept of Probiotics - characteristics and applications.

**Unit – IV****(09 Hrs)**

**Food borne infections and intoxications:** Food poisoning and food borne infections – Bacterial infections- Salmonellosis. Bacterial intoxication-Botulism. Fungal – Mycotoxicosis and Mycotoxins. Investigation of food poisoning out breaks- food standards.

**Unit – V****(10 Hrs)**

**Food and sanitation:** Sanitation in manufacture and retail trade. Food control agencies and their regulations. Hazard Analysis and Critical Control Points (HACCP), Plant sanitation – Employee health standard.

**Text Book:**

1. James M Jay. 2000. Modern food Microbiology, 6<sup>th</sup> edition, Aspen Publishers, Inc.

**References:**

2. Adams, M.R. and Moss, M.O. 2008. Food Microbiology. 3<sup>th</sup> edition, RSC Publication.

- Frazier, W.C. and West hoff. D.C. 2008. Food Microbiology. 4<sup>th</sup> edition, McGraw Hill Pvt. Ltd.



Since - 1947

**Objectives:**

Antimicrobial Chemotherapy tells about

- The concept and basics of the chemotherapeutic agents.
- The use therapeutic agents in inhibiting or killing various microbial pathogens.
- Mode of action of chemotherapeutic agents.
- Mechanism of drug resistance and control of spread of resistance.

**Unit – I****(10 Hrs)**

**Introduction of antimicrobial chemotherapy:** The development of chemotherapy – general characteristics of antimicrobial drugs – factors influencing the effectiveness of Antimicrobial drugs.

**Unit – II****(08 Hrs)**

**The use of chemical agents in control:** Mode of action and applications of Phenols, alcohols, halogens, heavy metals, Quaternary ammonium compounds, aldehydes. Phenol co-efficiency Test.

**Unit – III****(10 Hrs)**

**Mechanism of action of antimicrobial drugs:** Sulphonamides and sulfa drugs, Penicillins – Cephalosporins – Tetracyclines – Aminoglycoside antibiotics – Erythromycin- Chloramphenicol; Antifungal drugs – Antiviral drugs.

**Unit – IV****(10 Hrs)**

**Antiparasitic drugs:** Antihelminthic drugs, malarial drugs (protozoan drugs).  
**Antimicrobial susceptibility testing:** Tube and agar dilution disc diffusion tests – assay of antibiotics. Drugs for infections - Urinary infections – Respiratory tract infection, gastro intestinal infection, Bacteraemia and endocarditis, Mycobacterial disease.

**Unit – V****(12 Hrs)**

**Drug resistance:** Mechanism of drug resistance – Efflux mechanism through multi drug transporters – Enzymatic inactivation (extra and intra target modification), the origin and transmission of drug resistance. Control of the spread of resistance.

**Text Book:**

1. David Green Wood; 2007. Antimicrobial chemotherapy, 5<sup>th</sup> edition, Oxford University Press.

**References:**

1. Jawetz., E., J.L. Melnie and E.A., Adelberg. 2001. Medical Microbiology. Tata McGraw publishing house, New Delhi.
2. Robert Crushauk Vol I and II, 1975, Medical Microbiology, ELBS Chrchuil Livingston.

## Core Elective I

### 14MBU22B PRINCIPLES OF GOOD LABORATORY PRACTICES V Semester

#### Objectives:

The paper gives emphasis on

- Microbiological Quality control
- Internal quality control in laboratory
- External quality assessment
- Retrospective quality control

#### Unit – I (5 Hrs)

**Quality Control-** Internal and external Assessment, Quality improvement, Total Quality Control Programme. Quality Assurance – Attributes, Immunization programme.

#### Unit – II (5 Hrs)

**Internal Quality Control-** Clinical Microbiology Laboratories- Standard operating procedure manuals, Specimens- Equipments – Biosafety cabinets, Media, Tests\_ Biochemical, Staining, Antimicrobial Susceptibility, Serological Biological Production units.

#### Unit – III (5 Hrs)

**External Quality Assessment-** EQA-Types-Requirement of EQA programme. Organization of EQA, Scoring System in EQA, National External Quality Control assessment.

#### Unit – IV (5 Hrs)

**Good manufacturing practices – Quality Control-** Factors influencing GMP- Production and documentation- Principles of production and quality control of biologicals

#### Unit – V (5 Hrs)

**Quality Control-Analytical Validation.** Overview of Quality Assurance-Objectives & Components, Need for Quality Assurance & its benefits. Quality Management-Quality System, Quality plan.

#### References:

1. Rajesh Bhatia, Rattan Lal IchhPujani-Quality Assurance in Microbiology-CBS Publishers & Distributors-New Delhi-First Edition-1995
2. NCCLS Manual of SPM
3. Salle Microbiology

**Objectives:**

Recombinant DNA Technology deals with

- plant and animal transgenesis,
- gene therapy, and recombinant vaccines,
- GM products, GMO,
- therapeutic and diagnostic applications.

**Unit – I****(10 Hrs)**

**Plant biotechnology:** PTC – Methods and applications - Agrobacterium and plant genetic engineering – Agrobacterium mediated gene transfer and cloning - Types of plant vectors, Ti and Ri plasmids and their use in gene manipulation – Development of transgenic plant – Insect resistance (Bt and Non Bt) – Herbicide resistance, stress and senescence tolerance in plants – Biotic and Abiotic factors.

**Unit – II****(10 Hrs)**

**Animal Biotechnology:** Animal cell culture – Methods and Applications - Development of transgenic animals – methods – retroviral vector method – DNA microinjection, ES cell method – Transgenic animals – Mice, cattle, sheep, goat, pig, birds, fishes.

**Unit – III****(11 Hrs)**

**Applications of RDT in Medicine:** Production of hormone- insulin, HGH, tp A, interferon, subunit vaccines - Protein engineering - Drug design.

**IPR and bio-safety:** IPR – Copyright – Trademark – Patents – Patenting of biotechnology discoveries – Bio-ethics.

**Unit – IV****(07 Hrs)**

**Diagnostics of genetically related diseases:** Pedigree analysis – RFLP, ASO test, PCR/OLA, exon deletion analysis. Immuno scintigraphy – ISH – FISH. DNA Microarray – applications. DNA chips.

**Unit – V****(12 Hrs)**

**Techniques in biotechnology:** Development of Biotechnology in 20<sup>th</sup> century  
Therapeutics: Engineering Monoclonal antibodies – Applications, vaccines, gene therapy- Exvivo and Invivo gene therapy.

**Text Book:**

1. Satyanarayana. Biotechnology, Books and Allied Publications

**References:**

1. Glick Pasternak. Principles of Genetic Engineering. WMC Publishers.
2. James Watson, Tania Baker, Stephen Bell, Alexander Gann, Michael Levine & Richard Losick , Molecular Biology of the Gene. 6th Edition; CSHL Press.  
Joseph Sambrook & David Russell. 2001. Molecular Cloning: A laboratory manual, 3rd edition; CSHL press.
3. Maheshwari. D. K., R.C.Dubey, R.Saravanamuthu, 2010, Industrial Exploitation of Microorganisms, I. K. International Publishing house Pvt Ltd, New Delhi.
4. Old, R.W., Primrose S.B., 1993. Principles of Gene Manipulation, An Introduction to Genetic Engineering, Blackwell Science Publications.
5. Satyanarayana .U, 2005, Biotechnology, 1st edition published by books and allied (p) Ltd. Kolkata.

**Objectives:**

Industrial Microbiology explains

- the commercial applications of the industrially important organisms in fermentations and other process of product extraction,
- scale up of industrial process,
- downstream processing,
- engineering for strain development and kinetics etc.

**Unit – I****(11 Hrs)**

**An introduction to fermentation processes:** the range of fermentation process.

Industrially important microorganisms- isolation: primary and secondary techniques, preservation and improvement of strains- feedback inhibition & repression, auxotrophic mutants.

**Unit – II****(13 Hrs)**

**Fermentor:** Design of a general fermentor, Aseptic operation & containment, body construction- the agitator & the aeration system. Principles and types of fermentors: Tower fermentor, airlift fermentor and membrane bioreactor.

**Unit – III****(12 Hrs)**

**Upstream processing:** media in industrial fermentation – growth & production media, media formulation & sterilization. The development of inoculum for various fermentation processes- yeast, bacterial & mycelia. Mechanism of stirring & mixing- Reynold's & Fraude's number, power number, turbulent & laminar flow. Newtonian and Non Newtonian fluids.

**Unit – IV****(12 Hrs)**

**Down stream processing:** Extraction and purification of intracellular and extracellular products– cell disruption methods: physical, chemical & biological. Rotary Drum Filters. liquid-liquid extraction- low and high molecular weight products.

**Unit – V****( 13 Hrs)**

**Microbial Production of commercial products:** Solid state fermentation & submerged state fermentation. Production of organic acids – Citric acid, Lactic acid. Amino acids – Glutamic acid, Aspartic acid. Antibiotics : Penicillin, cephalosporins. Alcoholic beverages - Wine and beer production.

**Text Book:**

1. Patel, A.H. 1996. Industrial Microbiology. Macmillan India Ltd.,

**References:**

1. Casida, J.E. 1968. Industrial Microbiology. Wiley Eastern.
2. Stanbury, P.F., Whitaker, A and Hall, S.J. 1995. Principles of Fermentation Technology. 2<sup>nd</sup> edition, Butterworth Heinemann Ltd.
3. Cruegar W and Cruegar A, 2003. Biotechnology: A text book of Industrial Microbiology. 2<sup>nd</sup> edition, Panima Publications.

4. Ratledge C and Kristiansen B, 2003. Basic Biotechnology. 3<sup>rd</sup> edition, Cambridge University press.



Since - 1947

**Objectives:**

Microbial Ecology deals with

- The study of the function and diversity of microbes in their natural environments, environmental aspects of microbial interactions.
- Biodegradation of dyes and pesticides, waste water treatment, solid waste disposal, bioleaching, bioremediation of heavy metals etc.
- Characterisation of key bacterial habitats such as the Rhizosphere, Spermosphere and phyllosphere, soil and groundwater ecosystems and open oceans.

**Unit – I****(09 Hrs)**

**Concepts of microbial ecology:** Microbial community - food chain: Aquatic, terrestrial and detritus food chain, food web, ecological pyramids, community succession, Darwin's theory of natural selection and species diversity.

**Unit – II****(10 Hrs)**

**Waste water Management:** Microorganisms in freshwater, marine and sewage environments. waste water recycling: Primary, secondary and tertiary treatment- activated sludge system, Trickling filter. Solid waste recycling: Composting, sludge disposal.

**Unit – III****(11 Hrs)**

**Pollution and Bioremediation:** Environmental impact of dyes: Sources, treatment: Physical, Chemical and Biological treatment of dyes. Heavy metals: Sources of heavy metals and its impact on human beings. Detoxification Strategies: biosorption of heavy metals mediated by microbes. Biodeterioration of Leather, Paper and Textiles.

**Unit – IV****(10 Hrs)**

**Microbial interactions with plant and soil:** Rhizosphere concept, Rhizoplane, Phyllosphere, Spermosphere, Mycorrhizae: Ecto, endo and VAM micorrhizal associations.

**Microbial diseases in plants:** Bacterial blight disease of paddy, wilt diseases in pulses (Red gram) -Soft rot disease of carrots, Rust disease of castor, Smut disease of sugarcane.

**Unit – V****(10 Hrs)**

**Microbial ecology of potable water and Biofuels:** Water borne pathogens. Environmental quality control-Indicator organisms, BOD, COD, pesticide degradation, Bioleaching, Biofuels from agricultural wastes: Production- Advantages.

**Text Book:**

1. Ronald M. Atlas, Richard Bartha. Microbial Ecology: Fundamentals and applications 4<sup>th</sup> Edition. Benjamin Cummings Publication.

**References:**

2. Campbell, R. 1983. Microbial ecology. 2<sup>nd</sup> edition. Blackwell Scientific Publications London.
3. Martin Alexander. 1997. Introduction to Soil Microbiology, 2<sup>nd</sup> edition. John Wiley & Sons, Newyork.
4. Vijaya Ramesh K (2004) Environmental Microbiology. 1<sup>st</sup> edition. MJP Publishers. Chennai.
5. Joseph C Daniel.1999. Environment Aspects of Microbiology. 1<sup>st</sup> edition. Bright sun Publications, Chennai.



**Objectives:**

Virology sticks itself to

- the specification of virus & its structure, characteristics & cultivation of viruses,
- reproduction types observed.
- bacteriophages and their life cycle.
- animal and plant viral infections and their characteristics.

**Unit – I****(7 Hrs)**

**Viruses - Introduction and general characteristics:** Early development of virology, General properties of Viruses – Structure of viruses – helical capsids, icosahedral capsids- nucleic acids – Viral envelopes and enzymes.

**Unit – II****(7 Hrs)**

**Cultivation of viruses:** Virus cultivation in embryonated eggs, experimental animals and cell cultures- primary and secondary cell cultures. Viral purification- differential and density gradient centrifugation, precipitation of viruses, denaturation of contaminants and Enzymatic digestion of cell constituents. Viral assays- Hemagglutination assay, Plague assay.

**Unit – III****(8 Hrs)**

**Bacteriophages:** Reproduction of lytic phages: ds DNA phage – T4 phage. The lytic cycle- one step growth curve experiment – adsorption, penetration – synthesis of phage, assembly of phage particles – release of phage particles. Example of ss DNA phage –  $\phi$ X174 – rolling circle replication. Lysogeny – Temperate bacteriophage-  $\lambda$  phage life cycle.

**Unit – IV****(8 Hrs)**

**Viruses of Eukaryotes - Animal viruses:** Reproduction of animal viruses – adsorption of virion, penetration and uncoating replication and transcription in DNA viruses. Replication and transcription in RNA viruses – synthesis and assembly of virus capsids – virion release – Cytocidal infections and cell damage. Oncogenic viruses.

**Unit – V****(7 Hrs)**

**Viruses of Eukaryotes- Plant viruses:** Virion morphology, plant virus reproduction – transmission of plant viruses – Viruses of Fungi and Algae – insect viruses- viroids and Prions.

**Text Book:**

1. Prescott L.M ; J.P Heavy and D.A. Klein 1993 Microbiology 7<sup>th</sup> edition Wm C- Brown Publishers.

**References:**

1. Luria, S.E., J.E. Darnell., D. Baltimore and A. Campbell 1978, General Virology 3<sup>rd</sup> edition, New York Wiley and Sons.
2. David Friefelder, Molecular Biology, Narosa Publications House. 1999.
3. Saravanan, Virology,
4. Jay A. Levy, Heinz Fraenkel – Conrat, Oliver S. Owens, Virology. 3<sup>rd</sup> Edition.

**Objectives :**

Biostatistics paper deals with

- Data collection methods and presentation,
- Measures and statistical calculations as central tendency, dispersion,
- Correlation and Regression analysis,
- Testing of hypothesis, and
- Research methodology

**Unit I:****(7 Hrs)**

**Statistical tools :** Definitions-Scope of Biostatistics, statistical methods- kinds of biological data- functions and limitations. - collection, classification and tabulation of data- graphical and diagrammatic representation- scale diagrams- Histogram- frequency Polygon- frequency curves.

**Unit II:****(8 Hrs)**

**Descriptive statistics:** Measures of central tendency- Arithmetic mean, median, mode. Measures of dispersion- standard deviation.

**Unit III:****(7 Hrs)**

**Correlation analysis:** types – Estimation of Correlation- Karl Pearson's method only- Regression- Simple, Linear Regression.

**Unit IV:****(7 Hrs)**

**Testing of Significance:** Hypothesis Testing- Level of Significance- Student 't' Test, 'chi' square test.

**Unit V:****(7 Hrs)**

**Research problem selection and project design:** Review of Literature- Sources of collection- Processing of data- Presentation of data- Graphs and significant figures- Errors- Editing the final draft, Structure of Research Project.

**Text Book:**

Gupta SP 1986 – Statistical methods, Sultan Chand and sons  
 Kothari Research Methodology

**Reference:**

1. Bernard Rosner, 1999, Fundamentals of Biostatistics ,Duxbury Press
2. Beth Dawson Robert G. Trapp Beth Dawson Robert Trapp, 2004. Basic and Clinical Biostatistics (LANGE Basic Science), McGraw-Hill.
3. Harvey Motulsky, 1995, Intuitive Biostatistics, Oxford University Press.
4. Jeffrey A. Witmer Myra L. Samuels, 2002. Prentice Hall Statistics for the Life Sciences (3rd Edition)
5. Marcello Pagano Kimberlee Gauvreau, 2000. Principles of Biostatistics , 2nd Edition, Brooks Cole
6. Nallasivam. V. 1999. Biostatistics.
7. Stanton A. Glantz, 2001. Primer of Biostatistics McGraw-Hill
8. Wayne W. Daniel, 2006. Biostatistics- A foundation for analysis in the Health Sciences. 7<sup>th</sup> edition. Wiley India publication.
9. Palanichamy S and Manoharan M 1994 – Statistical methods for Biologists- Palani Paramount Publications.
10. Sadasivam Statistical Methods. New Age Publishers
11. Nallasivam V 1999 – Biostatistics.

**14MBU28B  
Laboratories**

**Core Elective II  
Quality control in Clinical and Industrial Microbiology  
Semester VI**

**Objectives:**

The paper gives emphasis on

- Quality control of laboratory materials & specimens
- Quality control of media and stains
- Quality in clinical analysis
- Quality control in Vaccines

**Unit – I**

**(5 Hrs)**

**Quality control of laboratory materials and specimens-** Preservation of stock cultures- bacteria, fungi, mycoplasma, animal parasites.

**Unit – II**

**(5 Hrs)**

**Quality Control of media and stains,** performance of plated media- Quality in antimicrobial susceptibility testing, Quality control in parasitology.

**Unit – III**

**(5 Hrs)**

**Quality in clinical Analysis -** Errors in Analysis- Sources, monitoring and evaluating, Tests and use of Test result. Laboratory audit.

**Unit – IV**

**(5 Hrs)**

**Food Quality-** Sanitation in manufacture and trade. Food quality control agencies and their regulation. Hazard analysis and critical control points(HACCP), Plant sanitation- Employee health standard, waste treatment

**Unit – V**

**(5 Hrs)**

**Vaccine – clinical Trials-** phases of clinical trials, adverse and abnormal reactions to vaccines. Contraindications of vaccinations- precautions for all vaccines.

**References:**

Rajesh Bhatia, Rattan Lal IchhPujani-Quality Assurance in Microbiology-CBS Publishers & Distributors-New Delhi-First Edition-1995.

NCCLS Manual of SOP

Salle Microbiology

**Objectives:**

Practical III includes

- Identification of Medically important pathogens.
- Identification of microbes from spoiled food, Water and milk quality analysis.
- Antigen, antibody reactions.
- Checking the efficiency of disinfectants.
- Mushroom cultivation.
- Molecular, virology and Genetic experiments.

**Medical Microbiology**

1. Processing of clinical samples.
2. Bacterial identification: *Staphylococcus sp.*,
3. *Streptococcus sp.*,
4. *Escherichia coli*
5. *Klebsiella sp.*,
6. *Proteus sp.*,
7. *Salmonella sp.*,
8. *Shigella sp.*,
9. *Pseudomonas sp.*,
10. i) Tuberculosis (PSGIM)  
ii) *Vibrio Cholera* (PSGIM)  
iii) Processing of Clinical Specimens – Urine, stool, blood, sputum, pus, throat swab etc (PSGIM)  
iv) Study of parasites (PSGIM)
11. Fungus identification – Microscopic - L.F mount – *Aspergillus sp.*, *Penicillium sp.*,
12. Drug susceptibility testing – Kirby-Bauer method.

Note: Experiments demonstrated at PSGIM: Identification of *Mycobacterium tuberculosis*, *Vibrio cholera*, Stool Examination, Study of Parasites, Processing of clinical Specimens.

**Immunology**

Antigen – antibody reactions:

13. Precipitation method – Immuno diffusion.
14. Agglutination method: Blood Grouping
15. Serological tests: WIDAL test, RPR test.

**Environmental Microbiology**

16. Water analysis: MPN techniques

**Food Microbiology**

17. Dye reduction test - MBRT
18. Microbes associated with spoilage of tomatoes, pickles, Idly dough.
19. Mushroom cultivation

**Antimicrobial Chemotherapy**

20. Phenol co-efficient test

**Biotechnology**

21. UV mutagenesis
22. Immobilization technique

**Molecular Methods**

23. Extraction of nucleic acids. – Agarose gel electrophoresis
24. Pigment extraction.

**Virology**

25. Demonstration of Plaque formation

## Objectives:

Microbes In Daily Life deals with

- what microbes are, their characteristic feature & role in food spoilage.
- food safety, use of microbes as food,
- microbial pathogenicity and identification.
- vaccines and chemotherapeutic agents

**Unit – I****(7 Hrs)**

**Fermented foods and role of microbes in waste recycling:** Fermented foods – Dairy products - Cheese, Fermented vegetables - Sauer Kraut, Single Cell Protein. Role of microorganisms in biodegradation of solid waste - composting, Production of bio-fuel.

**Unit – II****(7 Hrs)**

**Clinical and Antimicrobial chemotherapy:** Normal flora microorganisms and their significance in health - Microbial pathogens: Contagious disease - AIDS, Nosocomial infections. Mode of action of antibiotics – Penicillin, Cephalosporin, Streptomycin, Chemical agents – Sulfonamides & Sulfa drugs.

**Unit – III****(6 Hrs)**

**Vaccines:** Definition, Types of vaccine-Whole microbial vaccines – Live and Attenuated vaccines, -Heat killed vaccines- Bacterial vaccines, viral vaccines, DNA vaccines, Vaccination schedule.

**Text Book:**

Frazier W.C and Westhoff D.C 1989 Food Microbiology. 8<sup>th</sup> Edition. Tata McGraw Hill LTD. New Delhi.

**References:**

Jeffrey C.Pommerville, Alcamo's Fundamentals of Microbiology, 8<sup>th</sup> edition. Blackwell Publications.

Prescott L.M ; J.P Heavy and D.A. Klein 1993 Microbiology 7<sup>th</sup> edition Wm C- Brown Publishers.

Ronald M. Atlas, Richard Bartha. Microbial Ecology: Fundamentals and applications 4<sup>th</sup> Edition. Benjamin Cummings Publication.