



**CIRCULAR NO.SU/Sci./M.Sc.Micro./58/2021**

It is hereby inform to all concerned that, the syllabus prepared by the Board of Studies in Mathematics and recommended by the Dean, Faculty of Science & Technology the Hon'ble Vice-Chancellor has accepted the **Syllabus of M.Sc. Microbiology Ist to IVth semester for affiliated Colleges and University Department** in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith.

This shall be effective from the Academic Year 2021-22 and onwards.

All concerned are requested to note the contents of this circular and bring notice to the students, teachers and staff for their information and necessary action.

University Campus,  
Aurangabad-431 004.

REF.No. SU/SCI/2021/4174-83

Date:- 29-11-2021.

*Deputy Registrar,  
Academic Section.*

**Copy forwarded with compliments to :-**

- 1] **The Principal of all concerned Colleges,**  
Dr. Babasaheb Ambedkar Marathwada University,
- 2] **Head of the Department, Department of Microbiology,**  
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad.
- 3] **The Director, University Network & Information Centre, UNIC,**  
**with a request to upload this Circular on University Website.**

**Copy to :-**

- 1] The Director, Board of Examinations & Evaluation, Dr. BAMU, A'bad.
- 2] The Section Officer, [M.Sc. Unit] Examination Branch, Dr. BAMU, A'bad.
- 3] The Programmer [Computer Unit-1] Examinations, Dr. BAMU, A'bad.
- 4] The Programmer [Computer Unit-2] Examinations, Dr. BAMU, A'bad.
- 5] The In-charge, [E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr. BAMU, A'bad.
- 6] The Public Relation Officer, Dr. BAMU, A'bad.
- 7] The Record Keeper, Dr. BAMU, A'bad.

**DR. BABASAHEB AMBEDKAR  
MARATHWADA UNIVERSITY,  
AURANGABAD.**



**Curriculum under Choice Based Credit &  
Grading System**

**M.Sc.I & II Year Microbiology**

**Semester-I to IV**

**Run at college level from the  
Academic Year 2021-22 & onwards**

*[Signature]*  
26/11/21  
Dean  
Faculty of Science & Technology  
Dr. Babasaheb Ambedkar Marathwada  
University, Aurangabad

*[Signature]*  
Dr. Hamdi U.S.  
Bos Microbiology

**DR. BABASHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD**

**M.Sc. MICROBIOLOGY REVISED SYLLABUS**

**(CBCS System)**

**(Effective from June 2021 Phase wise)**

**REVISED SYLLABUS AT A GLANCE COURSE STRUCTURE**

**M.Sc.(MICROBIOLOGY)**

Paper No.	Title of the theory Paper	Marks/Credits	Practical	Marks/Credits
<b>Semester I</b>				
Th-I	Biostatistics Computer Applications and Research Methodology	100/04	P-I	50/02
Th-II	Bioenergetics and Enzymology	100/04	P-II	50/02
Th-III	Bioinstrumentation Techniques and Applications	100/04	P-III	50/02
Th-IV	Industrial Food and Dairy Microbiology	100/04	P-IV	50/02
<b>Semester II</b>				
Th-V	Recent Trends in Virology.	100/04	P-V	50/02
Th-VI	Molecular Immunology.	100/04	P-VI	50/02
Th-VII	Microbial Physiology.	100/04	P-VII	50/02
Th-VIII	Microbial Diversity and Extremophiles	100/04	P-VIII	50/02
<b>Semester III</b>				
Th-IX	Enzyme Technology	100/04	P-IX	50/02
Th-X	Bioprocess Engineering and Technology.	100/04	P-X	50/02
Th-XI	Molecular Microbial Genetics.	100/04	P-XI	50/02
Th-XII	Environmental Microbial Technology	100/04	P-XII	50/02
<b>Semester IV</b>				
Th-XIII	Recombinant DNA Technology	100/04	P-XIII	50/02
Th-XIV	Fermentation Technology	100/04	P-XIV	50/02
Th-XV	Bioinformatics, Microbial Genomics and Proteomics.	100/04	P-XV	50/02
Th-XVI	Pharmaceutical Microbiology	100/04	P-XVI	50/02

\*Semester IV Practical(P-XV and XVI) or a research project of 100 marks.



# M.Sc. MICROBIOLOGY SYLLABUS

M.Sc. Microbiology Course of two years is divided into four semesters. Each semester is of 600marks.

Each semester (I, II, III) will have four (04) theory papers each of 100 marks and four practical papers each of 50 marks.

Last semester will have four (04) theory papers each of 100 marks/04 Credits and four practical papers each of 50 marks/02 Credits. In the last semester instead of two practical papers research project of 100 marks/02 Credits will be assigned between three students.

## Semester I

Paper-Th-I- Biostatistics Computer Applications and Research Methodology (04 Credits)  
Paper-Th-II-Bioenergetics and Enzymology (04 Credits)

Paper-Th-III- Bioinstrumentation Techniques and Applications (04 Credits)  
Paper-Th-IV-Industrial Food and Dairy Microbiology (04 Credits)

Practical papers P-I to P-IV based on four theory papers. (02X4=08 Credits)

-----Total 16 Theory + 08 Practical = 24 Credits/Semester

## Semester II

Paper-Th-V- Recent Trends in Virology (04 Credits)  
Paper-Th-VI-Molecular Immunology (04 Credits)

Paper-Th-VII- Microbial physiology (04 Credits)

Paper-Th-VIII-Microbial Diversity and Extremophiles (04 Credits)

Practical papers P-V to P-VIII based on four theory papers. (02X4= 08 Credits)

-----Total 16 Theory + 08 Practical = 24 Credits/Semester

## Semester III

Paper-Th-IX-Enzyme Technology (04 Credits)

Paper-Th-X- Bioprocess Engineering and Technology (04 Credits)

Paper-Th-XI-Molecular Microbial Genetics (04 Credits)

Paper-Th-XII-Environmental Microbial Technology (04 Credits)

Practical papers P-IX to P-XII based on four theory papers. (02X4=08 Credits)

**SemesterIV**

Paper-Th-XIII- Recombinant DNA Technology (04  
Credits)Paper-Th-XIV-FermentationTechnology (04  
Credits)

Paper-Th-XV-Bioinformatics, Microbial Genomics and Proteomics (04 Credits) Paper-  
Th-XVI-Pharmaceutical Microbiology (04 Credits)

Practical papers P-XIII to P-XVI based on four theory papers or a research project of 50 marks each. (02 X 4 =  
08 Credits)

-----Total 16 Theory + 08 Practical = 24 Credits / Semester

-----Overall 24 X 04 = 96 Credits

**INFRASTRUCTURE, INSTRUMENTAL LIBRARY & OTHER  
FACILITIES REQUIRED FOR M. Sc. COURSE IN MICROBIOLOGY (for  
25 Students INTAKE CAPACITY).**

1. Two laboratories (for Part I and Part II) each measuring at least 1000 Sq. Ft. With sufficient no. of tables and Stools. Lab should be provided with basic Instruments such as autoclave, incubator, oven, pH meter, hot plate, cyclo mixers, water bath shakers, colorimeter, fridge, distillation plant etc.
2. A culture room with a laminar airflow measuring 300 Sq. Ft.
3. An Instrumentation Room with Double door, Air Conditioner, and inverter, power generator for sophisticated Instruments measuring 500 Sq. Ft.
4. Two Lecture halls (for Part I and Part II) with Overhead projector facility and measuring 400 Sq. Ft. with tables and chairs.
5. A media preparation and storage room at least 400 Sq. Ft.
6. A computer in Bioinformatics Laboratory with 4 – 5 computers (P – IV) with printer and internet facility.

  
26/11/21  
Dean  
Faculty of Science & Technology  
Dr. Babasaheb Ambedkar Marathwada  
University, Aurangabad



14. S-[F]NPW-02June-2015-16AllSyllabusScienceDept.College M.Sc.Microbiology-6-  
**LISTOFBASICINSTRUMENTSREQUIREDFORM.Sc.PRACTICALS**

1. LaminarAir Flow.
2. CompoundMicroscope
3. Autoclave
4. Incubators
5. HotAirOven.
6. BODIncubators
7. pHMeter
8. WaterBathIncubatorShaker
9. Colorimeter
10. Spectrophotometer
11. HotPlate.
12. Cyclomixer.
13. ElectrophoreticApparatus
14. OrbitalIncubatorShaker
15. HighSpeedCentrifuge-(10000RPM)
16. DistillationApparatus(Single&Double)
17. Refrigerators
18. PaperChromatography Cabinet
19. RoughBalances
20. BacterialFilterAssembly
21. GeneralPurposeCentrifuge.
22. VortexMixers
23. MagneticStirrers
24. UVCabinet
25. TLCApparatus
26. DissolvedOxygenMeter
27. MetlerBalances
28. DigitalBalances
29. WaterBathShakers
30. Colony Counter
31. RotaryShaker
32. ColumnsforChromatography

14. S-[F]NPW-02June-2015-16AllSyllabusScienceDept.College M.Sc.Microbiology-7-
33. FractionCollector
  34. GasBurners
  35. LPGCylinders
  36. DistillationApparatus.

#### **LIST OF SOPHISTICATED INSTRUMENTS REQUIRED FOR PRACTICAL**

1. UV-Vis Spectrophotometer.
2. Gas Chromatography
3. Sonicator
4. High Speed Refrigerated Centrifuge
5. Microprocessor based pH Analyser
6. Horizontal Paper Electrophoresis Unit
7. Vertical Electrophoresis Unit
8. Submarine Electrophoresis Unit
9. Immuno Electrophoresis Apparatus
10. Power Pack With Constant Voltage or Current Adjustment
11. PAGE Electrophoresis Unit
12. DNA Sequencer
13. ELISA Reader
14. PCR (Thermal Cycler)
15. Gel Documentation Unit
16. Semi Dry Transfer Apparatus
17. Deep Freezer ( $-30^{\circ}\text{C}$ )
18. Fermenter
19. Atomic Absorption Spectrophotometer
20. COD & BOD Analyser
21. Phase Contrast Microscope
22. Binocular Microscope
23. HPLC
24. Lyophilizer
25. Pentium IV Computer With Printer
26. Micropipette
27.  $\text{CO}_2$  Incubator



### **OTHER REQUIREMENTS**

The department should have required chemicals, DEHYDRATED MEDIA, STAINS, ACIDS, SOLVENTS, FINE CHEMICALS, ENZYMES, ANTI SERA IMMUNODIAGNOSTIC KITS, and SPECIFIC MICROBIAL CULTURES WITH KNOWN GENETIC MARKERS AND GLASSWARES to conduct the prescribed syllabus. Cold room facility is preferred.

### **LIBRARY FACILITY**

The library should have ample no of prescribed text books, reference books recommended in the prescribed syllabus and the library should also subscribe National and International and Scientific Magazines.

### **INSTRUCTIONS:**

1. M.Sc. Course of Microbiology is divided into four semesters.
2. Each Semester will have four theory papers and four practical papers, except in the IV semester, either there will be four practical papers or two practical papers and a research project equivalent to two practical papers i.e. for 50 marks. The decision to have practical or research project will be the discretion of the department and will depend upon the availability of chemicals, instruments, lab space, budget and other facilities, etc.
3. The department should complete a minimum of six practicals of each paper.
4. The workload of research project will be equivalent to the workload of 2 practical papers.
5. One theory paper will have 4 lectures each of 60 min. Duration per week and practical will have 6 hrs. duration.
6. There should be regular seminars and tutorialson emerging topics of subject concerned for



14.S-[F]NPW-02June-2015-16AllSyllabusScienceDept.College M.Sc.Microbiology-9-  
students.

7. It is mandatory for students to have not less than 75% of attendance in each semester.
8. Department should organise lectures of subject experts and should also arrange study tours to industries and National research institutes.


**Dr. BABASAHEB AMBEDKAR**  
**MARATHWADA UNIVERSITY,**  
**AURANGABAD.**

REVISED SYLLABUS OF

M.

Sc.(MICROBIOLOG  
Y) SEMESTER-I

Paper No.	Title of the theory paper	Marks/Credits	Practical	Marks/Credits
Semester I				
Th-I	Biostatistics Computer Applications and Research Methodology	100/04	P-I	50/02
Th-II	Bioenergetics and Enzymology	100/04	P-II	50/02
Th-III	Bioinstrumentation Techniques and Applications	100/04	P-III	50/02
Th-IV	Industrial Food and Dairy Microbiology	100/04	P-IV	50/02

  
26/11/21

## **SEMESTER I**

### **PAPER TH-I**

#### **BIOSTATISTICS, COMPUTER APPLICATIONS AND RESEARCH METHODOLOGY**

**Marks 100/ Credits 04**

#### **Unit –I Introduction to Biostatistics (0.8 Credits)**

Basic definitions of terms in Biostatistics and applications of biostatistics in different fields.  
Sampling: Basic definition of sample and Population. Representative sample, sample size, types of sampling with examples.

Data collection and presentation: Types of data, methods of collection of primary and secondary data, methods of data presentation, graphical representation by histogram, polygon, ogive curves and pie diagram with definition and examples of each.

#### **Unit –II Measures of central tendency (0.8 Credits)**

Definition and calculation with examples of Mean, Median, Mode. Merits and Demerits.  
Measures of variability: Standard deviation, standard error, range, mean deviation and coefficient of variation definition and calculations with examples.

Correlation and regression: Positive and negative correlation and calculation of Karl-Pearsons coefficient of correlation.

Linear regression and regression equation and multiple linear regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation.

#### **Unit – III Tests of significance (0.8 Credits)**

Tests of significance : Small sample test (Chi-square t test, F test), large sample test (Z test ) and standard error.

Introduction to probability theory and distributions, (concept without deviation), Theorems and rules of Probability with One example of each rule. Binomial, poisson and normal (only definitions and

problems)

#### **Unit- IV Introduction to computers and computer applications (0.8 Credits)**

Introduction to computers: Computer application, basics, organization, PC, mainframes and Super-computers, concept of hardware and software, Input and Output devices ,concept of file, folders and directories, commonly used commands, flow charts and programming techniques. Operating systems and its types. Introduction to MS Office software - Word processing, spreadsheets and presentation software. Introduction to internet- Basic definitions and concepts. LAN, VAN,MAN concepts. Introduction to scientific search Engines. Introduction and use of Medline and Pubmed for accessing biological information.

#### **Unit - V Research Methodology (0.8 Credits)**

Introduction to Research Methodology: Meaning of Research, Objectives of Research, Motivations in Research, types of Research, Research Approaches, Significance of Research, Research Methods v/s Methodology, Research and Scientific Methods, Research Process, Criteria of Good Research. Defining the Research Problem: Concept and need, Identification of Research problem, defining and delimiting Research problem.

Different research schemes (minor and major), preparation of research scheme proposals, formats, funding agencies, scientific writing: research article, dissertation, review, abstract, synopsis, technical report.

Literature search, analysis of scientific report, compilation of data, presentation of experimental data, tabulation, graph, diagrams, histograms, interpretation of tables, graphs, photographs, and diagrams.

### **PRACTICAL**

#### **PAPER P-I**

#### **BIOSTATISTICS, COMPUTER APPLICATIONS AND RESEARCH METHODOLOGY**

**Marks: 50/ (02 Credits)**



1. Representation of Statistical data by
  - a) Histograms b) Ogive Curves c) Pie diagrams
2. Determination of Statistical averages/ central tendencies. a) Arithmetic mean b) Median c) Mode
3. Determination of measures of Dispersion
  - a) Mean deviation
  - b) Standard deviation and coefficient of variation
4. Tests of Significance-Application of following a) Chi-Square test b) t- test c) Standard error
5. Computer operations-getting acquainted with different parts of Computers.
6. Creating files, folders and directories.
7. Applications of computers in biology using MS-Office.
  - A] MS-Word B] Excel C] Power Point
8. Creating an e-mail account, sending and receiving mails.
9. An introduction to INTERNET, search engines, websites, browsing and Downloading.
10. Searching research articles in Medline and Pubmed.
11. Writing of abstracts, synopsis, research paper.
12. oral presentation of research article.

## REFERENCES

1. Statistics in biology, Vol. 1 by Bliss, C.I.K. (1967) Mc Graw Hill, NewYork.
2. Practical Statistics for experimental biologist by Wardlaw, A.C. (1985).
3. How Computers work - 2000. by Ron White. Tech. Media
4. How the Internet Work 2000 by Preston Gralla Tech. Media.
5. Statistical Methods in Biology - 2000 by Bailey, N.T. J. English Univ. Press.
6. Biostatistics - 7th Edition by Daniel
7. Fundamental of Biostatistics by Khan
8. Biostatistical Methods by Lachin
9. Kothari, C.R. Research Methodology (Methods and Techniques), New Age Publisher.
10. Statisticsfor Biologist by Campbell R.C.(1974)Cambridge University Press , UK.
11. INTERNET – CDC publication, India.
12. UGC, DST and DBT web-sites.

## **PAPER TH-II**

### **BIOENERGETICS AND ENZYMOLOGY**

**Marks 100 / (04 Credits)**

#### **Unit – I Carbohydrate catabolic pathways and microbial growth on C1**

##### **Compounds (0.8 Credits)**

EMP, HMP, ED, Phosphoketolase pathway, TCA cycle, Glyoxylate bypass. Anaplerotic sequences, catabolism of different carbohydrates (Fructose, Lactose, Manose, Allose, Gluconate, Mannitol, Sorbitol, Arabinose) and 2,3 butanediol metabolism, regulation of aerobic and anaerobic carbohydrate metabolism,

Microbial growth on C1 Compounds (Cyanide, Methane, Methanol, methylated amines and carbon monoxide ) with reference to microorganisms and biochemical reactions with enzymes involved.

#### **Unit - II Bacterial fermentations and Biosynthesis (0.8 Credits)**

Principal classes of carbohydrate fermentations. Carbon energy and balance. Alcohol, lactate, mixed acid, butyric acid, acetone-butanol, propionic acid, succinate, methane, and acetate, butanediol, acetoin fermentations.

Biosynthesis of amino acids (formation of glutamic acids, conversion of glutamic acid to glutamine, proline and arginine, formation of alanin, serinine, glycine and cysteine),

Bbiosynthesis of Purines and Pyrimidines.

#### **Unit – III Endogenous metabolism and degradation of aliphatic and aromatic compounds. (0.8 Credits)**

Functions of endogenous metabolism, types of reserve materials, enzymatic synthesis, degradation and regulation of reserve materials - glycogen, polyphosphates and polyhydroxybutyrate (PHB), PHB production and its futuristic applications.

Microbial degradation of aliphatic hydrocarbons (microorganisms involved, mono-terminal,

biterminal oxidation of propane, decane, etc. ) and aromatic hydrocarbons and aromatic compounds ( via catechol, protocatechuate, dissimilation of catechol and protocatechuate, homogentisate pathways ).

#### **Unit – IV Properties of Enzymes (0.8 Credits)**

Classification of enzymes into six major groups with suitable examples. Numerical classification of enzymes. Different structural conformations of enzyme proteins (Primary, secondary, tertiary and quaternary structures). Forces that maintain protein structures. Enzymes as biocatalysts, , activation energy, substrate specificity, active site, theories of mechanisms of enzyme action (Induced fit and lock and key). Determination of active site amino acid, Mechanism of action of, chymotrypsin and ribonuclease. Monomeric, Oligomeric and multienzyme complex, isozymes and allosteric enzymes.

#### **Unit – V Enzyme kinetics (0.8 Credits)**

Importance of enzyme kinetics, factors affecting rates of enzyme mediated reactions ( pH, temperature, substrate concentration ,enzyme concentration and reaction time ). Derivation of Michaelis - Menton equation and its significance in enzyme kinetic studies. Lineweaver-Burke plot, Haldane-Briggs relationship, sigmoidal kinetics steady state kinetics.

### **PRACTICAL**

#### **PAPER P-II :BIOENERGETICS AND ENZYMOLOGY**

**Marks 50 / (02 Credits)**

1. Isolation and Identification of Reserve food material (Glycogen / polyphosphates, PHB) of *B. megaterium* and *Azotobacter SP.*
2. Quantitative estimation of amino acids by Rosen's method.
3. Quantitative estimation of proteins by Folin-Lowry / Biuret method
4. Quantitative estimation of sugars by Summner's method.
5. Demonstration of endogenous metabolism in *B megaterium* or *E. coli* and their survival under starvation conditions
6. Production of alpha amylase using submerged/solid-state fermentation/ prouction of protease by bacterial species.
7. Partial Purification of alpha-amylase or bacterial protease.
8. Studies on enzyme kinetics of alpha amylase/Protease [Optimization of parameters viz.

Substrate, enzyme concentration, reaction temperature, reaction pH,  $K_m$ ,  $V_{max}$  and metal ions as activators and inhibitors).

## REFERENCES

1. Understanding Enzymes by Trevor Palmer
2. Enzyme Kinetics by Paul Engel. 1977. John Wiley and Sons. Inc., New York.
3. Enzymes by Dixon and Webb, 3 rd Edition 1979. Academic Press, New York
4. Biochemistry by Stryer 5th Edition WH Freeman 2001
5. Laboratory techniques in Biochemistry and Molecular Biology by Work and Work.
6. Principles of Enzyme Kinetics. 1976. by Athel Cornish - Bowden. Butterworth and Co.
7. Fundamentals of Enzymology. 3rd Edition by Price
8. Biochemistry by Chatwal
9. Methods in Enzymology by Drolittle
10. Biochemistry by Garrett
11. Principles of Biochemistry. 2 nd Edition by Horton
12. Biochemistry by Voet.
13. Methods of Biochemical Analysis by David Glick, John Wiley and Sons, New York.
14. Biotechnology Vol. VIII and VII A edited by H. J. Rehmen and G. Reed.
15. Bacterial metabolism 2nd edition by H. W. Doelle
16. Advances in microbial physiology Vol. VII and XXIV edited by A. H. Rose, J Morris D. W. Tempest.



### **PAPER TH-III**

### **BIOINSTRUMENTATION TECHNIQUES AND APPLICATIONS**

**Marks 100 / Credits 04**

#### **Unit –I Basic laboratory Instruments (0.8 Credits)**

Principle, working and applications of following instruments: pH meter; laminar-air flow and biosafety cabinets; centrifuge- types of centrifuge machines, preparative and analytical centrifuges, differential centrifugation, sedimentation velocity, sedimentation equilibrium, density gradient methods; PCR machine.

#### **Unit – II Chromatographic techniques(0.8 Credits)**

Theory, principles and applications of paper chromatography, thin layer chromatography, gel filtration chromatography, ion-exchange chromatography, affinity chromatography, Hydrophobic interaction chromatography, gas-liquid chromatography, high pressure/ performance liquid chromatography (HPLC).

#### **Unit – III Electrophoretic techniques(0.8 Credits)**

Basic principles of electrophoresis, theory and application of paper, starch gel, agarose, native and denaturing PAGE, isoelectric focusing, capillary, microchip and 2-D electrophoresis.

#### **Unit – IV Spectroscopy(0.8 Credits)**

Principles and applications of spectroscopic techniques: turbidometry, nephelometry, luminometry, UV-visible spectrophotometry, IR and Raman spectroscopy, NMR spectroscopy, fluorescence spectroscopy, atomic absorption spectrophotometry, mass spectroscopy, introduction to atomic force microscopy.

#### **Unit – V Radioisotopic techniques(0.8 Credits)**

Radioactive decay, radioactive labeling, principle and application of tracer techniques, detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger- Muller counters and scintillation counters, autoradiography, dosimetry.

## **PRACTICAL**

### **PAPER P-III BIOINSTRUMENTATION TECHNIQUES AND APPLICATIONS**

**Marks 50/ (02 Credits)**

1. Studies on pH titration curves of amino acids/ acetic acid and determination of pKa values and Handerson-Hasselbach equation.
2. Separation of bacterial lipids/amino acids/sugars/organic acids by TLC or Paper Chromatography.
3. Separation of serum protein by horizontal submerged gel electrophoresis.
4. Study of UV absorption spectra of macromolecules (protein, nucleic acid, bacterial pigments).
5. Quantitative estimation of hydrocarbons/pesticides/organic Solvents /methane by Gas chromatography.
6. Demonstration of PCR, DNA sequencer.
7. Separation of haemoglobin or blue dextran by gel filtration.
8. Paper electrophoresis.
9. Friske dosimetry.
10. Density gradient centrifugation.

## **REFERENCES**

1. Instrumental Methods of Analysis. 6th Edition by H.H. Willard, L.L. Merritt Jr. and others. 1986. CBS Publishers and Distributors.
2. Instrumental Methods of Chemical Analysis. 1989 by Chatwal G and Anand, S. Himalaya Publishing House, Mumbai.
3. A Biologists Guide to Principles and Techniques of Practical Biochemistry. 1975 by Williams, B.L. and Wilson, K.
4. Spectroscopy. Volume 1. Edited by B.B. Straughan and S. Walker. Chapman and Hall Ltd.
5. Gel Electrophoresis of Proteins- A Practical Approach by Hanes.

6. Chromatography: Concepts and Contrasts- 1988 by James Miller. John Wiley and Sons. Inc., New York.
7. Analytical Biochemistry by Holme.
8. Introduction to High Performance Liquid Chromatography by R. J. Hamilton and P. A. Sewell.
9. Spectroscopy by B.P. Straughan and S. Walker.
10. Practical aspects of Gas Chromatography and Mass Spectrometry 1984 by Gordon M. Message, John Wiley and Sons, New York.
11. Gel Chromatography by Tibor Kremmery. Wiley Publications.
12. Isotopes and radiations in Biology by C.C. Thornburn, Butterworth and Co. Ltd., London.
13. The use of radioactive isotopes in the life sciences by J.M.Chapman and G.Ayrey, George Allen and Unwin Ltd., London.
14. Analytical biotechnology edited by Thomas G M Schalkhammer.

## **PAPER TH-IV**

### **INDUSTRIAL FOOD AND DAIRY MICROBIOLOGY**

**Marks 100/ (04 Credits)**

#### **Unit – I Industrial Food fermentations**

**(0.8 Credits)**

Introduction, food fermentation, the science and technology.

Oriental fermented foods (Soya sauce, Natto, Miso),

Cereal products, mixed preparations (Idli, KhamangDhokala, Papadam and Jilebies),

Fermented cassava flour, fermented peanut milk,

Grape based fermented products- wine production (pre fermentative, fermentative and post fermentative practices, general methods of wine production),

Fermented vegetables – Sauerkraut, Fermented Meat – Sausages.

#### **UNIT – II Industrial Dairy fermentations.**

**(0.8 Credits)**

Taxonomy of lactic acid bacteria present in fermented products.

Acid fermented milks -(acidophilus milk, yoghurt). Slightly acid fermented milks (Cultured butter milk), Acid alcoholic fermented milk (Kefir).

Fermented milk production with extended self life - (labneh).

Starter cultures for fermented dairy products (*Strptococcusthermophilus*, *Lactobacillus bulgaricus* and other bacterial species). Metabolism of starter cultures, biochemical changes in fermented milk (Fermentation of lactose to lactic acid, production of Vitamin B complexes and aromatic compounds, hydrolysis of proteins and lipids)

Cheese- biological entities in cheese systems (Milk, microorganisms, enzymes and other additives). Cheese production (Milk quality and composition, steps involved in manufacturing of cheese, Preservation, Spoilage, classification and nutritional aspects of cheese.

#### **Unit –III Advanced Food and dairy Microbiology**

**(0.8 Credits)**



Genetically modified foods. Probiotic role of lactic acid bacteria and fermented milk products,

Applications of microbial enzymes in food and dairy industry [Protease, Lipases], Food Additives, microbial anti oxidants, biosurfactants as emulsifiers, microbial polysaccharides as stabilizers and thickeners, flavors (esters, diacetyl, pyrazines, lactones and terpenes, monosodium glutamate and microbial colors from molds).

Production of Baker's Yeast, Tea & coffee fermentation.

**Unit –IV Food preservation methods and utilization of dairy waste (0.8 Credits)**

Food preservation by Radiations (UV, Gamma and microwave).

Food preservation by low and high Temperature, chemicals and naturally occurring antimicrobials

Biosensors in food industry.

Utilization and disposal of dairy by-product - whey.

**Unit – V Food spoilage and Quality assurance (0.8 Credits)**

Food borne infections and intoxications: bacterial with examples of infective and toxic types

– Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter, Listeria.

Mycotoxins in food (Types, structures, producer organism and its toxicity).

Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, FSSAI, ISO.

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**PRACTICAL**

**PAPER - P-IV**

**INDUSTRIAL FOOD AND DAIRY MICROBIOLOGY**

**Marks 50 / (02 Credits)**

1. Production and estimation of lactic acid by *Lactobacillus Sp.* or *Streptococcus Sp.*
2. Production of Extraction and estimation of diacetyl.
3. Production of fermented batter of Idli, KhamanDhokala, Jilebies and study of bacteria involved in them.
4. Sauerkraut fermentation and study of bacteria involved in it.

5. Laboratory Production of wine from grapes and study of yeast involved in production of it.
6. Production and study of microorganisms involved in fermented milk – Curd, acidophilus milk, yoghurt, cultured butter milk, Acid alcoholic fermented milk (Kefir).
7. Laboratory production of fermented Soya sauce and peanut milk and study of bacteria involved in them.
8. Isolation and study of food infection and food poisoning bacteria / fungi from contaminated foods.
9. Extraction and detection of afla toxin from infected foods.
10. Laboratory Production of Baker's yeast
11. Preservation of potato/onion by UV radiation
12. Production of Whey powder as a source of proteins and nutrients and estimation of protein content in it by biuret method.
13. Rapid analytical techniques in food quality control using microbial Biosensors.

#### REFERENCES:

1. Food Microbiology. 2nd Edition By Adams
2. Basic Food Microbiology by Banwart George J.
3. Food Microbiology: Fundamentals and Frontiers by Dolle
4. Biotechnology: Food Fermentation Microbiology, Biochemistry and Technology. Volume 1& 2 by V.K. Joshi.
5. Fundamentals of Dairy Microbiology by Prajapati.
6. Essentials of Food Microbiology. Edited by John Garbult. Arnold International Students Edition.
7. Microbiology of Fermented Foods. Volume I and II. By Brian J. Wood Elsevier Applied Science Publication.
8. Microbiology of Foods by John C. Ayres. J. Orwin Mundt. William E. Sandinee. W. H. Freeman and Co.
9. Dairy Microbiology by Robinson. Volume I and II.
10. Food Microbiology: Fundamentals and Frontiers. 2nd Edition by Michael P. Doyle, Larry R. Beuchat and Thomas I. Montville (Eds.), ASM Publications.
11. Bacterial Pathogenesis A Molecular Approach. 2 nd Edition. 2001 by Abigail A. Salyers and Dixie D. Whitt. ASM Publications.
12. Advances in Applied Microbiology by D. Pearlman, Academic Press.

13. Food Microbiology 4<sup>th</sup> Edition by William C. Frazier & Denis C. Westhoff
14. The technology of Food Preservation : 4<sup>th</sup> Edition Norman N.Potter (1987) by CBS publication.
15. Milk & Milk products: 4<sup>th</sup> Edition Clarence H. Frazier. TMH Publications.
16. Food Processing: Biotechnological Applications (2000). S.S.Marwaha & Arora. Asiatech Publications, New Delhi.
17. Food Microbiology by James De & De
18. Dairy Microbiology by P. Parihar
19. Fundamental Food Microbiology: Bibek Ray, Arun Bhunia

## REVISED SYLLABUS OF

### M. Sc. (MICROBIOLOGY)

#### SEMESTER-II

Paper No.	Title of the theory paper	Marks/Credits	Practical	Marks/Credits
Semester II				
Th-V	Recent Trends in Virology.	100/04	P-V	50/02
Th-VI	Molecular Immunology.	100/04	P-VI	50/02
Th-VII	Microbial Physiology.	100/04	P-VII	50/02
Th-VIII	Microbial Diversity and Extremophiles.	100/04	P-VIII	50/02



## **SEMESTER II**

### **PAPER TH-V**

#### **RECENT TRENTS IN VIROLOGY**

**Marks 100/CREDITS 04**

##### **Unit-I Classification and Morphology of Viruses. (0.8 Credits)**

Brief outline on discovery of viruses. Classification and nomenclature of viruses, the Classical System, Classification by Genome Type: Baltimore System, Cataloging the virus through virus classification schemes of ICTV / ICNV. Morphology and ultra-structure of viruses. Virus related agents: viroids and prions.

##### **Unit-II Cultivation and assay of viruses (0.8 Credits)**

Cultivation of viruses: embryonated eggs, experimental animals and cell cultures (Cell-lines, cell strains and transgenic systems). Isolation and Purification of viruses Structural investigation- (Electron Microscopy, Protein and Nucleic acids studies). Detection of viruses and virus components: Antigen, Nucleic acid

Assay of Viruses: Measurement of Infectious unit, serological methods – haeme agglutination and ELISA. Genetic analysis of viruses by classical genetic methods.

##### **Unit-III Introduction to virus transmission and Multiplication. (0.8 Credits)**

Transmission of viruses: vectors and non-vectors: general principles



Overview of virus replication, Animal viruses - Mechanism of virus adsorption and entry into the host cell, Bacteriophages – Lytic and lysogenic replication

DNA and RNA viruses– Mechanism of genome replication Transcription, post transcriptional changes, translation, assembly, exit and maturation of progeny virions.

#### **Unit-IV Pathogenesis of Viruses**

**(0.8 Credits)**

Outcome of viral infection (Abortive, Latent, Productive infection and Programmed cell death), Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses Adenovirus, Herpes virus, Picorna virus, Poxvirus and Orthomyxovirus, pathogenesis of plant [TMV] Satellite viruses and their role in plant virus replication. Insect viruses [NPV] Viruses pathogenic to algae and fungi.

Host cell transformation by viruses and oncogenesis of DNA and RNA viruses.

#### **Unit-V Control of Viruses and Emerging Viruses**

**(0.8 Credits)**

Control of viral infections: Viral vaccines and chemotherapeutic agents.

Virus neutralization by antibody and interferons

Structure, genomic organization, pathogenesis and control of Human immunodeficiency virus.

SARS and Emerging viruses

### **PRACTICAL**

#### **PAPER P-V**

#### **RECENT TRENTS IN VIROLOGY**

**Marks 50 / Credits 02**

1. Isolation of bacteriophages
2. Plaque assay
3. One step growth curve for determination for virus titre.
4. Phage typing of *E. coli* bacteriophages.
5. Induction of lambda lysogen by UV radiations.
6. Studies on Specialized transduction.
7. Isolation of lambda DNA and their characterization.
8. Amplification of lambda DNA by PCR.
9. Cultivation and assay of viruses using embryonated eggs and Tissue culture Technique.

## REFERENCES: -

1. Medical virology 10 th edition by Morag C and Tim bury M C 1994..ChurchilLivingstone , London.
2. Introduction to modern virology 4 th Edition by Dimmock N J, Primrose S. B. 1994. Blackwell scientific publications. Oxford.
3. Virology 3<sup>rd</sup> edition by Conrat H. F. ., Kimball P. C. and Levy J. A. 1994. Prentice Hall, Englewood Cliff, New Jersey.
4. Text Book on Principles of Bacteriology, Virology and Immunology, Topley and Wilson 1995.
5. Molecular Biology, Pathogenesis and Control by S. J. Flint and others. ASM Press, Washington , D. C.
6. Applied Virology. 1984. edited by EdnordKurstak. Academic Press Inc.
7. Introduction to Modern Virology by Dimmock.
8. Prion diseases by Gaschup, M. H.
9. Clinical Virology Mannual by Steven, S. ,Adinka, R. I., Young , S. A.
10. Principles of virology. 2000 by Edward Arnold.
11. Virology : principles and applications by John Carter and Venetia Saunders.
12. Principles of virology ,—4th edition by Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, with Lynn W. Enquist.

## **PAPER TH-VI**

### **MOLECULAR IMMUNOLOGY**

**Marks 100/ CREDITS 04**

#### **Unit-I Immune System**

**(0.8 Credits)**

Innate and Adaptive immune responses. Memory of self and non self discrimination. Organs and cells involved in immune system. Lymphocytes, their subpopulation, their properties and functions, membrane bound receptors of lymph cells, helper T cells, T cells suppression, lymphocyte trafficking.

#### **Unit-II Antigens and Immunoglobulins**

**(0.8 Credits)**

Concept of haptens, determinants, conditions of antigenicity, antigens and immunogenicity, super antigen.

Immunoglobulin: Deducing antibody Structure. Antigenic determinants on Immunoglobulin –Isotopes, Allotypes and Idiotype

Structure and properties of immunoglobulin classes. Theories of antibody formation, hybridoma technology for monoclonal antibodies and designer monoclonal antibodies.

**Multiple myeloma** and structural basis of antibody diversity. Freund's adjuvants and its significance.

#### **Unit-III Antigen – Antibody reactions**

**(0.8 Credits)**

Strength of Antigen and Antibody Interactions – Antibody Affinity and Antibody Avidity.  
Antigen Antibody reaction by precipitation, agglutination and complement fixation.  
Inflammation and Nonspecific immune mechanism: - Surface defenses and tissue defenses, opsonization.  
Tissue metabolites with bactericidal properties (lysozyme, nuclein, histone, protamine, basic peptides of tissues – leukines, phagocytins, lecterins, haemocompounds)

#### **Unit-IV Expression and Regulation of Immune Response (0.8 Credits)**

T lymphocyte and B lymphocyte development and maturation, antigen processing and presentation, generation of humoral and cell mediated immune response, activation of B and T lymphocytes, cytokines and their role in immune regulation, T cell regulation, MHC restriction, immunological tolerance.  
Cell mediated cytotoxicity: Mechanism of Cytotoxicity of T cell and NK mediated lysis, antibodydependent cell mediated cytotoxicity, and macrophage mediated cytotoxicity.  
Compliment system: Classical, alternate, lectin pathway of complement activation.  
Regulation of complement activation.  
Transplantation immunology: MHC, types of grafts, grafts rejection, GVH reactions.  
Mechanism of graft rejection, and prevention of graft rejection.

#### **Unit-V Immunity and Immunoassays (0.8 Credits)**

Defense against bacteria, viruses, fungi and parasites.  
Immuno-assays: SRID, ELISA, ELISA-PCR, RIA, Western Blotting, Immunofluorescence and their application.  
Immune deficiencies and autoimmunity, Hypersensitivity.

### **PRACTICAL PAPER P-VI MOLECULAR IMMUNOLOGY**

**Marks 50 /Credits 02**

I. Diagnostic immunologic principles and methods  
Precipitation method  
- Immunodiffusion.



- Immunoelectrophoresis.

Agglutination method

- Widal test.

- Haemagglutination.

- ELISA method.

2. Separation of serum protein by submerged agarose gel electrophoresis.

3. Purification of human immunoglobulins from serum and confirmation of its antigenicity.

4. Identification of *S. typhi* by serotyping. [Purification of H and O antigens from *S. typhi*]

5. Clinical diagnosis of Rheumatoid arthritis by purifying immunoglobulins and albumins and confirmation by lattice agglutination test.

6. Estimation of Alkaline phosphatase from patient's serum

7. Demonstration of Western blotting.

8. Clinical diagnosis of viral diseases by PCR, ELISA-demonstration..

#### REFERENCE:

1. Essential of Immunology by Riott I. M. 1998. ELBS, Blackwell Scientific Publishers, London.

2. Immunology 2 nd Edition by Kuby J. 1994. W. H. Freeman and Co. New York.

3. Immunology – Understanding of Immune System by Claus D. Elgert. 1996. Wiley – Liss , New York.

4. Fundamentals of Immunology by William Paul.

5. Cellular and Molecular Immunology. 3 rd Edition by Abbas.

6. Immunobiology: The immune system in Health and Diseases. 3rd edition by Travers.

7. Immunology – A short course. 2 nd Edition by Benjamin.

8. Manual of clinical laboratory and Immunology 6th Edition. 2002 by Noel R. Rose, Chief editor: Robert G. Hamilton and Barbara Detrick (Eds.), ASM publications.

9. Pocket Guide to Clinical Microbiology. 2 nd Edition. 1998 by Patrick R. Murray. ASM Publications

## **PAPER TH-VII**

### **MICROBIAL PHYSIOLOGY**

**Marks 100/ (04 Credits)**

#### **Unit – I Photosynthesis (0.8 Credits)**

Energy consideration in photosynthesis, light and dark reaction, electron carriers in photosynthesis, Organization of photo system I and II, cyclic and non-cyclic flow of electrons, Z scheme, Hill reaction, photolysis of water. Bacterial photosynthesis: scope, electron carriers, Photosynthetic reaction center, cyclic flow of electrons, bacterial photophosphorylation in various groups of phototrophic bacteria, electron donors other than water in anoxygenic photosynthetic bacteria.

#### **Unit – II Bacterial Respiration (0.8 Credits)**

##### **Aerobic Respiration:**

Mitochondrial electron transport chain, structure and function of ATPase (bacterial and mitochondrial), generation and maintenance of proton motive force, oxidative phosphorylation, inhibitors and un-couplers of electron transport chain and oxidative phosphorylation, Atkinson's energy charge, phosphorylation potential and its significance, Energy generation in all groups of chemolithotrophs.

##### **Anaerobic Respiration:**

Concept of anaerobic respiration, oxidized sulfur compounds, and nitrate as electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogenesis, Biochemistry of ammonia oxidation, ammonia oxidation by members of Genus Nitroso group, nitrite oxidation by Nitro group of genera.

### **Unit –III Bacterial Permeation (0.8 Credits)**

#### **Structure and organization of membrane**

(Glyco-conjugants and proteins in membrane systems), fluid mosaic model of membrane. Methods to study diffusion of solutes in bacteria, passive diffusion, facilitated diffusion, different mechanisms of active diffusion (Proton Motive Force, PTS, role of permeases in transport, different permeases in *E. coli*. Transport of amino acids and inorganic ions in microorganisms and their mechanisms.

### **Unit – IV Bacterial Sporulation (0.8 Credits)**

Sporulating bacteria, molecular architecture of spores, induction and stages of sporulation, Influence of different factors on sporulation. Cytological and macromolecular changes during sporulation. Heat resistance and sporulation.

### **Unit –V Bacterial Chemolithotrophy and Nitrogen Metabolism: (0.8 Credits)**

Physiological groups of chemolithotrophs, Oxidation of molecular hydrogen by Hydrogenomonas species. Ferrous and sulfur/sulfide oxidation by Thiobacillus species. Biochemistry of biological nitrogen fixation, properties of nitrogenase and its regulation, ammonia assimilation with respect to glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation

## **PRACTICAL**

### **PAPER P-VII MICROBIAL PHYSIOLOGY**

**Marks 50/ (02 Credits)**

1. Isolation of Photosynthetic bacteria
2. Glucose uptake by *E. coli* / *Saccharomyces cerevisiae* [Active and Passive diffusion]
3. Effect of UV, gamma radiations, pH, disinfectants, chemicals and heavy metal ions on spore germination of *Bacillus* SP.
4. Determination of Iron Oxidation Rate of *Thiobacillus ferrooxidans*.



5. Determination of Sulfur Oxidation Rate of *Thiobacillus thiooxidans*.
6. Microbial degradation, decolorization and adsorption of organic dyes (by free and immobilized cells).
7. Estimation of calcium ions present in sporulating bacteria by EDTA method.
8. Demonstration of utilization of sugars by oxidation and fermentation techniques.
9. Isolation and characterization of (as nitrogen fixers) of *Azospirillum* and detection of IAA by *Azospirillum*

## REFERENCES

1. Microbial Physiology and Metabolism by Caldwell D.R. 1995 Brown Publishers.
2. Microbial Physiology by Moat A.G. and Foster J. W. 1999. Wiley.
- 3.. Prokaryotic Development by Brun. Y.V. and Shimkets L.J. 2000. ASM Press.
4. Advances in Microbial Physiology. Volumes. Edited by By A.H. Rose. Academic Press, New York.
5. Applied Microbial Physiology by Rhodes.
6. Biosynthesis by Smith.
7. The Bacteria. Volumes by I.C. Gunsalus and Rogery Stanier, Academic Press.
8. Microbial Physiology by Benjamin
9. Bacterial Metabolism by H.W. Doelle
10. Segel Irvin H. (1997) Biochemical Calculations 2nd Ed., John Wiley and Sons, New York.
11. Voet Donald and Voet Judith G. (1995) Biochemistry, 2nd Ed.. John Wiley and sons New York.
12. White Abraham, Handler Philip, Smith Emil, Hill Rober, Lehman J. (1983) Principles of Biochemistry, Edition 6, Tata Mc-Graw Hill Companies, Inc.
13. White David (2000) Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press, New York.
14. Zubay Geoffrey (1998) Biochemistry, 4th Ed., W. C. Brown, New York.



## **PAPER TH-VII**

### **MICROBIAL DIVERSITY AND EXTREMOPHILES Marks**

**100 Marks (04 Credits)**

#### **Unit - I Biodiversity**

**(0.8 Credits)**

Introduction to microbial biodiversity – distribution, abundance, ecological niche.

Types- Bacterial, Archaeal and Eucaryal. General characters of actinomycetes, fungi, algae, protozoa and yeasts

#### **Unit – II Ecology**

**(0.8 Credits)**

**Community ecology:** community structure, benevolent interactions, control within the microbial communities of rhizosphere- antagonistic interactions, (competition, antibiosis, predation etc.). Rhizosphere, rhizoplane, siderophore, flavonoid from plants, lectines, octapine, nipotine, indole acetic acid.

**Mycorrhiza:** Host-fungus specificity, host fungus interactions, rhizosphere environment and recognition phenomenon, interaction of mycorrhizal fungi with non-host plants, functional capability.

**Marine ecosystem:** Environment of marine bacteria, bacterial growth in sea and its regulation by environmental conditions, modeling of growth and distribution of marine micro

plankton, mechanism of dissolved organic matter production (DOM), strategies of organic matter utilization and microbial utilization of organic matter in sea.

**Unit – III Characteristics and classification of Archaeobacteria. (0.8 Credits)**

Thermophiles: Classification, hyperthermophilic habitats and ecological aspects.  
Extreme Thermophilic Archaeobacteria, Thermophily, commercial aspects of thermophiles.  
Applications of thermozymes. Methanogens: Classification, Habitats, applications.

**Unit – IV Alkalophiles and Acidophiles (0.8 Credits)**

Alkalophiles: Classification, alkaline environment, soda lakes and deserts, calcium alkalophily, applications.

Acidophiles: Classification, life at low pH, acidotolerance, applications.

**Unit – V**

**Halophiles and Barophiles (0.8 Credits)**

Classification, Dead Sea, discovery basin, cell walls and membranes – Purple membrane, compatible solutes. Osmoadaptation / halotolerance. Applications of halophiles and their extremozymes.

Barophiles: Classification, high-pressure habitats, life under pressure, barophily, death under pressure.

**PRACTICAL**

**PAPER- P-VIII**

**MICROBIAL DIVERSITY AND EXTREMOPHILES**

**Marks 50 (02 Credits)**

1. Isolation of thermophiles from hot water spring [Study at least one enzyme].
2. Studies on halophiles isolated from seawater. [Pigmentation and Salt tolerance]
3. Studies on alkalophiles isolated from Lonar water/sea water. [Study at least one enzyme]
4. Biogenic methane production using different wastes.
5. Isolation of *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans* cultures from metal sulfides, rock coal and acid mine waters.
6. Estimation of microbial species diversity in microecosystem

7. Detection of siderophore production by *Azospirillum* and *Pseudomonas*
8. Slide culture technique for yeast isolation.
9. Cover slip culture technique for actinomycetes identification

#### REFERENCES:

1. Extremophiles by Johri B.N. 2000. Springer Verlag, New York
2. Microbial Diversity by Colwd, D. 1999, Academic Press.
3. Microbial Life in Extreme Environments. Edited by D. J. Kushner. Academic Press.
4. Microbiology of Extreme Environments. Edited by Clive Edward. Open University Press. Milton Keynes.
5. Microbiology of Extreme Environments and its potential for Biotechnology. Edited by M.S. Da Costa, J.C. Duarate, R.A. D. Williams. Elsevier Applied Science, London.
6. Extreme Environment. Mechanism of Microbial Adaptation. Edited by Milton R. Heinrich. Academic Press.
7. Thermophiles. General, Molecular and Applied Microbiology. Edited by Thomas D. Brock. Wiley Interscience Publication.
8. Microbiology: Dynamics and Diversity by Perry.
9. Microbial Ecology. Fundamentals and Applications by. Ronald M. Atlas and Richard Bartha. 2nd and 4th Edition. The Benjamin Cummins Publication Co. Inc.
10. Microbial Ecology. 2nd Edition. by R. Campbell. Blackwell Scientific Publication.
11. Brocks Biology of Microorganisms. 8th Edition. (International Edition - 1997) by Michael T. Madigan, John M. Martinko. Jack Parker. Prentice Hall International Inc.
12. Advances in Applied Microbiology. Vol. 10. Edited by Wayne W. Umbreit and D. Pearlman. Academic Press.
13. Macan, T. T. (1974). Freshwater Ecology. Longman Group Ltd., London,.
14. Meadows, P. S. and J. I. Campbell. (1978). An introduction to Marine Science. Blackie & Son Ltd., Glasgow.
15. Richards, B.N. (1987). Microbiology of Terrestrial Ecosystems. Longman Scientific & Technical, New York.


## REVISED SYLLABUS OF

M. Sc.

(MICROBIOLOGY) SEMEST

ER-III

aperNo.	Title of the theory paper	Marks/Credits	Practical	Marks/Credits
Semester III				
Th-IX	Enzyme Technology	100/04	P-IX	50/02
Th-X	Bioprocess Engineering and Technology.	100/04	P-X	50/02
Th-XI	Molecular Microbial Genetics.	100/04	P-XI	50/02
Th-XII	Environmental Microb ial Technology	100/04	P-XII	50/02

 26/11/21



### **SEMESTER III**

#### **PAPER IX**

#### **ENZYME TECHNOLOGY**

**Marks 100 (04 Credits)**

##### **Unit -IExtraction and Purification of Microbial Enzymes (0.8 Credit)**

Importance of enzyme purification, different sources of enzymes. Extra cellular and intracellular enzymes. Physical and chemical methods used for cell disintegration. Concentration of the enzyme extract, Enzyme fractionation by precipitation methods, chromatographic methods of enzyme purification- ion exchange chromatography, gel filtration, affinity chromatography and electrophoretic methods of enzyme purification. Enzyme crystallization techniques, Purification table, concept of enzyme units and specific activity. Analysis of purity of enzymes.

##### **Unit II- Enzyme Inhibition and kinetics- (0.8 Credit)**

Irreversible and reversible enzyme inhibitions. Competitive, uncompetitive and non-competitive enzyme inhibitions with suitable examples and their kinetic studies.

**Allosteric inhibition-** Positive and negative cooperativity, sigmoidal kinetics and allosteric enzymes. Models accounting cooperativity – Hill, Adair, MWC and KNF models. Cooperative binding of oxygen to haemoglobin – significance of sigmoidal behavior. Aspartate transcarbamoylase as allosteric enzyme.

**Regulation of enzyme activity-** Allosteric regulation, feedback regulation and cascade system (Genetic regulation), covalent modification.

### **Unit III Immobilization of enzymes (0.8 Credit)**

Principles, parameters, carriers/matrices used for immobilization, techniques of enzyme immobilization, Economic argument for immobilization, Effect of solute partition and diffusion on the kinetic properties of immobilized enzymes.

Analytical therapeutic, environmental and industrial applications of immobilized enzymes. Application of immobilized enzymes in bioconversion processes, Bioreactors using immobilized enzymes. Immobilization of whole cells versus immobilization of enzymes.

### **Unit IV Enzyme/Protein Engineering (0.8 Credit)**

Objectives of Protein Engineering, basic strategy of enzyme engineering. Protein engineering versus enzyme engineering as a biocatalyst. Techniques of Protein Engineering, Chemical modification and Site directed mutagenesis to study the structure- function relationship of industrially important enzymes. Properties of enzymes modified by enzyme engineering. Hybrid enzymes. Examples of Protein Engineering applications- Improvement in stability, catalytic efficiency, selectivity and substrate specificity, purification and biopharmaceutical applications etc.

### **Unit V Clinical Enzymology (0.8 Credit)**

Enzymes in clinical diagnostics (Blood Glucose, Blood Urea, Cholesterol, Diagnosis of liver disorders and heart disorders like Myocardial infarction). Enzymes and inborn errors, their use as markers in cancer and other diseases.

Enzyme sensors for clinical purposes-glucose oxidase, urease, cholesterol biosensors. Enzyme immunoassay.

Enzyme therapy – Treatment of genetic deficiency diseases, Enzymes in cancer therapy, Enzyme inhibitors and drug design. ADEPT and GDEPT.

**PRACTICAL**  
**PAPER IX**  
**ENZYME TECHNOLOGY**

**Marks 50 (02 Credits)**

1. Microbial production, extraction, purification and confirmation of  $\alpha$ - Amylase/ Protease/Lipase/ Invertase/ Urease.
2. Determination of efficiency of enzyme purification by measuring specific activity at various stages viz. Salt precipitation, Dialysis, Electrophoresis etc.
3. Studies on activation and inhibition of extracted enzyme. (Effect of heavy metal ions, chelating agents, activators and inhibitors)
4. Immobilization of cells and enzyme using Sodium alginate/ egg albumin and measurement of enzyme activity of immobilized  $\alpha$ - Amylase/ Protease/Lipase/ Invertase/ Urease.
5. Impact of immobilization on enzyme activity in terms of temperature tolerance,  $K_m$ /  $V_{max}$  using various forms of  $\alpha$ - Amylase/ Protease/Lipase/ Invertase/ Urease.
6. Determination of molecular weight of enzymes using PAGE technique.
7. Preparation of Urease biosensor and determination of its activity.
8. Determination of blood glucose by glucose oxidase biosensor.

**REFERENCES**

1. Methods in Enzymology Volume 22- Enzyme purification and related techniques. Edited by William B. Jakoby, Academic Press, New York.
2. Allosteric Enzymes – Kinetic Behaviour, 1982 by B.I. Kurganov, John Wiley and Sons. Inc., New York.
3. Biotechnology Volume 7A – Enzymes in Biotechnology, 1983. Edited by H.J. Rehm and G.Reed, Verlag Chemie.
4. Handbook of Enzyme Biotechnology by Wiseman.
5. Enzyme as Drugs Edited by John S. Holcenberg and Joseph Roberts, John Wiley and Sons. Inc., New York.
6. Methods of Enzymatic Analysis by Hans Ulrich, Bergmeyer, Academic Press
7. Methods in Enzymology by W.A.Wood, Academic Press
8. Advances in Enzymology by Alton Meister, Interscience Publishers.



9. Topics in Enzyme and Fermentation Biotechnology by L.N. Wiseman, John Wiley and Sons. Inc., New York.
10. Fundamentals of Enzymology by Nicholas C. Price and Lewis Stevens, Oxford University Press.
11. Biocatalysts and Enzyme technology by Klaus Buchholz, Volker Kasche, Uwe T. Bornscheuer, Wiley- VCH Verlag GmbH and Co., Germany.
12. Protein Purification techniques Edt. Simon Roe, Oxford University Press.
13. Enzymes- Biochemistry, Biotechnology, Clinical chemistry by Trevor Palmer. East- West Press Edition.

## **PAPER X**

### **BIOPROCESS ENGINEERING AND TECHNOLOGY**

**Marks 100/ (04 Credits)**

#### **Unit-I: Introduction to Industrial Bioprocess Engineering (0.8 Credits)**

Definition of bioprocess engineering, bioprocess engineer, biotechnology and bioprocess engineering, approach of biologist and engineers towards research, regulatory constraints of bioprocess. Batch growth (growth pattern and kinetics in batch culture, environmental factors affecting growth kinetics), Monod's equation, continuous culture, Chemostat and turbitostat (construction and working), mixed culture in nature, industrial utilization of mixed culture.

#### **Unit-II : Bioreactors (0.8 Credits)**

Design of basic bioreactor, bioreactor configuration, design features, individual parts, baffles, impellers, foam separators, spargers, culture vessel, cooling and heating devices, probes for on-line monitoring, computer control of fermentation process, measurement and control of



process. Ideal batch reactor, ideal continuous flow stirred tank reactor, packed bed reactor bubble column reactor, fluidized bed bioreactor, Trickle bed reactor (Their basic construction, working, and distribution of gases).

### **Unit III: Mass Transfer and Sterilization**

**(0.8 Credits)**

Transport phenomena in bioprocess system: Gas liquid mass transfer in cellular systems, basic mass transfer concept, Rate of metabolic oxygen utilization, Determination on oxygen transfer rates, determination of  $K_L a$ , Heat transfer, aeration / agitation and its importance. Sterilization of bioreactors, nutrients, air supply, product and effluents, process variable and control

### **Unit-IV: Upstream processes**

**(0.8 Credits)**

Inoculum development, formulation of production media, sterilization of media, maintenance of stock culture, scale up of the process from shake flask to industrial level. , choosing cultivation methods, Modifying batch and continuous reactors, immobilization of cell systems, active and passive immobilization, solid state fermentation process.

### **Unit-V: Down Stream Process**

**(0.8 Credits)**

Downstream processes: Introduction, Recovery of particulates filtration, centrifugation, sedimentation, emerging technologies for cell recovery , product isolation , extraction , solvent extraction , aqueous two phase system , sorption , precipitation , reverse osmosis, ultra filtration. Product recovery trains: Commercial enzymes, Intracellular foreign proteins from recombinant E. coli, polysaccharide and biogum recovery, antibiotic, organic acids, ethanol, single cell protein.

## **PRACTICAL**

### **PAPER P-X**

## **BIOPROCESS ENGINEERING AND TECHNOLOGY**

**Marks 50 (02 Credits)**

1. Isolation of industrially important microorganisms for microbial processes (citric / lactic/ alpha amylase) and improvement of strain for increase yield by mutation.

2. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) microorganisms for design of a sterilizer.
3. [A] Determination of growth curve of a supplied microorganism and also determine substrate degradation profile. [B] Compute specific growth rate ( $\mu$ ), growth yield ( $Y_{1/2}$ ) from the above.
4. Extraction of Citric acid / Lactic acid by salt precipitation.
5. Monitoring of dissolved oxygen during aerobic fermentation.
6. Preservation of industrially important bacteria by lyophilization.
7. Product concentration by vacuum concentrator.
8. Cell disruption for endoenzymes by sonication.

#### REFERENCES:

1. James E .Bailey and David F Ollis, Biochemical Engineering Fundamentals, McGraw Hill Publication.
2. Shuler and FikretKargi, Bioprocess Engineering basic concepts, 2nd edition , Prentice Hall Publication.
3. Stanbury PF, Whitekar, A And Hall SJ, Principles of fermentation Technology, Pergamon Press.
4. Peppler and Perlmen , Microbial Technology, Vol I and II , Academic Press.
5. Cruger and Cruger , Biotechnology : A text Book of Industrial Microbiology.
6. Fermentation- A practical Approach
- 7.Bioprocess Technology: Fundamentals and Applications, Stockholm KTH.
8. Biochemical Reactors by Atkinson B., Pion Ltd. London
9. Fermentation Biotechnology: Industrail Perspectives by S. Chand and Co.
10. Biotechnology : A text book of Microbiology by Cruger
- 11.Biotechnology, Vol. 3 Edited by H.J. Rehm and G.Reed Verlag Chemie 1983.
12. Advances in Biochemical Engineering by T.K. Bhosh, A. Fiechter and N. Blakebrough, Springer, Verlag Publications, New York.
13. Bioprocess Engineering Kinetics, Mass Transport, Reactorsand Gene Expressions by Veith, W.F., John Wiley and Sons.
14. Applied Microbiology Series.
15. Industrial Microbiology by L.E. Casida, Wiley Eastern.
16. Bioseperation: Down Stream Processing for Biotechnology by Belter P.A., Cussler E.L. and Hu W.S., John Wiley and Sons, New York.

17. Separation Processes in Biotechnology by Asenjo J.A., Eds. Marcel Dekker, New York.
18. Bioprocess Engineering Principles by Doran, Academic Press, London.
19. Bioprocess Engineering Principles by Nielsen J. and Villadsen, Plenum Press, New York.
20. Fermentation, Biocatalysis and Bioseparation, Encyclopedia of Bioprocess Technology by Chisti Y., Vol. 5, John Wiley and Sons., New York.

## **PAPER TH-XI**

### **MOLECULAR MICROBIAL GENETICS**

**Marks 100 (04 credits)**

#### **Unit –I Molecular Structure Of Chromosome (0.8 Credits)**

**DNA:** Gene, chromosome, genome, Comparative account of genome organization of prokaryotic, archaea & Eukaryotic cell; C-Value and C-value paradox, Structure of DNA (Primary structure -linear polynucleotide, Secondary structure- double stranded helical structure, Tertiary Structure); Topological properties of DNA; Physical characteristics of DNA (Buoyant density, UV-absorption, denaturation, renaturation and hybridization, Cot curve); Forms of DNA (A, B, C and Z forms)

**Prokaryotic DNA replication:** Meselson and Stahl experiment, Replication Initiation, replication elongation and termination; Mechanism of rolling Circle replication; Types of DNA polymerases, Post replication process (Methylation of DNA)



**Mutation:** Mechanism of mutation (Random, and Nonadaptive phenomenon); Types of mutation - Base substitution (Transition and transversion), Frameshift mutation (Deletion, Insertion, inversion); Missense, Silent, Non-sense mutation

Molecular basis of mutation – (i) Spontaneous mutation- DNA polymerase errors, mutation due to recombination, mutation due to tautomerization of nitrogen bases, mutation due to deamination nitrogen bases; (ii) Induced mutations - Chemical mutagens (Base analogue, Nitrous oxide, Hydroxylamine, alkylating agents, and acridine orange); Physical mutagens (Ionizing radiation, non-ionizing radiation)

**DNA repair:** Necessity of DNA repair; Types of repairs - Photoreactivation, Base excision repair, Mismatch repair, Nucleotide excision repair, SOS-Inducible repair

## **Unit -II MOLECULAR MECHANISM OF GENE EXPRESSION (0.8 Credits)**

**Mechanism of gene expression:** Transfer of Genetic Information (Central Dogma); chromatin remodeling and gene expression (eukaryotes), Exons and Introns (Eukaryotes); Polycistronic RNA (prokaryotes)

**Types of RNA-** —mRNA, tRNA, rRNA, Small nuclear RNAs(snRNA), and Micro RNAs (miRNAs)

**Transcription in Prokaryotes:** RNA Polymerase, Upstream, Promoter, downstream region, consensus sequences, Initiation of RNA chains, elongation of RNA chains, termination of RNA chains (Rho dependent & Independent); Transcription inhibitors

**RNA processing:** Differences in Prokaryotic & Eukaryotic RNA Processing, Processing for t-RNA & r-RNA. Polyadenylation, capping of mRNA, and introns splicing

**Genetic code-** Discovery, genetic code table, silent features of genetic code, exception to universal genetic code

**Prokaryotic translation** – Ribosome and ribosome subunits; Activation of tRNA, Initiation, elongation, and termination of protein synthesis

Overview of differences in prokaryotic and Eukaryotic systems of transcription and translation, Inhibitors of protein synthesis; Post/Co translational modification- modifications in primary proteins, role of chaperons.

## **Unit – III Regulation Of Gene Expression (0.8 Credits)**

**Gene expression:** Central dogma of molecular biology, Gene induction and repression; Gene expression product, types of gene regulation (Constitutive and inducible gene regulation) and



Significance gene regulation, and levels of gene regulation (Transcriptional regulation, translational regulation, post transcription/post translation regulation), Gene silencing

**Operon:** Lac operon, Positive regulation of Lac operon, Negative regulation of lac operon, Lac mutants

Genetic attenuation (Trp operon) – Positive and negative regulation; Arabinose operon

#### **Unit -IV Transposable Elements and Recombination (0.8 Credits)**

**Transposable elements** – Discovery, General types of transposons, Transposable element of *Zea mays*

**Bacterial transposable element** – IS element and Complex transposons (Composite transposon, Tn3 transposon, Transposable phages)

**Mechanism of transposition** Conservative and Replicative model

**Recombination** - Homologous and non-homologous recombination, Gene mapping using bacterial recombination - Co-transformation, Co-transduction, and Mapping by conjugation (Intermittent mating experiment with Hfr cell)

#### **Unit – V Genetics Of Viruses (0.8 Credits)**

**Viral genome:** General Features, Linear and circular viral genome, Hershey and Chase experiment, Viral genome replication and expression (Outline), Significance of reverse transcriptase, Genetic complementation, and S. Benzer experiment

**Virulent and temperate bacteriophages:** T4 Bacteriophage – Structure, feature of viral genome, Virus multiplication (Lytic); Lambda bacteriophage Structure, feature of viral genome, Virus multiplication (Lysogeny); M13 bacteriophage - Structure, genome replication, and significance; phi x 174 bacteriophage Structure, genome replication, and significance

**Phage gene regulation:** Molecular mechanism of lysogenic regulation in lambda phage

**Viral mutants:** Rapid lysis mutant, conditional lethal mutant, and host range mutant

### **PRACTICAL**

#### **PAPER - PR-XI**

#### **MOLECULAR MICROBIAL GENETICS**

**Marks 50 (02 Credits)**

Isolation and Purification of genomic DNA from *E. coli* / *Bacillus* sp.

1. Isolation and purification of bacterial Plasmid
2. Estimation of DNA: UV method, Spectrophotometric confirmation of DNA purity
3. Estimation of DNA: Diphenyl amine Method,
4. Isolation and purification of RNA from yeast
5. Estimation of RNA: Orcinol method.
6. Determination of LD50 value for E. coli using ultraviolet radiations (UV survival pattern of E. coli/yeast)
7. Studies on light and dark repair mechanisms in E. coli/yeast using UV radiations
8. Isolation of antibiotic resistant mutants / auxotrophic mutant. (Replica plate method)
9. Studies on regulation of synthesis of inducible enzyme beta galactosidase in E. coli
10. Studies on gene transfer by conjugation\Transformation in E. coli.

#### REFERENCES

1. Lewin B. (2013) Gene XI, Pearson Prentice Hall, Pearson Education, Inc., NT, USA
2. Clark, David P. and Nan Pazdernik (2013) Molecular biology, (2e) Academic Press and Elsevier
3. Malacinski GM (2003) Freifelder'S Essentials of Molecular Biology, 4th edn., Jones &Batiett, London
4. David Freifelder (2004) Molecular Biology, Narosa Publishing House.
5. Ulhas Patil, JS Kulkarni, AB Chaudhari and SB Chincholkar (2021) Foundations in Microbiology, (10<sup>th</sup> ed) NiraliPrakashan, Pune
6. Watson JD, Baker JA, Bell SP, Gann A, Lewin M, Losick R (2004) Molecular Biology of the Gene, Benjamin Cummings- CSHL Press, USA.
7. Berg JM, Tymoczko, JL, Stryer, L (2012) Biochemistry 7th edn. W. H. Freeman &Co.New York.
8. Wink M. (2006) An Introduction to Molecular Biotechnology, Wiley-VCH Verlag Gmbh& Co., Weinheim, Germany
9. Weaver, RF (1999) Molecular Biology, WCB McGraw-Hill Co. Inc., NY (ISBN: 0-697- 14750-9).
10. Nelson DL& Cox MM (2005) Lehninger's Principles of Biochemistry, 4th edn., McMillan Worth Publ. Inc. NY.
11. Russell, PJ (1998) Genetics, 5th edn, Benjamin-Cummings Publ. Co. Inc., NY

12. Klug, WS and Cummings, MR (2003) Concepts of Genetics, 7th edn., Pearson Education Inc.,

13. David Plummer, (2017) An Introduction to Practical Biochemistry | 3rd Edition McGraw Hill

a. \*\*\*\*\*

## **PAPER TH-XII**

### **ENVIRONMENTAL MICROBIAL TECHNOLOGY**

**Marks 100 (04 Credits)**

#### **Unit – I Environment and Ecosystems**

**(0.8 Credits)**

Definitions, biotic and abiotic environment. Interaction between biota and its environment, Environmental segments. Composition and structure of environment. Concept of Habitat, Concept of biosphere, communities and ecosystems. Ecosystem characteristics structure and function. Homeostasis of ecosystem, Food chains, food webs and trophic structures. Ecological pyramids. Ecological Succession



**Unit – II Eutrophication****(0.8 Credits)**

Water pollution and its control: Need for water management. Sources of water pollution. Measurement of water pollution, Eutrophication: Definition, causes of eutrophication, and microbial changes in eutrophic bodies of water induced by various inorganic pollutants. Effects of eutrophication on the quality of water environment, factors influencing eutrophication. Qualitative characteristics and properties of eutrophic lakes. Measurement of degree of eutrophication. Algae in eutrophication, algal blooms, their effects and toxicity, coloured waters, red tides, and cultural eutrophication. Physicochemical and biological measures to control eutrophication.

**Unit –III Effluent treatment techniques****(0.8 Credits)**

Microbiology of wastewater and solid waste treatment: -Waste-types-solid and liquid waste characterization, physical, chemical, biological, aerobic, anaerobic, primary, secondary and tertiary treatments. Anaerobic processes: Anaerobic digestion, anaerobic filters, and upflow anaerobic sludge. Treatment schemes for effluents of dairy, distillery, tannery, sugar and antibiotic industries (Types, microbes used, types of Effluent Treatment Plants). Bioconversion of Solid Waste and utilization as fertilizer. Bioaccumulation of heavy metal ions from industrial effluents.

**Unit – IV Bioremediation of Xenobiotics****(0.8 Credits)**

Definition of recalcitrant/ xenobiotic compounds, their presence in the natural ecosystem, Concept and consequences of biomagnification, Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behavior, biomagnification and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants and pesticides. Genetically Modified Organisms released and its environmental impact assessment and ethical issues.

**Unit – V Global environmental problems****(0.8 Credits)**

Concept of sustainable development. Need of sustainable development, Role of Microbial technology for achieving sustainable development, Improving and restoration of Barron/ degraded lands, Renewable energy sources using microorganisms, Biodiversity and its conservation, Ozone depletion, UV-B, greenhouse effect and acid rain, their impact and biotechnological approaches for management.

**PRACTICAL****PAPER P-XII**



## **ENVIRONMENTAL MICROBIAL TECHNOLOGY**

**Marks 50 (02 Credits)**

1. Physical analysis of sewage / industrial effluent by measuring total solids, total dissolved solids and total suspended solids.
2. Determination of indices of pollution by measuring BOD / COD of different effluents.
3. Bacterial reduction of nitrate from ground waters.
4. Isolation and purification of degradative plasmid of microbes growing in polluted environments.
5. Recovery of toxic metal ions of an industrial effluent by immobilized cells.
6. Utilization of microbial consortium for the treatment of solid waste [Municipal Solid Waste].
7. Biotransformation of toxic chromium (+6) into non-toxic (+3) by *Pseudomonas* species.
8. Tests for the microbial degradation precursors of aromatic hydrocarbons / aromatic compounds.
9. Reduction of distillery spent wash (or any other industrial effluent) BOD by bacterial cultures.
10. Microbial dye decolorization / adsorption.

### **REFERENCES:**

1. Bioremediation by Baker K.H. and Herson D.S. 1994, McGraw Hill Publications, New York.
2. Waste Water Engineering- Treatment, Disposal and Re-use by Metcalf and Eddy, Tata McGraw Hill, New York
3. Pollution: Ecology and Biotreatment by EcEldowney S., Hardman D.J. 1993 Longman Scientific Technical.
4. Environmental Microbiology edited by Ralph Mitchell, John Wiley and Sons., New York.

5. Waste Water Microbiology, 2 nd Edition by Bitton.
6. Chemistry and Ecotoxicology of Pollution, Edited by Des. W. Connell, G.J. Miller, Wiley Interscience Publications.
7. Environmental Biotechnology Edited by C.F. Forster and D.A. John Wase, Ellis Horwood Ltd.
8. Advances in Waste water Treatment Technologies 1998 Vol. I and II by R.K. Trivedy, Global Science Publications.
9. Biocatalysis and Biodegradation: Microbial transformations of organic compounds. 2000, by Lawrence P. Wacekett, C. Douglas Hershberger, ASM Publications
10. A Manual of Environmental Microbiolgy 2 nd edition 2001 by Christon J. Hurst( Chief Editor), ASM Publications.
11. Biodegradation and Bioremediation, Academic Press, San Diego.
12. Biotechnology in the sustainable environment, Plenum Press, New York.
13. Basic Principles of Geo Microbiology by A.D. Agate, Pune.

REVISED SYLLABUS OF

M. Sc.  
(MICROBIOLOGY)SEMES  
TER-IV

Paper No.	Title of the theory paper	Marks/Credits	Practical	Marks/Credits
Semester IV				
Th-XIII	Recombinant DNA Technology	100/04	P-XIII	50/02
Th-XIV	Fermentation Technology	100/04	P-XIV	50/02
Th-XV	Bioinformatics, Microbial Genomics and Proteomics.	100/04	P-XV	50/02
Th-XVI	Pharmaceutical Microbiology	100/04	P-XVI	50/02



**SEMESTER IV**

**PAPER TH - XIII**

## RECOMBINANT DNA TECHNOLOGY

Marks 100 (04 Credits)

### Unit-I. Enzyme And Basic Techniques Used In rDNA Technology (0.8 Credit)

**Core technique of rDNA:** Restriction-methylation system in bacteria; Discovery of restriction enzymes, Approach of genetic engineering, Significance of rDNA in cloning and genetic engineering, Common steps of core rDNA technology

**Enzymes used in rDNA;** Restriction endonuclease (Nomenclature); DNA ligase (T4 & E.coli ligase); Reverse transcriptase; Alkaline phosphatase, polynucleotide kinase, Nucleotide transferase, Bal 31 and S1 nuclease, DNA polymerase, RNase, Ribozymes; Commercial source of enzymes and Kit used in rDNA technology

**Basic techniques:** Isolation of genomic-DNA from various cell (Human, bacteria, plant fungi); Isolation of plasmid-DNA from bacteria and yeast.

**Electrophoretic separation of DNA:** Agarose gel electrophoresis, PAGE, Pulse field gel electrophoresis, DISC gel electrophoresis, and Separation of purified DNA from Gel, Southern and Northern Blotting

**Methods of detection for nucleic acids-** radioactive labeling of nucleic acids and autoradiography; fluorescence detection of nucleic acids; and chemical tagging with biotin or digoxigenin, DNA-probe, RNA-probe.

### Unit-II Advanced Techniques In rDNA Technology

(0.8 CREDIT)

**Principle, technique, and applications of -** chromosome walking, chromosome jumping, RFLP, RAPD, AFLP, DNA fingerprinting, Chromosome microdissection and micro cloning, Fluorescence in Situ Hybridization (FISH)

**Microarray-** principle, methodology, advantages, and applications.

**DNA sequencing:** sequencing-Maxam-Gilbert, Sanger's dideoxy and automated methods of DNA sequencing.

**Nucleic acid amplification by Polymerase chain reaction (PCR):** Principle and General procedure of PCR, Primer designing, Thermal cycler

**Types of PCR –** Principle and significance of Inverse PCR, asymmetrical PCR, multiplex PCR, Hot start PCR, Reverse transcriptase PCR (RT-PCR), Real-time quantitative PCR and immuno PCR.

### Unit-III Cloning Vectors

(0.8 Credit)



General Properties of Cloning Vectors, Useful Traits for Cloning Vectors, Specific Types of Cloning Vectors

Criteria to select the cloning vector

**Cloning Vectors for E. coli:** Plasmids Cloning vectors: The nomenclature of plasmid cloning vectors; Properties and significance of pBR322, pUC8; pGEM3Z

Bacteriophage Cloning vectors -:  $\lambda$  bacteriophage, M13 bacteriophage and cosmid

**Cloning Vectors for yeast:** 2  $\mu$ m plasmid, Yeast episomal plasmids; YAC vector

**Cloning vectors for higher plants:** Ti plasmid of *Agrobacterium tumefaciens*; Limitations of cloning with *Agrobacterium* plasmids; Ri plasmid, Plant viruses as cloning vectors (Caulimovirus vectors, Geminivirus vectors)

**Cloning Vectors for animal:** SV 40 plasmid vectors, retrovirus vectors.

**Concept, example, and significance of Shuttle vectors**

#### **Unit -IV Gene Cloning Technique**

**(0.8 Credit)**

**Isolation of gene of desired interest:** Physical and Enzymatic using Restriction endonucleases, modification of cut ends, Chemical synthesis of genes and methods joining the fragments into vectors

**Host and rDNA insertion in host Cell:** Various types of hosts used in rDNA technology, Ideal features of host Various methods of transformation, Isolation of recombinant clones.

**Gene library:** Construction of genomic and cDNA libraries: concept of library construction, significance of gene library

**Selection and Identification of clones containing recombinant vectors:** Selectable and scorable markers, Insertional inactivation, colony hybridization, plaque lift assay, In Vitro translation (Hybrid arrested translation and hybrid release translation). Fluorescence activated cell sorter, Mini and maxi cells.

**Screening for protein expression-** Reporter gene expression, Phage display, south-western, Immunodiffusion, Radiolabeled antibody test (RIA), ELISA, and western blotting.

#### **Unit -V Applications Of Genetic Engineering**

**(0.8 Credit)**

Production of recombinant Insulin, Covid Vaccine production by rDNA technology, Construction of BT cotton plant and transgenic plants; Knockout mice for medical research, CRISPR-CAS and genome editing, DNA forensics; Genomics and precision medicine; Genetically modified foods; Gene therapy; Bioethics in Genetic engineering.

**PRACTICAL**  
**PAPER PR - XIII**  
**RECOMBINANT DNA TECHNOLOGY**

1. DNA analysis using agarose Gel Electrophoresis.
2. Determination of melting point of DNA
3. Restriction Digestion analysis of DNA.
5. Studies on DNA Ligation
6. Southern blotting /Northern blotting /
7. Western blotting or Immunodiffusion
8. DNA amplification by PCR
9. Gene Cloning: - Cloning of GFP Gene
10. Blue white screening
11. Demonstration RAPD / RFLP/ribotyping analysis/RTPCR

**REFERENCES**

1. T.A. Brown (2016) Gene Cloning And DNA Analysis- An Introduction (7 ed) Wiley Blackwell
2. Dominic W. S. Wong (2018) The ABCs of Gene Cloning, (3e) Springer Publication
3. Clark, David P. and Nan Pazdernik (2013) Molecular biology, (2e) Academic Press and Elsevier
4. Watson JD, Baker JA, Bell SP, Gann A, Lewin M, Losick R (2004) Molecular Biology of the Gene, Benjamin Cummings- CSHL Press, USA.
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6. Wink M. (2006) An Introduction to Molecular Biotechnology, Wiley-VCH Verlag GmbH & Co., Weinheim, Germany
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9.Klug, WS and Cummings, MR (2003) Concepts of Genetics, 7th edn., Pearson Education Inc.,

10.Alexander J. Ninfa, David P. Ballou, Marilee Benore (2009) Fundamental Laboratory Approaches for Biochemistry and Biotechnology Fitzgerald Science Press, Maryland

## **PAPER XVI**

### **PHARMACEUTICAL MICROBIOLOGY**



**MARKS: - 100/ (04 Credits)**

**Unit I: Principles of Antimicrobial chemotherapy. (0.8 Credit)**

Introduction and selection of antimicrobial agents Concept of Bioassay, therapeutic index, MIC and LD50. Penetrating defenses, as cellular permeability barriers, Cellular transport system and drug diffusion.

Definition and classification of antibiotics, with respect to their mechanism of action, Antibacterial spectrum, Structural activity and relationship (SAR), acquisition of drug resistance, pharmacokinetics and adverse drug effect  $\beta$ -Lactum (Penicillin, Amoxicillin, cefuroxime), aminoglycosides (Streptomycin, Gentamicin), Tetracyclines (Tetracyclin, doxycyclin), Macrolides (Erythromycin, Azithromycin), Peptide antibiotics (Bacitracin, polymyxin), Sulphonamides (sulfamethoxazole), co-trimoxazole and quinolones (ciprofloxacin) Chloramphenicol, trimethoprim.

**Unit II: Molecular aspects of Antimicrobial Chemotherapy. (0.8 Credit)**

Definition, classification, Mechanism of action and examples of chemical disinfectants, antiseptic and preservatives. Definition, classification, Mechanism of action and examples of antiviral (Acyclovir, zidovudine), Antifungal (amphotericin B, Fluconazole) and Antitumor (Bleomycin, ductinomycin) antibiotics. Drug delivery system in gene therapy. Approaches and safety considerations associated with gene therapy. Immunological problems associated to gene therapy. Pre-requisites and candidate diseases for human gene therapy. Drug carrier, Macromolecular, cellular, and synthetic Viral and non viral mediated gene delivery. Introduction, concept and types of drug targeting, cellular level events of drug targeting, targeting ligands, blood cell receptors for endogenous compounds/ ligands, carrier and vesicular system for targeting, specialized liposomes for cellular drug targeting.

**Unit III: Microbial Production and spoilage of Pharmaceutical Products.(0.8 Credit)**

Manufacturing procedure and in-process control of Pharmaceutical products: Bacterial and Viral vaccine, sterile injectables, Solid dosage forms, liquid orals and Ointments New Vaccine production: DNA vaccines, synthetic, peptide vaccines, multivalent subunit vaccines, edible vaccines and their trials. Microbial production and

applications of therapeutic / diagnostic enzymes: Asparaginase, Streptokinase, beta lactamases Microbial production contamination and spoilage of Pharmaceutical products (sterile injectables, ophthalmic preparations and implements) and their sterilization Applications of Biosensors in pharmaceutical industries.

#### **Unit IV: Regulatory Practices and Policies in Pharmaceutical Industries. (0.8 Credit)**

FDA, Govt. regulatory practices and policies. Concept of R & D and Financing R and D, Quality control and market planning. Significance of IP, BP and USP.

Reimbursement of drugs, Biological and legislative aspects. Rational drug design (Quantitative structure activity relation QSAR of drug) and computational aspect of drug design. Screening and utilization of bioactive phytochemicals. Patenting of drugs and Biological products.

#### **Unit V: Quality Assurance and Validation. (0.8 Credit)**

Regulatory aspects of QC, QA, and QM. GMP , GLP and CMP in Pharma Industry. ISO, WHO, USFDA certification. Microbial Limit test of Pharma products. Sterility testing , pyrogen testing and LAL test of Sterile Pharma products. Sterilization- heat, D-value, Zvalue and survival curve, radioactive, gaseous and filtration. Chemical and biological indicators. Designing layout for microbiology laboratory.

### **PRACTICALS**

#### **PAPER XVI: PHARMACEUTICAL MICROBIOLOGY**

**MARKS: 50 (02 Credits)**

1. Spectrophotometric/ Microbiological methods for the determination of Griseofulvin.
2. Microbial production and Bioassay of Penicillin.
3. Bioassay of Chloramphenicol/Streptomycin by plate assay method or turbidometric assay methods.
4. Screening, Production and assay of therapeutic enzymes: Glucose Oxidase/Asperginase/beta lactamase.
5. Treatment of bacterial cells with cetrimide, phenol, and detection of Leaky substances such as amino acids, nucleic acids as cytoplasmic membrane damaging substances.



6. Determination of MIC and LD50 of Ampicillin / Streptomycin.
7. Sterility testing by using *B. stercorarius*/ *B. subtilis*.
8. Testing for microbial contamination. Microbial loads from syrups, suspensions, creams, and other preparations, Determination of D-value and Z-value for heat sterilization in pharmaceuticals.
9. Determination of antimicrobial activity of chemical compounds (like phenol, resorcinol and formaldehydes) Comparison with standard products.

## REFERENCES

1. Pharmaceutical Microbiology- Edited by W. B. Hugo & A.R. Russel Sixth Edition. Blackwell Scientific Publications.
2. Lippincott's illustrative Reviews: Pharmacology Edition: 02 Maryjnycek by Lippincott's review Publisher Philadelphia 1997.
3. Principles of medicinal chemistry Vol. 1 by Kadam S.S., Mahadik K.R., Bothra K.G. Edition: 18, Nirali Publication.
4. Pharmacognosy by Gokhle S.D., Kothakota C.K.. Edition: 18, Nirali Publication.
5. Biotechnology – Expanding Horizon by B.D. Singh ., First Edition, Kalyani Publication, Delhi.
6. Analytical Microbiology- Edited by Fredrick Kavanagh volume I &II. Academic Press New York.
7. Pharmaceutical Biotechnology by S. P. Vyas & V.K. Dixit. CBS publishers & distributors, New Delhi.
8. Quinolone antimicrobial agents- Edited by David C. Hooper, John S. Wolfson. ASM Washington DC.
9. Quality control in the Pharmaceutical industry - Edited by Murray S. Cooper Vol. 2, Academic Press New York.
10. Biotechnology- Edited by H.J. Rhein & Reed, vol 4 VCH publications, Federal Republic of Germany.
11. Good manufacturing practices for Pharmaceuticals. By Sydney H. Willing, Murray M. Tuckerman, William S. Hitchings IV. Second edition Marcel Dekker NC New York.
12. Advances in Applied Biotechnology series Vol.10, Biopharmaceutical in transition., Industrial Biotechnology Association by Paine Webber., Gulf Publishing Company Houston.



13. Drug carriers in biology & medicine Edited by Gregory Gregoriadis. Academic Press New York.

14. Quality Assurance in Microbiology by Rajesh Bhatia, Rattan Lal Ihhpunjani. CBS publishers & distributors, New Delhi.

**PAPER NO. - PXV**

**BIOINFORMATICS, MICROBIAL GENOMICS AND PROTEOMICS.**

## **100 Marks (Credit – 04)**

### **Unit- I Bioinformatics and its Applications**

**(0.8 Credit)**

Introduction to Bioinformatics: Introduction and overview of History of Bioinformatics, relationship between molecular evolution and bioinformatics. Structure function relationship, Applications of Bioinformatics

Biological Databases: Types and importance

Nucleotide sequence databases; Primary nucleotide sequence databases- EMBL, GenBank, DDBJ (Sequence file format, sequence submission and retrieval of information). Overview of Secondary nucleotide sequence databases

Protein sequence database – SWISS PROT, TrEMBL, PIR, MIPS

Protein Family database – PFAM, PROSITE, PRINTS, BLOCKS, eMOTIF

Protein Structure database – PDB, SCOP, CATH

### **Unit – II Whole Genome Analysis**

**(0.8Credit)**

Human genome project, uses and application, Genome information and special features, coding sequences, (CDS), Untranslated regions (UTR'S), Expressed sequence Tags (EST). Approach to gene identification, Gene Prediction- Importance and Methods.

Genomic and cDNA library, BacterialArtificial Libraries, Shotgun Libraries and sequencing, Conventional sequencing (Sanger,Maxam and Gilbert method), Automated sequencing.

### **Unit – III Sequence Analysis**

**(0.8 Credit)**

Sequence Alignment, Algorithms; uses and applications, Local and Global sequence alignment, Pairwise alignment:

Scoring Matrix – PAM, BLOSUM,

Dynamic programming – Needleman – Wunsch, Smith- waterman

Heuristic Methods- FASTA, BLAST for protein and nucleic acid.

Multiple Sequence Alignment;ClustalW ,PROFILE,Hidden Markov Models (HMMs)

Annotation of Gene, Open reading frames (ORF),

Phylogenetic tree construction methods

### **Unit- IV DNA – Microarray**

**(0.8 Credit)**

Concept of expression analysis, SAGE, DNA micro array, Spotted arrays, Oligonucleotide arrays, Designing the experiment, Two– colour micro array experiments, Computational analysis of microarray data.

Printing of oligonucleotide and PCR products on glass slides, nitrocellulose paper. Whole genome analysis for global patterns of gene expression using fluorescent labeled cDNA or end labeled RNA probes, analysis of SNP Using DNA chips.

Overview of tools for microarray analysis: xCluster, MADAM,

Advantage, disadvantage and application of DNA microarray.

### **Unit- V Proteomics**

**(0.8 Credit)**

Definition, Protein sequence information, composition and properties, physicochemical properties based on sequence, database, Two dimensional separation of total cellular protein, isolation and sequencing, Analysis individual protein spot by Mass spectroscopy (MALDI- TOF), Electro Spray Ionization (ESI), Tandem mass spectroscopy (MS/MS) tryptic digestion and peptide Mass finger printing (PMF), 3D structure prediction methods; Homology, ab initio, Advantage, disadvantage and application of protein microarray.

## **PRACTICAL**

### **PAPER- P-XV**

### **BIOINFORMATICS, MICROBIAL GENOMICS AND PROTEOMICS.**

**Marks 50 (02 Credits)**

Use of Internet /software for sequence analysis of nucleotides and proteins. 1. Studies of public domain databases for nucleic acid and protein sequences. 2. Determination of protein structure (PDB) by using RASMOL, CN -3D software 3. Genome sequence analysis by using BLAST algorithm 4. Protein sequence analysis by using BLAST algorithm

### **REFERENCES**

1. Bioinformatics. 1998 by Baxevanis
2. Bioinformatics 2000 by Higgins and Taylor OUP.
3. Nucleic acid Research 2001. Jan. Genome database issue.
4. The Internet and the new Biology: Tools for Genomics and Molecular Research by Peruski, Jr. and Peruske (ASM) 1997.
5. Functional Genomics. A Practical Approach Edited by Stephen P Hunt and Rick Liveey (OUP) 2000.



6. DNA microarrays: A practical approach edited by Mark Schena (OUP)
7. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis.
8. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgs.
9. Bioinformatics - from Genomes to drug. 2 volumes by Lenganer.
10. Bioinformatics Methods and Protocols - Misener.

## **PHARMACEUTICAL MICROBIOLOGY**

**Marks 100 (04 Credits)**

### **Unit I: Antibiotics Vitamins, and enzymes**

**(0.8 Credit)**

Antimicrobial chemotherapy: Brief History of Chemotherapy; General Properties of Antimicrobial Agents (Selective Toxicity, Spectrum of Activity, Modes of Action, Kinds of Side Effects, The Resistance of Microorganisms; Determining Microbial Sensitivities to Antimicrobial Agents

Concept of Bioassay, The Disk Diffusion Method, The Dilution Method, Antibiotic assay (Indian pharmacopeia); Therapeutic index, MIC, MBC, MFC and LD50; Serum Killing Power, Automated Methods; Attributes of an Ideal Antimicrobial Agent

Structure, Mode of action, pharmacokinetics, and resistance of –

$\beta$ - Lactum (Penicillin, Amoxicillin, cefuroxime), aminoglycosides (Streptomycin, Gentamicin), Tetracyclines (Tetracyclin, doxycyclin), Macrolides (Erythromycin, Azithromycin), Peptide antibiotics (Bacitracin, polymyxin, ), Sulphonamides (sulfamethoxazole), co-trimoxazole and quinolones; Antiviral (Acyclovir, zidovudine), Antifungal (amphotericin B, Fluconazole) and Antitumor antibiotics. (Bleomycin, dactinomycin)

Vitamin: Mode of action, microbial production, pharmacokinetics, and significance of – Riboflavin, Cyanocobalamin.

Growth promotion test; Vitamin assay as per Indian pharmacopoeia

Enzymes: Therapeutic / diagnostic use of enzymes: Asparaginase, Streptokinase

### **Unit II Aspects of large-scale Vaccine manufacturing**

**(0.8 Credit)**

General aspects of immunization: Objectives of a vaccine/immunization program; Disease severity; Vaccine effectiveness; Safety; Public perceptions; Cost; Longevity of immunity; Immunization of special risk groups

Types of vaccine: Live vaccines, Killed and component vaccines (Toxoid vaccines; Bacterial cell component vaccines, Conjugate vaccines, Viral subunit vaccines); DNA vaccines

Vaccine manufacturing- The seed lot system

Bacterial vaccine: Production of the bacteria and the cellular components of bacterial vaccines; Fermentation; Processing of bacterial harvests

Viral vaccine: Production of the viruses and the components of viral vaccines; Growth of viruses; Processing of viral harvests  
Blending, Filling, and drying of vaccine  
Quality control in vaccine production - In process control; Final product control, Assays, Safety tests, Tests of general application  
Immune sera - Preparation and Quality control.

### **Unit III: Microbial control aspects in pharmaceutical Industry (0.8 Credit)**

Microbial contamination, spoilage, and preservation of medicines; Need to protect medicines against microbial spoilage, Products, and materials vulnerable to spoilage, Sources and control of microbial contamination, Sources and types of contaminating organisms, Factors influencing the growth of spoilage organisms, Control of contamination and spoilage during manufacture, Selection and use of preservatives, Preservative interactions with formulation components and containers  
Definition, classification, Mechanism of action and examples of chemical disinfectants, antiseptic and preservatives, Preservative efficacy tests, Disinfectant evaluation (Rideal-Walker and Chick-Martin tests, Kelsey-Sykes test); Aseptic conditions, Environmental monitoring, Biosafety levels, and biosafety cabinets  
Non-sterile products: Indian pharmacopeia specifications for the microbiological quality of major categories of pharmaceutical products; Methods of counting of microorganisms in pharmaceutical products; Microbial Limit test

### **Unit IV: Sterilization procedures and sterility assurance (0.8 Credit)**

Sterilization parameters - D value and Z value and F value  
Definition, classification, Mechanism of action of - Heat sterilization, Gaseous sterilization, Radiation sterilization, Filtration sterilization, High-level disinfection, Ultrahigh pressure, High-intensity light pulses, Ultrasonication, Gas plasma.  
Practical utility of sterilization process in pharma industry; Validation of a sterilization process - Process indicators (Chemical and biological indicators), Testing filtration efficacy, Limitations of sterilization methods  
QA of sterile products - Sterility testing, pyrogen testing and LAL test



### **Unit V: Quality Aspects and Regulatory Policies in Pharmaceutical Industries. (0.8 Credit)**

Regulatory aspects of QC, QA, and QM. GMP, GLP and CMP, CGMP in Pharma Industry. ISO, WHO, USFDA certification, of Pharma products.

Designing layout for microbiology laboratory, Autoclave validation, HEPA efficiency testing

FDA, Govt. regulatory practices and policies; Significance of pharmacopoeia, (IP, BP and USP), Pharmaceutical audit, Concept of R & D, Reimbursement of drugs, Rational drug design (Quantitative structure activity relation QSAR of drug) and computational aspect of drug design.

Patenting of drugs and biological products

### **PRACTICAL**

### **PAPER XVI**

### **PHARMACEUTICAL MICROBIOLOGY**

**Marks 50 (02 Credits)**

1. Sterility testing as per IP
2. Microbiological assay of Chloramphenicol/Streptomycin as per IP
3. Microbiological assay of vitamin
4. Screening, Production, and assay of therapeutic enzymes: Glucose Oxidase/Asperginase/beta lactamase.
5. Evaluation of disinfectant (RW test/ Chick martin/ Kelsey–Sykes test)
6. Determination of MIC and MBC of Ampicillin / Streptomycin. **OR** Determination of MIC and MFC of Amphotericin
7. Determine sterilization efficiency using biological indicators
8. Microbial limit test
9. Determination of D-value and Z-value for heat sterilization in pharmaceuticals.
10. Determination of efficacy of preservative
11. Environmental monitoring of pharmaceutical preparation sections

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2. Aulton's Pharmaceutics Edited by Michael E. Aulton and Kevin M. G. Taylor; Elsevier (2018)

3. Lippincott's illustrative Reviews: Pharmacology Edition: 02 Maryjnyceck by Lippincott's review Publisher Pheladelphia 1997.
4. Principles of medicinal chemistry Vol. 1 by Kadam S.S., Mahadik K.R., Bothra K.G. Edition: 18, Nirali Publication.
5. Pharmacognosy by Gokhle S.D., KoKateC.K.. Edition: 18, Nirali Publication.
6. Biotechnology – Expanding Horizon by B.D. Singh ., First Edition, Kalyani Publication, Delhi.
7. Analytical Microbiology- Edited by Fredrick Kavanagh volume I &II. Academic Press New York.
8. Pharmaceutical Biotechnology by S. P. Vyas & V.K. Dixit. CBS publishers & distributors, New Delhi.
9. Quniolinone antimicrobial agents- Edited by David C. Hooper, John S. Wolfson. ASM Washington DC. 9. Quality control in the pharmaceutical industry - Edited by Murray S. Cooper Vol. 2, Academic Press New York.
10. Biotechnology- Edited by H.J. Rhem& Reed, vol 4 VCH publications, Federal Republic of Germany. 11. Good manufacturing practices for Pharmaceuticals. By Sydney H. Willing, Murray M. Tuckerman, Willam S. Hitchings IV. Second edition Mercel Dekker NC New York.
11. Advances in Applied Biotechnology series Vol.10, Biopharmaceutical in transition., Industrial Biotechnology Association by Paine Webber, Gulf Publishing Company Houston.
12. Drug carriers in biology & medicine Edited by Gregory Gregoriadis. Acedemic Press New York.
13. Quality Assurance in Microbiology by Rajesh Bhatia, Rattan Lal Ihhpunjani. CBS publishers & distributors, New Delhi.

## **SERVICE COURSE-I**

### **Applied Agricultural Microbiology**

**MARKS:- 100(04 Credits)**

#### **Unit-I**

**(0.8Credit)**

**Introduction to biofertilizers,** Biofertilization processes - Decomposition of organic matter and soil fertility and vermicomposting. Mechanism of phosphate solubilization and phosphate mobilization. Nitrogen fixation - Free living and symbiotic nitrogen fixation. Ecto and endomycorrhizae and their importance in agriculture. Biotechnological application in nitrogen fixation.

#### **Unit-II**

**(0.8Credit)**

**Microorganisms as biofertilizers:** Biofertilizers and symbiotic associations; *Rhizobium* - taxonomy, physiology, host-*Rhizobium* interaction, mass cultivation; Associative and nonsymbiotic association -

*Azospirillum*, *Azotobacter*, Cyanobacteria (*Nostoc* and *Anabaena*) Mycorrhiza and actinorrhiza in plant nutrition and stress tolerance; Interaction of mycorrhiza with *Rhizobium* and *Pseudomonas*; Commercial production of biofertilizers, formulations and BIS specifications; their applications and limitations for Indian agriculture.

#### **Unit-III**

**(0.8Credit)**

**Nitrogenous Biofertilizers** - Isolation and purification of *Azospirillum* and *Azotobacter*, mass multiplication of *Azospirillum* and *Azotobacter*, formulation of inoculum of *Azospirillum* and *Azotobacter*, application of inoculants of *Azospirillum* and *Azotobacter*. Isolation and purification of *Rhizobium*, mass multiplication and inoculum production of *Rhizobium*, Methods of application of *Rhizobium* inoculants.

#### **Unit-IV**

**(0.8Credit)**

**Microorganisms as biopesticides:** Microbiology of plant surfaces; Principles and mechanism of



biological control; biocontrol agents for insect pest and weed control. Commercial production of biopesticides with reference to *Bacillus thuringiensis*; integrated pest management; Their applications and limitations for Indian agriculture.

## **Unit-V**

**(0.8 Credit)**

### **Plant Pathology**

Mode of entry of pathogens, disease symptoms, Brief account of algal disease, fungal disease, bacterial disease, viral disease, diseases caused by mycoplasmas and nematode. Specially - brown spot of rice, black stem rust of wheat, stem rot of jute, rice disease by Tungro virus, grey blight of tea, red rot of sugarcane, TMV, Blast of rice, leaf blight of potato, Powdery mildew of cucurbit) - dissemination and control measurement.

### **Reference Books:**

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- The nature and properties of soil. Authors - Harry buckman and Nyle C. Brady.

## Introduction to soil Microbiology International. Authors- Martin Alexander.

1. Introduction

2. The soil micro-organisms

3. The soil micro-organisms and the soil environment

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**Service Course -**  
**II Applied Medical Microbiology**

**MARKS:- 100(04 Credits)**

**HAEMATOLOGY**

**(02Credits)**

1. Methods of collection of blood.
2. Preparation and labeling of anticoagulant bulbs.
3. Preparation of various stain solutions.
4. Preparation of blood smears and staining them using different stains.
5. Hemoglobin estimation - different methods.
6. RBC count
7. WBC count by manual methods.
8. Platelet count
9. Estimation of E.S.R.
10. P.C.V.
11. Calculating absolute values.
12. Study of peripheral blood smear in different types of anaemia.
13. Reticulocyte count.
14. Test for sickling.
15. Osmotic fragility test.
16. Detection of foetal haemoglobin.
17. Haemoglobin electrophoresis.
18. Differential W.B.C. count and buffy coat preparation.



19. Study of P.B.S. in different types of leukemia.
20. Cytochemical stains for leukemias.
21. Bleeding and clotting time.
22. Prothrombin time.
23. Partial thromboplastin time with Kaolin.
24. Thromboplastin generation time.
25. Routine, naked eye and microscopic examination of stool and study of parasitic ova and cysts in the stool.
26. Routine physical, chemical and microscopic examination of urine.
27. Demonstration of normal and abnormal findings in pleural, pericardial, ascitic, cerebrospinal fluid and semen.
28. The use and maintenance of the following centrifuge, colorimeter, chemical balance, haematocrit, various types of pipettes, urinometer, microhaematocrit centrifuge.
29. L.E. cell preparation. Study of parasites in the blood.
30. Study of parasites in the blood.

#### **TRANSFUSIONOLOGY:**

**(02 Credits)**

1. Determination of blood group by both tube and slide methods.
2. Sources of errors in group determination—their elimination.
3. Titration of blood group antibodies in serum.
4. Coomb's test.
5. Major and minor cross matching (compatibility test),
6. Investigations of transfusion reactions.
7. Tests to detect diseases that can be transmitted through blood transfusion (VDRL test, tests for HbsAg, HIV using different methods).
8. Collection and storage of blood.

## REFERENCES:

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2. Practical Clinical Biochemistry-Verley Publications, W.H. Heinemann
3. A Biologist Guide to principle & Techniques of Practical Biochemistry :-  
William & Wilson, Edward Arnold
4. Lynch Medical Laboratory Technology-Rephale D.B, W.B Saunders.
5. Practical Biochemistry-Plummer
6. Text Book of Biochemistry-Ramkrishanan, Prasman & Rajan
7. Medical Biochemistry-A.C Deb
8. Medical Biochemistry-M.N. Chatterjee, Shinde
9. Medical Biochemistry-Das
10. Clinical Laboratory Methods -John D. Bener
11. Manual of Histopathological Techniques & their Diagnostic application-  
John D Bancroft, Hay C. Cook, Churchill Livingstone
12. Clinical Diagnosis by Laboratory Examination John A Kokmer.
13. Text Book of Pathology Vol. I & II-N.C. Dey
14. Clinical Laboratory Diagnosis-Levinson SA, MacFate R.D.
15. Clinical Lab. Methods & Diagnosis Vol. I & II-Alex C, SL Garelt.
16. Clinical Lab. Methods-John D Benger, Philip G. Achermann, Gelsaon Toro
17. Handbook of Histopathological Technique-C.F.A. Culling.
18. Histopathological & Histological Technique-J.A. Kierman.
19. A New short Text Book of Microbial & Parasitic Infections-B.I. Duerden, T.M.S. Reid,  
J.M. Jewsbury, D.C. Turk.
20. District Laboratory Practice in Tropical Countries Part-1 & 2-  
Monica Cheesbrough. Cambridge Low-Price Edn.

21. Medical Laboratory Technology Vol. I, II & III - K.L. Mukherjee.

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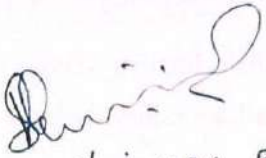
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26. Text Book of Microbiology - Chakrabourty.

  
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