M.Sc. Microbiology	2022

CENTRE FOR BIOTECHNOLOGY
UNIVERSITY COLLEGE OF ENGINEERING SCIENCE AND TECHNOLOGY
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
Kukatpally, Hyderabad-500 085,
Telangana State, India

Master of Science
in
MICROBIOLOGY

(FTPG)

COURSE STRUCTURE
&
DETAILED SYLLABUS
W.E.F.2022

EACH SEMESTER IS APPROXIMATELY 20-21 WEEKS DURATION INCLUDING EXAMINATIONS. EACH PERIOD IS ABOUT 45 MINITUES DURATION. THERE WILL BE NORMALLY FOUR SESSIONS PER DAY EACH OF ABOUT 90 MINITUES DURATION. TWOSESSIONS OF LABORATORY IS EQUIVALENT TO ONE SESSION OF THEORY

M.Sc. Microbiology **2022**

Centre for Biotechnology (CBT)
M.Sc MICROBIOLOGY Course
Structure

Semester I

Subject Code	Course Title	Int. Marks	Ext. Marks	L	P	C
1MBPC101	**Program Core – I** Cell Biology	40	60	3	-	3
1MBPC102	**Program Core – II** Microbiology	40	60	3	-	3
1MBPC103	**Program Core – III** Microbial Biochemistry	40	60	3	-	3
1MBPE104	**Program Elective- I** 1. Microbial Genetics & Molecular Biology 2. Microbial Physiology & Metabolism	40	60	3	-	3
1MBOE105	**Open Elective -I** 1. Basic Mathematics & Biostatistics 2. Bioenterprenurship	40	60	3	-	3
1MBL106	**Lab I** -Cell Biology & Microbiology Lab	40	60	-	6	3
1MBL107	**Lab II** - Microbial Biochemistry & Microbial Genetics and Molecular Biology Lab/Microbial Physiology & Metabolism Lab	40	60	-	6	3
1MBS108	SEMINAR	-	50	3	-	2
TOTAL		**280**	**470**	**18**	**12**	**23**

Semester II

Subject Code	Course Title	Int. Marks	Ext. Marks	L	P	C
2MBPC209	**Program Core – IV** Enzymology & Bioenergetics	40	60	3	-	3
2MBPC210	**Program Core – V** Immunotechnology	40	60	3	-	3
2MBPC211	**Program Core – VI** Virology	40	60	3	-	3
2MBPE212	**Program Elective- II** 1. Fermentation Technology 2. Microbial Biotechnology	40	60	3	-	3
2MBOE213	**Open Elective -II** 1. Microbial Ecology & Environmental Microbiology 2. Bioethics, Biosafety & Regulatory Affairs	40	60	3	-	3
2MBL214	**Lab III** Enzymology & Bioenergetics & Virology Lab	40	60	-	6	3
2MBL215	**Lab IV** Immunotechnology &Fermentation Technology Lab/Microbial Biotechnology lab	40	60	-	6	3
2MBS216	Seminar	-	50	3	-	2
TOTAL		**280**	**470**	**18**	**12**	**23**

Semester III

Subject Code	Course Title	Int. Marks	Ext. Marks	L	P	C
3MBPC317	**Program Core -VII** r-DNA Technology	40	60	3	-	3
3MBPC318	**Program Core- VIII** Bioinformatics	40	60	3	-	3
3MBPC319	**Program Core - IX** Medical Microbiology	40	60	3	-	3
3MBPE320	**Program Elective- III** 1. Bioanalytical Techniques 2. Research Methodology & Communication Skills	40	60	3	-	3
3MBOE321	**Open Elective -III** 1. Food Science & Technology 2. Pharmaceutical Microbiology	40	60	3	-	3
3MBL322	**Lab V** r-DNA Technology & Medical Microbiology Lab	40	60	-	6	3
3MBL323	**Lab VI** Bioinformatics and Bioanalytical Techniques Lab	40	60	-	6	3
3MBS324	Seminar	-	50	3	-	2
TOTAL		**280**	**470**	**18**	**12**	**23**

SEMESTER: IV

Subject Code	IV Semester	Int. Marks	Ext. Marks	L	P	C
Dissertation Work Review-I		**00**	**00**	**0**	**0**	**0**
4MB425	Dissertation Work Review-II	50	-	-	4	2
4MB426	Dissertation Evaluation (Viva Voce)	-	100	-	18	09
TOTAL		**50**	**100**	**-**	**22**	**11**

Marks: 750+750+750+150=**2400**

Credits: 23+23+23+11=**80**

Signature of the Subject Expert | Signature of the Subject Expert | Signature of the Subject Expert | Signature of the Subject Expert | Signature of the Subject Expert

Signature of the Subject Expert | Signature of the Subject Expert | Signature of the Subject Expert | Signature of the Subject Expert | Signature of the Subject Expert

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PROGRAM CORE I

CELL BIOLOGY

Course Objective: The cell biology course provides a basic understanding of the structure and function of cellular organelles and components, and the functional interaction of the cell with its microenvironment

UNIT-I: CELL STRUCTURE AND FUNCTION: Diversity of cell size and shape; Cell theory; Structure of Prokaryotic and Eukaryotic cells; Cellular organelles and their organization, Intracellular compartmentalization–Endoplasmic reticulum– types and function, Structure and function of peroxisomes, endosomes and lysosomes, Structure functions of mitochondria, and chloroplast; Extracellular matrix, Structure and function of cell wall in microbes.

UNIT-II: PLASMA MEMBRANE STRUCTURE AND FUNCTION: Chemical composition and molecular arrangement (lipid bilayer, membrane proteins and carbohydrates), models of membranes (fluid mosaic)., Membrane Transport: Active and passive transport of ions, Na+/K+ pump, ATPase pumps, Co-transport, Symport, Antiport, Endo cytosis and Exocytosis.

UNIT-III: CELL INTERACTIONS AND CYTOSKELETON: Cell adhesion molecules: cadherins, Immunoglobulin like molecules, integrins and selectins. Cell junctions: tight junction, desmosome, hemidesmosome and gap junctions. Microtubules, microfilaments and their dynamics. Centrosome, cilia, flagella. Mitotic apparatus and movement of chromosomes.

UNIT-IV: CELL CYCLE AND CHECK POINTS AND CANCER: Cell cycle- Various phases of cell cycle, Interphase, Mitosis, Meiosis and Cytokinesis Cell cycle Control & Checkpoints, Disruption in cell cycle; Cancer; Types and stages. Tumor suppressor genes and protooncogenes. Molecular basis of cancer.

UNIT-V: CELL SIGNALING, APOPTOSIS AND NECROSIS: Overview, Cytosolic, Nuclear & membrane bound receptors, Concept of Secondary messengers, cAMP, cGMP, Protein kinases, G proteins, Signal transduction mechanisms. Wnt, JAK-STAT pathways. Senescence, Necrosis– classification, morphological patterns of necrosis, causes of necrosis, Apoptosis - programmed cell death; mechanisms of apoptosis; apoptosis triggered by internal signals; apoptosis triggered by external signals; apoptosis inducing factor; apoptosis in cancer Apoptosis - programmed cell death; mechanisms of apoptosis; apoptosis triggered by internal signals; apoptosis triggered by external signals; apoptosis inducing factor; apoptosis in cancer.

COURSE OUTCOMES:

At the end of the course student will be able to

CO1. Classify organisms, understand the basic differences between prokaryotic and eukaryotic cells, structural and functional integrity of a cell.
CO2. Evaluate the transport across plasma membrane transport across the organelles.
CO3. Analyze the cellular interactions and importance of cytoskeleton.
CO4. Evaluate the molecular mechanism behind cell cycle, causes of deregulation of cell cycle and effects
CO5. Understand the molecular mechanism of cell signaling, different types receptors, different signal transduction pathways with examples, difference between apoptosis and necrosis.

TEXT BOOKS:

1. Molecular Biology of cell, Alberts. B et al.
2. Molecular Cell Biology, Lodish et al.
3. Developmental Biology, SF Gilbert, Sinauer Associates Inc.
4. Cell in Development and inheritance, EB Wilson, MacMilan, New York.
5. Developmental Biology- Scott F Gilbert.
6. Essential Developmental Biology - Jonathan Slack
7. Developmental Biology,-Werner A Muller

REFERENCE BOOKS:

1. Reproduction in Eukaryotic cells, DM Prescott, Academic press.
2. Principles of Development - Lewis Wolpert
3. Fertilization, FT Longo, Chapman and Hall
4. The Coiled Spring, Ethan Bier, Cold Spring Harbor Press.

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PROGRAM CORE II

MICROBIOLOGY

Course Objective: The main objective of this course is to provide knowledge of the classification & identification of microorganisms, their nutrition, growth & ecological characteristics, culture & control methods, and genetics.

Unit – I. Pioneers of Microbiology:
Microscopy - Principles, Working and Applications of Bright Field Microscope, Fluorescent Microscope, Phase Contrast Microscope, Electron Microscope. **Microbial Cell Structure:** Prokaryotic & Eukaryotic cells, Organization and function of Cellular Organelles. General Characteristics & Economic importance of Bacteria, Algae, Fungi, & Protozoa's.

Unit – II. Control of Microorganism:
Control of Microorganism by Physical and Chemical Agents. Narrow and Broad Spectrum Antibiotics, Mode of action of antimicrobial agents. Antibiotic resistance mechanisms.

Unit – III. Microbial Growth and Nutrition:
Microbial Growth. Bacterial generation time. Monoauxic, Diauxic and Synchronized Growth Curves. Factors affecting microbial growth. **Principles of Microbial Nutrition**: Nutritional requirements, Major & Minor elements, Trace metals and Growth factors, Nutrient media (selective, differential, enriched, enrichment and special purpose media). Nutritional types based on energy source, carbon source and electron donor.

Unit – IV. Maintenance and preservation of microbial cultures:
Sub culturing, Slant culture, Stab culture, Soil culture, Mineral oil overlaying, Glycerol preservation and Lyophilization. Types of culture collection centers - Indian and Global - ATCC, MTCC and NCIM etc.

Unit – V. Identification Methods and Classification of Bacteria:
Microscopic Identification Characteristics, Staining methods. Ecological Identification Methods, Nutritional (Cultural) Identification Characters, Biochemical Identification Methods, Immunological Characteristics, Molecular and Genetic Characteristics Identification (16s rRNA). **Principles of Bacterial Taxonomy and Classification:** Numerical Taxonomy, Bergy's Manual and its importance, General properties of bacterial groups.

COURSE OUTCOMES:

At the end of the course student will be able:

CO1. Understand the basic information of the classification of microorganism and ultra structure of bacteria
CO2. Evaluate the knowledge of control of microorganisms.
CO3. Understand the Microbial Growth and Preservation of microorganisms.
CO4. Understanding the Knowledge of Identification methods, Classification and bacterial Taxonomy.
CO5. Analyze the knowledge of Microbial Genetics.

TEXT BOOKS:

1. A. J. Salle, Fundamental Principles of Bacteriology.
2. Brock T.D. Madigan M.T. Biology of Microorganisms. Preentice Hall Int. Inc.
3. Pelczar, M. J., Chan, E.C.S. and Krieg, N.R. (2001). Microbiology: Concepts and Applications. McGraw-Hill Inc. USA.
4. Willey, J.M., Sherwood, L., and Woolverton, C. (2013). Prescott's Microbiology 9th Revised Edition, McGraw Hill Higher Education, New York.
5. Jeffery C. Pommerville (2000). Alcamo's Fundamentals of Microbiology, Jones and Bartlett Publishers.

REFERENCE BOOKS:

1. Bergey's Manual of Systematic Bacteriology – P.H.A. Sneath, N.S. Mair, M. Elizabeth.
2. The Prokaryotes – A. Balows, A. G. Thuper, M. Dworkin, W. Harder, K. Schleifer Springer – Verlag 1991.
3. Principles of Biochemistry – Zubey GL, Parson WW and Vance DE, WM. C. Brown Publishers, Oxford, England.
4. Biochemistry – Stryer L, W.H. Freeman Company, New York.
5. Modern Microbiology – Brige EA, WM. C. Brown Publishers, Oxford, England.
6. General Microbiology – Stainer RY, Ingraham JL, Wheelis ML, Painter PR, Macmillan Ltd, London.
7. The Bacteria – Gunsales IC, Stainer RY, Vol. I, II, III, Academic Press.

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PROGRAM CORE III

MICROBIAL BIOCHEMISTRY

Course Objective: The main objective of the course is to study the various biomolecules, structures, properties and their biological importance.

Unit-I: Chemistry of Life and Special Microbial Molecules: Bonds: Covalent and Non Covalent intereactions, Water as a biological solvent and its role in biological processes. Concept of buffer, pH, Henderson-Hasselbalch equation, strength of buffer, range of buffer, important biological buffers.

Unit-II: Bioenergetics: Thermodynamics, entropy, enthalpy, free energy, Gibbs free energy equation, Oxidation and Reduction reactions, high energy compounds, coupled reactions, determination of feasibility of reactions. ATP and other different groups of high energy phosphate compounds.

Unit-III:Carbohydrates & Lipids: Carbohydrates: Monosaccharide's, disaccharides, oligosaccharides and polysaccharides, Physico – Chemical Properties of Carbohydrates; Metabolism of Carbohydrates- Glycolysis, TCA cycle, HMP Shunt and Synthesis of Starch. **Lipids:** Saturated and unsaturated fatty acids, Physico - Chemical Properties of Lipids; Fatty acid oxidation, Biosynthesis of fatty acids (C16), Cholesterol synthesis.

Unit- IV: Proteins and Amino acids: Amino acids; classification of amino acids, Physico-Chemical Properties of Amino Acids; peptide linkage, structural classification of proteins, primary, secondary, tertiary and quaternary structures of proteins. Ramchandran plot, Physico - Chemical Properties of Proteins; Transamination, Deamination and Decarboxylation, Metabolism of Glutamate, Tryptophan, Cysteine and Proline.

Unit-V: Nucleic Acids: Physico - Chemical Properties on Nucleic Acids; Structure of purines, pyrimidines, nucleosides and nucleotides. Metabolism of purine and pyrimidine Nucleotides (Denovo and Salvage pathway).

COURSE OUTCOMES:

At the end of the course students will be able to

CO1. Understand the basics of biochemistry and buffers.
CO2. Evaluate the knowledge of bioenergetics in biochemistry.
CO3. Analyze the knowledge of carbohydrates and Lipids.
CO4. Evaluating the knowledge of Proteins and Amino acids.
CO5. Analyze the knowledge of types of nucleic acids and their properties.

TEXT BOOKS:

1. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J., and Stryer, L. (2015). *Biochemistry,* 8th Edition.
2. Geoffrey L. Zubay (2017). *Principles of Biochemistry by* Brown Co, USA.
3. Moat A.G., Foster J. W Spector M. P. (2002) *Microbial Physiology* John Wiley& Sons.
4. Nelson D. L. and Cox M. M. (2017) Lehninger *Principles of Biochemistry* by W. H. Freeman.
5. White, D, Drummond J. Fuqua C (2011) *The Physiology and Biochemistryof Prokaryotes* Oxford University Press.
6. Cohen G. N. (2014) *Microbial Biochemistry* Springer.
7. Ferrier D. R. (2013) *Lippincott's Illustrated Reviews: Biochemistry* LippincottWilliams & Wilkins.
8. Irwin H. Segel (2004) *Biochemical Calculations* Wiley.
9. Palmer, T. Horwood E (1991) *Understanding Enzymes* Wiley.

REFERENCE BOOKS:

1. Biochemistry White, Handler and R.B. Smith 7th Ed. Fundamentals of Biochemistry by J.L. Jain, Sunjay Jain AND Nitin Jain, S. Chand and Company L
2. Donald Voet& Judith G. Voet Biochemistry second edition .
3. Bacterial Physiology and Metaboloism BH Kim, GM Gadd –

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PROGRAME ELECTIVE I

i. MICROBIAL GENETICS & MOLECULAR BIOLOGY

Course Objective: The objective of this course is to explain the basics in microbial genetics, structure of nucleic acids, gene regulation and Demonstrate knowledge and understanding of the molecular machinery of living cells and the principles that govern the structures of macromolecules and their participation in molecular recognition.

UNIT-I: MICROBIAL GENETICS: Bacterial Recombinations-Discovery, gene transfer, molecular mechanism, detection, efficiency calculation and applications. Bacterial transformation- Competency and resistance. Bacterial conjugation – Sex factor in bacteria, F and HFR transfer, linkage mapping. Bacterial transduction – transduction phenomenon, methods of transduction, co-transduction, generalized, specialized and abortive transduction, sex-ductions.

UNIT-II MUTATION and DNA REPAIR: Types of mutagens, Molecular basis of mutations. Physical and chemical mutagenic agents: UV, Ethidium Bromide and Nitrous oxide. Detection and analysis of mutations (Replica plating,Antibiotic enrichment, Ames test etc). DNA damage and repair mechanisms. Recombination: Homologous and non-homologous recombination.

UNIT-III: GENETIC MATERIAL & MOBILE GENETIC ELEMENTS: Discovery of DNA and RNA as genetic material; Structure and types of DNA, Replication. Eukaryotic chromosome Structure, regulatory elements. RNA**:** Different classes of RNA and their functions. Transposable elements – Types of bacterial transposons and their applications

UNIT-IV: GENE EXPRESSION REGULATION: Transcription in prokaryotes and eukaryotes, other post transcriptional modifications, RNA editing, transport mechanisms (exportins & importins). Regulations of gene expression in prokaryotes (Lac. Ara and His operons). Transcriptional controls in Eukaryotes (Complexity of genome organization, Regulatory elements, Motifs of protein secondary structure/Transacting elements); Regulation at Post-transcriptional level.

UNIT-V: GENE EXPRESSION - TRANSLATION: Genetic code, Wobble hypothesis, Translation in prokaryotes and eukaryotes, post translational modifications, translational controls and inhibitors of polypeptide synthesis, protein targeting.

COURSE OUTCOMES:

At the end of the course students will be able to

CO1. Understand the basic concepts in Microbial genetics.

CO2. Analyze the DNA repair & Mutation.

CO3. Differentiate DNA, RNA structures and understand the mobile genetic elements.

CO4. Analyze the gene regulation in prokaryotes and eukaryotes and understand the post translation modifications

CO5. Understand the process of translation, their inhibitors, post translation modifications and protein targeting.

TEXT BOOKS:

1. "Molecular Biology of the gene" by Waston et al 4th edition.
2. "Genes VI" by Benjamin Lewis
3. Biochemistry and Molecular biology, William H. Elliott and Daphne C. Elliott, Third Edition, Indian edition, Oxford University press, 2005.

REFERENCE BOOKS:

1. "Genetics" by Ursula Goodenough
2. "Cytogenetics" by lGarl P. Swanson, Mertz & Young
3. "Biochemistry" by Stryer

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PROGRAME ELECTIVE I

ii. **MICROBIAL PHYSIOLOGY & METABOLISM**

Course Objective: The main objective of the course is to study the Bacterial photosynthesis, aerobic and anaerobic respiration, and permeation and sporulation process.

Unit- I: Bacterial Photosynthesis: Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria**.** Carbon dioxide fixation pathways.

Unit- II: Bacterial aerobic Respiration: Bacterial aerobic respiration, components of electron transport chain, free energy changes and electron transport, oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain. Electron transport chain in heterotrophic and chemolithotrophic bacteria.

Unit–III: Bacterial Anaerobic Respiration: Introduction. Nitrate, carbonate and sulfate as electron acceptors. Electron transport chains in some anaerobic bacteria. Catalase, super oxide dismutase, mechanism of oxygen toxicity.

Unit - IV: Bacterial Permeation: 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 - V: Bacterial Sporulation: 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. **Bacterial Chemolithotrophy**: Physiological groups of chemolithotrophs, ammonia oxidation by members of Genus Nitroso group, nitriteoxidation by Nitro group of genera. Oxidation of molecular hydrogen by *Hydrogenomonas* species. Ferrous and sulfur/sulfide oxidation by *Thiobacillus* species.

COURSE OUTCOMES:

At the end of the course students will be able to:

CO1: Understand about the Bacterial Photosynthesis
CO2: Evaluate the knowledge of Bacterial aerobic respiration
CO3: Analyze the knowledge of Bacterial aerobic and anaerobic respiration

CO4: Evaluate the various types of membrane transport mechanisms
CO5: Analyze the various sporulation of bacteria and cheamolithotrophy

TEXT BOOKS:

1. Caldwell D.R. (1995) *Microbial Physiology and Metabolism*. BrownPublishers.
2. Moat A.G. and Foster J. W. (2002) *Microbial Physiology,* Wiley.
3. Brun. Y.V. and Shimkets L.J. (2000) *Prokaryotic Development*. ASM Press.
4. Rose AH *Advances in Microbial Physiology*. Vol. 36, Academic Press NewYork.
5. Gunsalus IC, Stanier R. (1960) *The Bacteria*, Academic Press.
6. White, D. (2011) *The Physiology and Biochemistry of Prokaryotes*, 4th Edition, Oxford University Press

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OPEN ELECTIVE I

i. **BASIC MATHEMATICS & BIOSTATISTICS**

Course Objective: The course intends to provide the knowledge of differential and integral calculus, matrices, statistics and concept of random variable**s**

UNIT-I: DIFFERENTIAL CALCULUS: Functions, limits, continuity and differentiation (only basics). Differentiation of sum, product and quotient of function. Differentiation of implicit, explicit, trigonometric, inverse trigonometric functions; Partial differentiation (Basics).

UNIT-II: INTEGRAL CALCULUS: Basics, Methods of substitution integration by parts. Integration of rational, irrational, trigonometric functions (Basics), Definite integrals (Basics); Trapezoidal rule, Simpsons 1/3 rule, Simpsons 3/8 rule.

UNIT-III: MATRICES: Basics, addition, subtraction, multiplication and Determinants of Matrices (Basic concept). Co-factors of matrix, Adjoint, inverse of a matrix, Real matrices: Symmetric, Skew symmetric and orthogonal Matrices, Rank of matrix (Basic)-Det method.

UNIT-IV: INTRODUCTION- DEFINITION AND SCOPE OF BIOSTATISTICS: concept of probability-definition of probability- addition and multiplication laws of probability (without proofs) and examples. Population – Sample- primary data and Secondary data-graphical and diagrammatic representation of data. Measure of central tendency: Mean median and mode. Measure of dispersion: Range – standard deviation, Mathematical Expectation, Skewness, Curtosis.

UNIT-V: STATISTICAL OPTIMIZATION TECHNIQUES: Estimation, types of estimation, estimation of parameters. Testing of Hypothesis – Z-test, t-Test, f-Test (Basics). Correlation & Regression; Coefficient of correlation – Regression coefficient – The lines of regression (Basics).

COURSE OUTCOMES:

At the end of the course students will be able to

CO1. Attain knowledge of the Functions, limits, continuity and differentiation
CO2. Analyse integral calculus
CO3. Apply matrices
CO4. Understand the various concepts of biostatistics
CO5. Evaluate various concepts of statistical optimization techniques.

TEXTBOOKS:

1. Statistical methods S.P.Gupta. S Chand Pubplications
2. Business Statistics by S.P Gupta &M.P.Gupta
3. Engineering Mathematics - N.P. Bali and others.
4. Engineering mathematics - B.V. Ramana
5. Fundamentals of Statistics, Gupta.M.K. Goon A.M, The world press, 2012.
6. Introduction to the theory of statistics, 3rd edition, Mood.A.M. Graybill, F.A &Boes. D.C (2007)
7. Probability and statistics by Rukmangadachari . E, Pearsln publications.

REFERENCE TEXT BOOKS:

1. Differential Calculus - Shanthi Narayan
2. Integral Calculus - Shanthi Narayan

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OPEN ELECTIVE I

ii. **BIOENTREPRENEURSHIP**

Course Objectives: The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

UNIT-I: Basics of Bioentrepreneurship Importance of entrepreneurship; advantages of being entrepreneur - freedom to operate; introduction to bioentrepreneurship – biotechnology in a global scale; Scope in bioentrepreneurship; types of bio-industries – biopharma, bioagri, bioservices and bioindustrial; innovation – types, out of box thinking; skills for successful entrepreneur – creativity, leadership, managerial, team building, decision making; opportunities for bioentrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India); patent landscape, IP protection & commercialization strategies

UNIT-II: Accounting and Finance Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/support from Government agencies like MSME/banks and private agencies like venture capitalists:/angel investors for bioentrepreneurship; business plan proposal for „virtual startup company"; statutory and legal requirements for starting a company/venture; basics in accounting practices: concepts of balance sheet, profit and loss statement, double entry 36 bookkeeping; collaborations & partnerships; information technology for business administration and expansion

UNIT-III: Business Strategy Entry and exit strategy; pricing strategy; negotiations with financiers, bankers, government and law enforcement authorities; dispute resolution skills; external environment/ changes; avoiding/managing crisis; broader vision–global thinking; mergers & acquisitions

UNIT-IV: Marketing Market conditions, segments, prediction of market changes; identifying needs of customers; Market linkages, branding issues; developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for „virtual startup company"

UNIT-V: Knowledge Centre and R&D Knowledge centreseg, in universities, innovation centres, research institutions (public & private) and business incubators; R&D for technology development and upgradation; assessment of technology development; managing technology transfer; industry visits to successful bio-enterprises, regulations for transfer of foreign technologies; quality control; technology transfer agencies; Understanding of regulatory compliances and procedures (CDSCO, NBA, GLP, GCP, GMP)

COURSE OUTCOMES:

At the end of the course the student will be able to

CO1. Understand the advantages and identify the scope of entrepreneurship in biosciences.
CO2. Analyse the ways and means of raising funds
CO3. Evaluate the various issues related to entry, exit, pricing strategies and managerial skills
CO4. Understand the marketing strategies involved in entrepreneurship
CO5. Evaluate the ways and means of developing research for business growth and expansion

TEXT BOOKS:

1. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for life scientists: Developing innovation and entrepreneurship in the biosciences. Bloxham: Scion.

2. Shimasaki, C. D. (2014). Biotechnology entrepreneurship: Starting, managing, and leading biotech companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.

REFERENCE BOOKS:

1. Onetti, A., & Zucchella, A. (n.d.). Business modeling for life science and biotech companies: Creating value and competitive advantage with the milestone bridge. Routledge.
2. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press. 5. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

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LAB I

CELL BIOLOGY & MICROBIOLOGY LAB

PART-A: CELL BIOLOGY LAB

Course Objective: To provide hands on training in cell biology techniques

LIST OF EXPERIMENTS:

1. Microscopy: Compound Microscope & Fluorescence Microscope
2. Motility of bacteria
3. Gram Staining
4. Osmosis -Egg
5. Cellular Fractionation
6. Analysis of subcellular fractions
7. Mitosis and cytokinesis

Course outcome: At the end of the course, students will have a thorough knowledge of the techniques involved in studying the motility of bacteria, isolation of cell organelles.

PART-B: MICROBIOLOGY LAB

Course Objective: To provide hands on training in microbiological techniques.

LIST OF EXPERIMENTS:

1) Isolation, Purification & Quantification of bacteria.
2) Cultural characteristics of bacteria
3) Morphological and Biochemical characterization of bacteria (Various staining, Amylase, Catalase, Gelatinase, Protease, Nitrate reductase, Urease, Indole, Methyl red, Vogesproskauer, Citrate utilization test).
4) Factors affecting bacterial growth (pH & Temperature).
5) Determination of thermal death point.
6) Determination of MIC of antimicrobial agents.

Course outcome: At the end of the course, students will have a thorough knowledge of distinguish between various types of microbial media, culturing methods, Inspect and isolate the microbes from the day to day sources.

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LAB II

MICROBIAL BIOCHEMISTRY AND MICROBIAL GENETICS & MOLECULAR BIOLOGY LAB/MICROBIAL PHYSIOLOGY & METABOLISM LAB

PART-A: MICROBIAL BIOCHEMISTRY LAB

Course objective: The main objective of the course is to study the different methods used to estimate the various biomolecules.

LIST OF EXPERIMENTS:

1. Titration of amino acids.
2. Determination of pK
3. Estimations of amino acids, Proteins, Sugars and Lipids
4. Analysis of oils-iodine number, Saponification value, acid number.
5. UV, Visible, Absorption spectra.
6. Centrifugation
7. Chromatography : Paper and TLC

Course outcomes: At the end of the course students will have through knowledge of Biomolecules estimations and analysis etc.

PART-B: MICROBIAL GENETICS & MOLECULAR BIOLOGY LAB

Course objective: The main objective of the course is to provide practical knowledge on microbial genetics and molecular biology techniques

LIST OF EXPERIMENTS:

1. Isolation of Nucleic Acids: Genomic DNA, RNA
2. Quality check for Isolated Nucleic Acids: Spectrophotometric (UV Method)
3. Visualization: Agarose gel Electrophoresis (Detection and separation of NA).
4. Induction of mutations by physical/chemical mutagens, screening and isolation of mutants,Replica plating technique.
5. Transformation in bacteria.

Course outcomes: At the end of the course students will have through knowledge of the techniques involved in isolation, quantification of DNA and gene transfer methods in bacteria.

PART-B: MICROBIAL PHYSIOLOGY & METABOLISM LAB

Course objective: The main objective of the course is to provide practical knowledge on the microbial growth on various media and factors affecting the microbial growth.

LIST OF EXPERIMENTS:

1. Preparation of microbiological media. Autotrophic media, minimal media, basic media, enriched media, enrichment media, differential media.
2. Culturing methods of microbes – slant and stab cultures, tube culture, flask cultures, shake flask cultures
3. Use of selective and /or differential media for isolation and Identification of specific bacterial cultures
4. Study of bacterial growth curve
5. Factors effecting the microbial growth (pH and temperature)
6. Effect of UV, gamma radiations, pH, disinfectant, chemicals and heavy metal ions on micro-organisms.

Course outcomes: At the end of the course students will have through knowledge of the microbial growth on various media and factors affecting the microbial growth

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PROGRAM CORE: IV

ENZYMOLOGY & BIOENERGETICS

Course objective: To provide deeper insights into how enzymes work and various applications of enzymes

UNIT-I: Introduction to Enzymes: Classification, Nomenclature and their chemical nature Factors affecting enzyme catalyzed reactions – pH, temperature, concentration of enzyme and concentration of substrate, Assay of enzymes.

UNIT-II: Enzyme Isolation & Purification: Methods of isolation and purification, recovery and yield, purity and characterization of enzyme preparations, Mechanism of action of – Chymotrypsin, Carboxy-peptidase, Ribonuclease, Lysozyme.

UNIT-III: Enzyme Kinetics: Derivation of Michaelis and Menten equation for uni-substrate reactions Determination of Km, V_{max}, K_{cat} and their significance, Linear transformation of Michaelis-Menten equation, Eadie-Hofstee, lineweaver-Burk, Hanes, Dixon plot, **Inhibition Kinetics:** Reversible and irreversible inhibition – competitive, non-competitive, uncompetitive inhibitions, determination of K_m and V_{max} in presence and absence of inhibitors Allosteric enzymes, **Immobilized Enzyme kinetics:** Methods of immobilization and applications of immobilized enzymes.

UNIT-IV: Application of Enzymes: Industrial applications of Enzymes, Production of glucose from starch, cellulose and dextran; use of lactase in dairy industry; production of glucose- fructose syrup from sucrose; use of proteases in food, detergent and leather industry; medical application of enzymes; use of glucose oxidase as enzyme biosensor, Ribozymes, Xeno nucleic acids.

UNIT-V: Bioenergetics: Biological oxido-reduction, Oxido-Reduction potential, Electron transport chain (ETC), ATP generation in ETC, Mechanism of Oxidative phosphorylation, ATP synthase, Incomplete reduction of oxygen.

COURSE OUTCOMES:

At the end of the course students will be able to

CO1: Understand the basics of enzymes
CO2: Analyze the knowledge of isolation & purification of enzymes and their mechanisms of action
CO3: Analyze the thorough knowledge of Enzyme kinetics
CO4: Understand the generation of high energy compounds.
CO5. Analyze the various applications of enzymes in industries.

TEXT BOOKS:

1. Biochemical Calculations, lrwin H. Segel, John Wiley and Sons Inc.
2. General Chemistry. Linus Pauling, W.H. Freeman & Company.
3. Organic Chemistry, DJ Cram and GS Hammond, McGraw Hill.
4. Biochemistry, D Voet and JG Voet, J Wiley and Sons.
5. Physical Biochemistry, D Freifilder, W.H. Freeman & Company.

REFERENCES:

1. Enzyme Kinetics: Catalysis &control by Daniel Purich, academic press 1st ed.
2. Contemporary enzyme kinetics and mechanisms, DanielPurich, academic press, 3rd ed.

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PROGRAM CORE V

IMMUNOTECHNOLOGY

Course Objective: This course intends to provide the knowledge of cells, organs of immune system, innate & acquired immunity, humoral immunity & cell mediated immunity, the role of immunity in infectious diseases and type of vaccine & technology.

UNIT – I: Immune system:

Phylogeny of Immune System: Innate and acquired immunity. **Organs** and **Cells of the immune system**: Lymphoid organs-Lymphoid follicle, Thymus, Lymph node, Spleen, MALT, GALT, SALT. Hematopoiesis and differentiation, Macrophages, Dendritic cells, Natural killer and Lymphokine activated killer cells, Eosinophils, Neutrophils and Mast-Cells. Clonal nature of immune response, antigens, immunogens, super antigens & MHC.

UNIT – II: Humoral immunity:

B cell types, B cell receptors and activation, Immunoglobulin diversity, Antibody structure and function, Antigen- antibody interactions (including ADCC), CDC antibodies in diagnosis, Hybridoma technology, B cell memory.

UNIT – III: Cell mediated immunity:

MHC restriction, Antigen presentation, T cell subsets and functions of each, T cell activation and regulation, Cell mediated immune functions- cytotoxicity, interferon; T cell memory - Central and peripheral.

UNIT – IV Immuno diseases:

Immune response to infectious diseases (humoral, cell-mediated, examples), autoimmune disorders: Rheumatoid arthritis, Insulin dependent Diabetes Mellitus, Cells and organs transplantation, Graft rejection and psoriasis.

UNIT – V: Immunotherapy, Vaccines and Adjuvants:

Vaccines–Types, Technologies, Adjuvants–Function, mechanism of action, new generation adjuvants, Immunotherapy – antibodies (Polyclonal, Monoclonal), Cytokines, Cell therapy, diseases (HIV, HCV).

COURSE OUTCOMES

At the formal end of this course student will be able to

CO1. Classify innate immunity, nature of antigens and cells and organs of immune system.

CO2. Equipped with the knowledge of humoral immunity, Evaluate antigen – antibody interactions and hybridoma technology.

CO3. Thorough understanding of MHC, mechanism of cytotoxicity and evaluate cell mediated immunity.

CO4. Classify and evaluate autoimmune disorders and the role of immune system in transplantation.

CO5. Evaluate role immune system in infectious diseases and immunotherapy.

TEXT BOOKS:

1. Kuby Immunology (Kindt, Kuby Immunology)-Thomas J. Kindt, Barbara A. Osborne, Richard A. Goldsby, and publisher: W. H. Freeman, 2006.
2. Immunology-David Male, Jonathan Brostoff, David Roth, Ivan Roitt, publisher: Mosby, 2006.
3. Essentials of immunology by Roitt, 13th edition by Peter J Delves, Johan Wiley.

REFERENCE BOOKS:

1) Fundamental Immunology-William E Paul, publisher: Lippincott Williams & Wilkins, 2008
2) Immunology, Infection, and Immunity-Gerald B. Pier, Jeffrey B. Lyczak, Lee M. Wetzler, publisher: ASM Press, 2004
3) Lecture Notes: Immunology, 5th Edition-Ian Todd, Gavin Spickett, publisher: Wiley-Blackwell, 2005.
4) Immunology: A Short Course-Richard Coico, Geoffrey Sunshine, publisher: Wiley-Blackwell, 2009.
5) Cellular and Molecular Immunology-Abul K. Abbas MBBS, Andrew H. Lichtman MD PhD, Shiv Pillai MD, publisher: Saunders, 2007.
6) Roitt's Essential Immunology (Essentials)-Peter Delves, Seamus Martin, Dennis Burton, Ivan Roitt, publisher: Wiley-Blackwell, 2006.
7) Schaum's Outline of Immunology-George Pinchuk, publisher: McGraw-Hill, 2001.

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PROGRAM CORE VI

VIROLOGY

Course Objective: This course intends to provide insights into the historical developments in Virology, Structures, Classification, Virological diagnostics methods and viral replications etc.

UNIT-I: Microorganisms lacking cell structures: Introduction to virology, nature of viruses, nomenclature and classification of viruses, General characteristics of viruses: Physical, Biological, Biochemical properties, Methods of cultivation, Purification and assay of viruses Biology of sub-viral agents

UNIT-II: Virological Methods: Diagnostic Methods: Immunodiagnostic, Haemagglutination and Haemagglutination-inhibition tests, complement fixation, neutralization, RIA, flow cytometry and immunohistochemistry

Nucleic Acid Based Diagnosis: Hybridization, Blotting techniques, polymerase chain reaction, Microarray and nucleotide sequencing

UNIT-III: Virus Cell Interaction: Cellular Receptors and Virus Entry: Polio, Herpes, VSV, HIV Mechanism of Entry into cells, **Mechanisms of Host Cell Damage**: Host cell 'Shut off', Apoptosis, Necrosis, Stress response, Alteration of signaling pathways, Cellular basis of transformation, Types of cytopathic effects

UNIT-IV: Virus Replication: RNA Viruses: Replication of Plus stranded RNA virus (Polio), Negative Strand RNA viruses (VSV and influenza) Replication of double Stranded RNA viruses (rota), and retro viruses (HIV and HTLV. **DNA Viruses:** Replication of doubles Stranded DNA Viruses (SV 40 and Pox), ss DNA Viruses (AAV), DNA tumor virus (Hepatitis B Virus).

UNIT-V: Application of viruses in biomedicine Viral vectors: Development of viral vectors, gene transfer, gene therapy, vaccine development Protein expression, Viral subunits (Virus like particles VLP), Oncolytic Virus(Virotherapy for cancer)

COURSE OUTCOMES:

At the end of the course student will be able to:

CO1. Understand the knowledge of the viruses, structures and their properties.

CO2. Evaluate the knowledge of the viral diagnostic methods and their analysis.

CO3. Understand the knowledge of the virus cell interactions and host cell damage Mechanisms.

CO4. Evaluate the knowledge of the viral replication of DNA and RNA viruses.

CO5. Analyze the knowledge of the applications of the viruses in biomedicine.

TEXT BOOKS:

1. Introduction to Modern Virology - Dimmock NJ, Primrose SB, Blackwell Scientific Publications, Oxford.
2. Text Book on Principles of Bacteriology, Virology and Immunology – Topley and Wilson's, Edward Arnold, London.

REFERENCE BOOKS:

1. Medical Virology – Morag C and Timbury M.C, Churchill Livingstone, London.
2. Virology – III – Conrat HF, Kimball PC and Levy JA, Prentice Hall, Englewood Cliff, New Jersey.
3. Diagnostic procedures for Viral and Rickettsial diseases – Lennetter EH, American Public Health Association, NY.
4. The Genetics of Bacteria and their Viruses – William Hayes, Blackwell Scientific Publishers, London.

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PROGRAM ELECTIVE II

i. **FERMENTATION TECHNOLOGY**

Course objective: The major objective of this course is to familiarize students to microbes & microbial processes, including fermentation and optimization covering all areas of industrial biotechnology.

UNIT-I: INTRODUCTION AND METHODS IN MICROBIOLOGY: History, Scope & milestones of microbiology, Ultra-structural organization of prokaryotic and eukaryotic cells. Isolation, and screening methods for industrially important micro organisms, Primary screening and secondary screening

UNIT-II STRAIN IMPROVEMENT & PRESERVATION TECHNIQUES: Strain selection and Strain improvement by selection of induced mutants for primary metabolites, Auxotrophs mutant, induced mutant for secondary metabolites, Isolation of Auxotrophic, Resistant, Revertant mutants. Recombinant DNA techniques, protoplast fusion, conjugation, and transformation for strain development, culture preservation techniques.

UNIT-III: MICROBIAL GROWTH, MEDIA COMPONENTS AND MEDIA DESIGN: Microbial growth: Microbial growth curve - mathematical expression of growth, classification of microbes based on physical factors (pH, temperature, O_2 requirement).

Media formulation: Microbial nutrition and types of microbial culture media, Different components of microbial culture medium and their physiological role in microbial growth, raw materials used in preparation of medium..

UNIT-IV: INOCULUM DEVELOPMENT, STERILIZATION, & FERMENTATION OPERATIONS: Inoculum Development**, Sterilization**: Introduction, media sterilization, the design of batch sterilization process, the design of continuous sterilization process, sterilization of fermentor, sterilization of feed, sterilization of air and filter design**. Fermentors:** Fermentation equipment and its uses, types of fermentors and different fermentation modes

UNIT-V CASE STUDIES: Antibiotics - Penicillin, Streptomycin; Organic acids – Citric acid, Lactic acid, Alcoholic beverages – Ethanol, Beer, Wine. Monoclonal antibodies (mAb's) and Bio- therapeutics Eg.: Insulin , vaccines. Food industry: Bakers' yeast and bread making, rennet and other proteolytic enzymes in cheese making, production of different cheeses

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COURSE OUTCOMES:

At the formal end of the course student will be able to:

CO1: Acquire the knowledge of isolation and identification of microorganisms.

CO2: Determine the mathematical expression of microbial growth kinetics & media formulation

CO3: Design the process of fermentation

CO4: Explain the production process of r DNA based products

CO5: Explain the production process of food and allied products

TEXT BOOKS:

1. "Principles of fermentation technology" by P F Stanbury and A Whitaker, Pergamon press (1984).
2. Industrial Microbilogy by A.H. Patel, Macmillan India Ltd.
3. Industrial Biotechnology by S.N. Jogdand, First edition, Himalaya Publishing House, (2006).

REFERENCE BOOKS:

1. “General Microbiology” 5th Edition Stanier et al.
2. “Enzymes in food processing” by Gerald Reed, Academic press.
3. “Comprehensive Biotechnology” Vols III & IV, Editor M.Moo young.
4. “Industrial Microbiology” by Prescott
5. “Industrial Microbiology” by Casida.

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PROGRAM ELECTIVE II

ii. **MICROBIAL BIOTECHNOLOGY**

COURSE OBJECTIVE: This course enables students to understand the development of various microbial products and their production followed by beneficial microbes and application of microbes in nanotechnology.

Unit-I: Development of Microbial Products: Microbial production of penicillin, Tetracycline and peptide antibiotics; Acetic acid; Lactic acid; Gluconic acid, recombinant biomolecules and therapeutic proteins, vaccines production**,** DNA based vaccines, antibody production, therapeutic enzymes Microbial production and commercial applications of Amylases, Proteases and Lipases. Biotransformation of steroid and non-steroid compounds.

Unit-II: Production of Microbial Products: Single cell protein: Use of Microorganisms; raw material used as substrate; condition for growth and production; nutritive value and uses of SCP. Mushroom production: cultivation of different types of mushroom; edible mushroom; therapeutic value of an edible mushroom. Genetically modified foods and their importance. Synthesis of commercial products using microbial systems: Biopolymers-xanthan gum and PHA's (Bioplastics). Renewable Bioenergy using Microorganisms: Methanogenesis, Methane production by anaerobic digestion of waste organic materials. Bioethanol and Biobutanol production by using microorganisms. Biohydrogen Generation, Microbial Fuel. Biodiesel from algae.

Unit–III: Beneficial Microbes: Biofertilizers- *Rhizobium, Azospirillum, Azotobacter, Gluconacetobacter, Azorhizobium,* phosphobacteria - *mycorrhizae* - Blue Green Algae and *Azolla*. Mass production of biofertilizers and composting, Nanobiofertilizers for sustainable development of agriculture. Designer Microbes and Health: Gut microbiota and diseases, approaches for engineering gut microbiota, therapeutic uses of gut microbiota, Bacteriophages in control of bacteria. Microbial biosensors and its applications.

Unit-IV: Microbial Nanotechnology: Microbial synthesis of Nanoparticles. Synthesis of nanodrugs – metal nanoparticles and drug delivery vehicles – Nanoshells – Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology.

Unit –V: Regulatory Approvals and Clinical Trials: Good laboratory practice (GLP), Current Good Manufacturing Practice (CGMP), different phases of clinical trials, difference between biologics, biosimilar and bio-better, development of biosimilars and generic biomolecules, analysis of process economics.

COURSE OUTCOMES:

The students will be able to:

CO1: Understand about the development of various microbial products

CO2: To know the production of microbial products

CO3: Identify the beneficial microbes in biofertilizers and human health

CO4: Evaluate the use of microbes in nanotechnology

CO5: Analyze the Good laboratory practice and current good manufacturing practice

SUGGESTED BOOKS:

1. W. B. Hugo and A. D. Russell, (2011) *Pharmaceutical Microbiology,* 8th Edition. Blackwell Scientific Publications.
2. Frederick Kavanagh, (2014). *Analytical Microbiology* Volume II. Elsevier.
3. S. P. Vyas and V. K. Dixit, (2012) *Pharmaceutical Biotechnology*. CBSPublishers & Distributors, New Delhi.
4. Elisabeth Papazoglou and Aravind Parthasarathy (2007). *Bionanotechnology*. Morgan & Claypool Publishers.
5. Bernd Rehm (2006). *Microbial Bionanotechnology: Biological Self-assemblySystems and Biopolymer-based Nanostructures*. Horizon Scientific Press.
6. Willey, J.M., Sherwood, L., and Woolverton, C. (2013). *Prescott'sMicrobiology* 9th Revised Edition, McGraw Hill Higher Education, New York.
7. Mehrotra RS and KR Aneja (2015*). An Introduction to Mycology*, New AgePublishers
8. Steven L. Stephenson (2010) *The Kingdom Fungi: The Biology ofMushrooms, Molds and Lichens.*
9. Reisner DE, Bronzino JD. (2008). *Bio-nanotechnology:Global Prospects*. CRC Press.

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OPEN ELECTIVE II

i. MICROBIAL ECOLOGY & ENVIRONMENTAL MICROBIOLOGY

Course Objective: The main objective of this course is to impart students an understanding of ecology and ecosystems, functions of all various components in the ecosystem. It also familiarizes them with various Technologies used in treatment of air, water, soil and other persistent chemicals in the environment.

UNIT-I: **ECOLOGY AND ECOSYSTEMS:** Fundamentals of Ecology and Ecosystems, Components of Ecosystems, Food chain, Food Web, Trophic levels, Energy flow, Role of Producers, Consumers and Decomposers. **Ecosystems:** Types, characteristic features, structure and functions of the following ecosystems: Pond ecosystem- Marine ecosystems - Grassland ecosystem - Forest ecosystem- Desert ecosystem – Cropland Ecosystem.

UNIT-II: ENVIRONMENTAL POLLUTION AND CONTROL: Introduction to Environmental pollution, Air, water and soil pollution- Types, common effects and control measures

Air Pollution Treatment Technologies: Biofilters and Bioscrubbers for treatment of industrial waste.

UNIT-III: WASTE WATER TREATMENT: Water: Waste water, Types of waste water, Major contaminants in waste water, Physical, chemical and biological methods of waste water treatment **Aerobic:** Activated Sludge Process, Trickling Filters, Biological Filters, Rotating Biological Contractors, Fluidized Bed Reactor, **Anaerobic:** Anaerobic digestion, anaerobic digesters, Contact Digesters, Packed Column Reactors, UASB for biological treatment process.

UNIT-IV: BIOREMEDIATION AND PHYTOREMEDIATION: Definition, constraints and priorities of Bioremediation, Types of bioremediation: *In-situ* and *Ex-situ* bioremediation techniques, Factors affecting bioremediation, Applications of bioremediation. **Phytoremediation**: Definition, Types and their role in degradation of pollutants, Natural attenuation and Vermicomposting. Microbial degradation of pesticides and other recalcitrant chemicals, microbial degradation of petroleum and hydrocarbons; biodeterioration and control.

UNIT-V: BIOENERGY & BIOMINING: Bio Energy: Energy and Biomass Production from wastes, biofuels, bio hydrogen production. **Biomining:** Bioleaching, Types, Applications. Biofilms formations and its use, microbially enhanced oil recovery, microbial fuel cells and their applications.

COURSE OUTCOMES:

At the end of the course students will be able to:

CO1: Understand the knowledge of various types of pollution, common effects and Control measures.

CO2: Evaluate the knowledge of the types of waste water, their contaminants and Treatment technologies.

CO3: Analyze the Microbial ecology and their adaptations followed by phytoremediation techniques.

CO4: Understand the knowledge of Bioremediation techniques and their applications followed by Biodeterioration and their control.

CO5: Evaluate the knowledge of Bioleaching, Biomining and microbial fuel cells and their applications.

TEXT BOOKS:

1. Fundamentals of Ecology by Eugene P. Odum (Author), Gary W. Barrett
2. Introduction to Environmental Science Hardcover – 2004 by Y Anjaneyulu

REFERENCE BOOKS:

1. Wastewater Engineering-Treatment, Disposal, and Resuse, Metcalf and Eddy, Inc., Tata McGraw Hill, New Delhi.
2. Industrial Pollution control Engineering- AVN Swamy., Galgotia Publication, (2006).Environmental Biotechnology- Allan Stagg.

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OPEN ELECTIVE II

ii. **BIO ETHICS, BIOSAFETY & REGULATORY AFFAIRS**

Course Objective: To introduce basic concepts of ethics and safety that are essential for different disciplines of science and about regulatory affairs and documentation

UNIT I:BIOETHICS: PRINCIPLES OF BIOETHICS, ETHICS IN CLINICAL RESEARCH: Bioethics: History and Different aspects of health care, historical cases; Informed consent, mental competence, Bioethics in Microbial (Bioterrorism), Plant (GMO) & Animal (Stem Cells, Cloning, human embryos and IVF).

UNIT II: BIOSAFETY CONCEPTS & REGULATIONS: Definition of Biosafety, Biosafety for human health and environment; Levels of biosafety for microbes, plants & animals; Cartagena protocol; Assessment of Biological hazard; Use of genetically modified organisms and their release in to the environment (special procedures for r-DNA based products); International dimensions in Biosafety Biotechnology and food safety (Case study – Bt Cotton, Bt Brinjal); DBT Biosafety Guidelines.

UNIT III: REGULATORY AFFAIRS : Regulatory aspects of quality control & Quality assurance; Indian context – requirements and guidelines of GMP, understanding of Drugs and Cosmetics Act 1940 and Rule 1945 with reference to Schedule N,U & Y 4.

UNIT IV: RELATED QUALITY SYSTEMS: Pharmaceutical Quality Management systems, Quality Risk management; Objectives and guidelines of USFDA, WHO and ICH Introduction to ISO series.

UNIT V: DOCUMENTATION: Documentation & Records - Harmonized GMP requirements; Development for global filings, ANDA, NDA, CTD, dealing with post – approval changes – SUPAC; Handling and maintenance including electronic documentation, 21CFR.

COURSE OUTCOMES:

At the end of the semester students will able to:

CO1: Understand the knowledge of ethical issues related to the industry and research of biosciences

CO2: Understand of biosafety measures that need to be followed in bioscience related industries and research
CO3: Evaluate the guidelines of GMP and drug and Cosmetics Act 1940 and rules of 1945
CO4: Understanding of guidelines laid by different quality systems
CO5: Analyze the different aspects of documentation in regulatory affairs

TEXT BOOKS:

1. Bioethics – Shaleesha A Stanley, Wisdom Educational Service, Chennai, 2008
2. V Sree Krishna. Bioethics & Biosafety in Biotechnology. New age International Publications, 2007.
3. Deborah E. Bouchoux, Intellectual Property for Paralegals – The law of Trademarks, Copyrights,
4. Patents & Trade secrets, 3rd Edition, Cengage learning, 2012
5. N.S. Gopalakrishnan& T.G. Agitha, Principles of Intellectual Property, Eastern Book Company, Lucknow, 2009.

REFERENCES:

1. Singer, Peter A.; Viens, A.M. (2008), Cambridge Textbook of Bioethics, Cambridge: Cambridge University Press, ISBN 978-0-521-69443-8
2. Anitha Rao R &Bhanoji Rao "Intellectual Property Rights – A Primer", Eastern Book Company, 2008.
3. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and Safety Assessment (3rd Ed). Academic Press.
4. M. M. S. Karki , Intellectual Property Rights: Basic Concepts, Atlantic Publishers, 2009
5. Neeraj Pandey &KhushdeepDharni, Intellectual Property Rights, Phi Learning Pvt. Ltd
6. AjitParulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications; Macmillan India ltd, 2006.
7. B. L. Wadehra. Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000.

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LAB III

ENZYMOLOGY & BIOENERGETICS AND VIROLOGY LAB

PART-A: ENZYMOLOGY & BIOENERGETICS LAB

Course Objective: This course intends to provide the practical knowledge required to study different aspects of microbial enzymes

LIST OF EXPERIMENTS:

1. Production of Cellulases / Proteases from *Aspergillus niger*
2. Enzyme assays – Cellulases / Proteases
3. Effect of P^H , Temperature and Substrate concentration on Enzyme activity
4. Determination of Km and Vmax
5. Immobilization of Enzymes
6. α – Glucosidase Enzyme Inhibition Assay

Course Outcome: By the end of this course student will acquire skill for production and estimation of microbial enzymes and their optimization studies.

PART- B: VIROLOGY LAB

Course objective: This course intends to provide insights to different isolation methods of viruses.

LIST OF EXPERIMENTS:

1. Mechanical Transmission of Tobacco Mosaic Virus.
2. Symptomatic Observation of Plant Viral Infections.
3. Effect of Nuclear Poly hedrosis Virus on Insects.
4. Quantification or Titration of Bacteriophages.
5. Isolation of Bacteriophages from Soil or Sewage.

Course Outcomes: By the end of the course students will have through knowledge of various method of for cultivation and enumeration of viruses**.**

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LAB IV

IMMUNOTECHNOLOGY & FERMENTATION TECHNOLOGY LAB/MICROBIAL BIOTECHNOLOGY LAB

PART-A: IMMUNOTECHNOLOGY LAB

Course Objective: This course intends to provide the practical knowledge of different immunological techniques.

LIST OF EXPERIMENTS:

1. Blood grouping – Agglutination
2. Agglutination reactions – Widal, VDRL, HA
3. Radial immuno diffusion,
4. Ouchterolony double immuno diffusion
5. Immuno-electrophoresis,
6. ELISA
7. Purification of antibodies
8. Latex agglutination test (Indirect agglutination-Pregnancy hCG Ag).

Course Outcome: By the end of this course student will acquire skill to perform different immune diffusion techniques, ELISA, immune-electrophoresis and purify antibodies.

PART- B: FERMENTATION TECHNOLOGY LAB

Course Objective: This course intends to provide the practical knowledge of Biopharmaceutical technology.

LIST OF EXPERIMENTS:

1. Microbial growth kinetics
2. Isolation of Industrially important microorganisms
3. Effect of operating parameters (PH, Temperature, Substrate concentration, Osmolarity, DO levels, etc).
4. Seeding Cell density
5. Effect of Time and level of induction
6. Absorbing of Fermenter
7. Effect of Impeller speed on growth profile
8. Kla Determination.

Course Outcome: By the end of this course student will acquire the knowledge of Fermenter principles and operating conditions etc.,

PART- B: MICROBIAL BIOTECHNOLOGY LAB

Course objective: The main objective of the course is to provide practical knowledge of production and estimations of industrially important components.

LIST OF EXPERIMENTS:

1. Estimation of streptomycin
2. Citric acid production by *Aspergillus niger*
3. Immobilization of microbial cells
4. Screening of amylase producing microorganisms
5. Screening of organic acid producing microorganisms
6. Strain improvement
7. Alcohol fermentation by Yeast cells
8. reparation of wine from Grapes and pomegranates

Course outcomes: At the end of the course students will have through knowledge of the production and estimations of the industrially important components

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PROGRAM CORE VII

r-DNA TECHNOLOGY

Course Objectives: To familiarize the student with emerging field of biotechnology i.e. recombinant DNA technology as well as create understanding and expertise in wet lab techniques in genetic engineering.

UNIT-I: INTRODUCTION AND TOLLS IN R-DNA TECHNOLOGY: Introduction to recombinant DNA technology , Molecular Tools in recombinant DNA technology – Restriction enzymes and DNA Modifying enzymes (Polmerases, Reverse Transcriptase, Ligases, Alkaline phosphatase, Terminal deoxynucleotide transferases, Nucleases - S1 nucleases etc) . Nucleic Acid isolation and purification yield analysis, Gel electrophoresis, DNA and RNA markers Restriction mapping of DNA fragments, Nucleic acid Amplification (PCR analysis) and its applications

UNIT-II: GENE CLONING STRATEGIES: Gene Cloning vectors (Plasmids, bacteriophages, cosmids, phagemids, Artificial chromosomes), Gene Cloning strategies, Transformation and selection of recombinants; Construction of DNA libraries (Genomic library and cDNA library preparations –mRNA enrichment, reverse transcription, use of linkers and adaptors); and their screening; Alternative strategies of Gene cloning; Cloning of differentially expressed genes

UNIT-III: GENE EXPRESSION: Study of introduced Gene expression – hybridization techniques, (Southern, Northern and Western blot analysis), Primer extension, S1 mapping, and Nucleic acid microarrays. Gene expression in bacteria and Yeast, expression in insect cells, expression in mammalian cells, expression in plants – characterization of recombinant proteins, stabilization of proteins; Phage display, Yeast Two- and three Hybrid system

UNIT-IV: TRANSGENIC TECHNOLOGY: Gene tagging (T-DNA tagging and Transposon tagging) in gene analysis (identification and isolation of gene), Transgenic and Gene Knockouts Technologies - Targeted gene replacement, Gene Therapy, Strategies of gene delivery, gene replacement/ augmentation, gene editing and silencing

UNIT-V: APPLICATIONS OF RECOMBINANT DNA TECHNOLOGY; Genome sequencing projects, site directed mutagenesis and protein engineering RNAi, antisense technology, CRISPAR/Cas 9

COURSE OUTCOMES:

At the end of the course students will be able to:

CO1. Understand the scientist's contribution and the enzymes involved in recombinant DNA technology and also know the PCR and its application

CO2. Analyze the knowledge on different types of vectors, cloning, transformation and selection and also Genomic and C-DNA library constriction and its application

CO3. Understand the different expression systems, protein interaction studies, and hybridization techniques.

CO4. Evaluate the different transgenic techniques (Gene Knockouts Technologies and Gene therapy) and also understand about gene tagging.

CO5. Understand the applications of genetic engineering principles.

TEXTBOOKS:

1. Molecular Cloning: a Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York, 2000.
2. DNA Cloning: a Practical Approach, .M. Glover and B.D. Hames, IRL Press, Oxford, 1995.

REFERENCES:

1. Molecular and Cellular Methods in Biology and Medicine, P.B. Kaufman, W. Wu. D. Kim and L.J. Cseke, CRC Press, Florida, 1995.
2. Methods in Enzymology vol. 152, Guide to Molecular Cloning Techniques, S.L. Berger and A.R. Kimmel, Academic Press, Inc. San Diego, 1998
3. Methods in Enzymology Vol 185, Gene Expression Technology, D.V. Goeddel, Academic Press, Inc., San Diego, 1990
4. DNA Science. A First Course in Recombinant Technology, D,A. Mickloss and G.A. Froyer. Cold Spring Harbor Laboratory Press, New YorK, 1990.
5. Molecular Biotechnology (2nd Edn.), S.B. Primrose. Blackwell Scientific Publishers, Oxford, 1994
6. Milestones in Biotechnology. Classic papers on Genetic Engineering, J.A. Davies and W.S. Reznikoff, Butterworth-Heinemann, Boston, 1992.
7. Route Maps in Gene Technology, M.R. Walker and R. Rapley, Blackwell Science Ltd., Oxford, 1997.

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PROGRAM CORE IV

BIOINFORMATICS

Course Objectives: This course is formulated to provide students an in depth knowledge of biological data analysis using compilation methods. It is also useful for investigating molecular biology Problems from computational perspective. To enhance knowledge about protein structural predictions, molecular docking and evolutionary relationships between organisms.

UNIT-I:INTRODUCTION TO BIOINFORMATICS & SEQUENCING ALIGNMENT CONCEPTS:
Need of Computers in Biotechnology Research; File Transfer Protocol; Bioinformatics-Introduction, Scope, Applications; Pair wise Alignment-Local, Global alignment; Gap- Gap penalty; Comparison of Pair wise and Multiple alignment.

UNIT-II: BIOLOGICAL DATABASES AND DATAMINING:
Biological Information on the web- Introduction to databases; Classification of Biological databases; Information retrieval from Databases; Sequence database search- FASTA, BLAST; Amino acid substitution matrices- PAM and BLOSUM; Data Mining and Visualization (PYMOL).

UNIT-III: PHYLOGENETIC ANALYSIS AND PREDICTION: Evolutionary process; Origins of Molecular Phylogenetics; Common Multiple Sequence alignment methods; Phylogenetic analysis: Methods& Tools (Clustal W).

UNIT-IV: GENOME MAPPING AND PREDICTION:
Genome Mapping; Gene Prediction Methods &Tools, Gene Annotation; Human Genome Mapping (HGP), Promoter analysis.
RNA Sequence and structure Analysis - si-RNA design and development, RNA secondary structure, RNA structure Prediction Methods.

UNIT-V: PROTEIN STRUCTURE PREDICTION METHODS:
Basics of Protein biology (Classification, Structural Organization, Domains & Motifs); Protein Structure Prediction Concepts - Secondary & Tertiary Structure Predictions (Chou-Fasman Method, GOR Method, Neural Network method, Homology Modeling, Abintio method, Threading methods), Molecular docking methods.

COURSE OUTCOMES:

At the formal end of the course student will be able to

CO1. Understand the fundamentals and application of computational and bioscience useful for bioinformatics programming.

CO2. Classify and apply Databases, data retrieval process, data mining, knowledge about the BLAST, FAST and Visualization tools for Proteomics.
CO3. Evaluate evolutionary relationships between species, sequence alignment process and alignment tools.
CO4. Understand sequencing and mapping of genomes which are useful in their molecular biology studies and RNA design and development
CO5. Analyse Protein structures and protein modeling methods and tools.

TEXT BOOKS:

1. Bioinformatics: Methods and Applications- SC Rastogi, N Mendiratta& P Rastogi.
2. Bioinformatics Basics, Applications in Biological Science and Medicine- Hooman
3. Bioinformatics: Genome and sequence analysis by David W Mount.
4. Bioinformatics: A practical guide to analysis of genes and proteins by Baxevanis, Andreas D Wiley – Interscience publishers.

REFERENCE BOOKS:

1. Computational Molecular Biology – An Introduction by Peter Clote, Rolf Backofen, Jhon Wiley & Sons
2. Essential Bioinformatics by Jin Xiong, Cambridge University Press
3. Bioinformatics Principles & Applications by Zhumur Ghosh, Oxford University Press.

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PROGRAM CORE IX

MEDICAL MICROBIOLOGY

Course objectives: To provide the knowledge of various methods used to detect the pathogens and their diagnosis.

UNIT-I: INTRODUCTION: Introduction to Medical Microbiology, pathogenesis, components of microbial pathogenicity, Population genetics of Microbial pathogenesis, methods to detect genetic diversity and structure in natural population, epidemiology, cryptic diseases.

UNIT-II: HOST DEFENCES & MODULATION OF IMMUNE RESPONSE: Host defense against pathogens, clinical importance of understanding host defense, components of the host surface defence systems like skin, mucosa, eye, mouth and respiratory tract, Components of the systemic defense like the tissues and blood, Modulation of immune response by vaccines, properties of vaccines, other immuno modulators.

UNIT-III: BACTERIAL INFECTIONS: Diphtheria disease by colonisation; Disease without colonisation, *Clostridium botulinum* and *Staphylococcus aureus;* Intestinal infections, *Shigella* and *Ecoli* infections; *Vibrio cholera, Salmonella* infections.

UNIT-IV: VIRULENCE AND HOST PARASITE INTERACTIONS: Virulence and virulence factors, Colonizing virulence factors, Virulence factors damaging host tissues, Measurement of virulence factors, virulence genes & regulation of virulence genes. Host parasite interactions related to bacterial and viral infections.

UNIT-V: Applications of Medical Microbiology: Gastric and duodenal ulcers, Lyme disease , Syphilis, Legionnaire's disease, Tuberculosis and other mycobacterial infections, Rheumatic fever and Glomerulo nephritis.

COURSE OUTCOMES:

At the end of the course students will be able to:

CO1: Understand the knowledge of introduction to microbial pathogenesis.
CO2: Evaluate the knowledge of host defense system against pathogens.
CO3: Understand the bacterial infections and their pathogenesis.
CO4: Analyze the knowledge of virulence and host parasite interactions with related to bacterial infections.
CO5: Analyze the future challenges of infections and their treatments.

TEXT BOOKS:

1. Iglewski B.H. and Clark V.L. Molecular basis of Bacterial pathogenesis, Academic press, 1990.
2. Janeway C.A. Jr, and Travers P. T. Immunobiology. Blackwell J Scientific Publishers, 1994.

REFERENCES:

1. Talaro K. and Talaro A. Foundations in Microbiology, W.C. Brown Publishers, 1993. Roitt I. Essentials of Immunology, 8th edition, Blackwell Scientific Publishers, 1994.
2. Austyn J.M. and Wood K.J. Principles Cellular and Molecular Immunology, OxfordUniversityPress,1993.

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PROGRAM ELECTIVE III

i. **BIOANALYTICAL TECHNIQUES**

Course Objectives: The objective of the course is to create general understanding of Microscopy, Spectroscopy, Electrophoresis, Sequencing methods and different chromatographic methods.

UNIT-I: MICROSCOPY: Microscopy (Theory: Simple and Compound, Types: Light Field, Dark Field, Phase Contrast, SEM, TEM, Fluorescent).

UNIT-II: SPECTROSCOPY: Spectroscopy techniques: (Theory of Light) UV, IR, NMR, LASER Raman Spectroscopy, Fluorescence Spectroscopy.

UNIT-III: RADIATION AND FLOURESCENCE BASED METHODS: Radioactivity, measurement of radioactivity, photographic emulsion, ionization chamber, autoradiography, RIA, Fluorescent and Chemiluminiscent methods, Fluorescent Probes, FISH.

UNIT-IV: SEQUENCING OF PROTEINS AND NUCLEIC ACIDS: N-terminal sequencing for determination of protein sequence (Edman degradation); MALDI-TOF analysis Nucleic acid sequencing automated methods (Sangers Dideoxy and Maxim Gilbert methods) and determination technologies.

UNIT-V: SEPARATION TECHNIQUES: Centrifugation: Preparative and analytical; Electrophoresis: Different methods of electrophoresis for protein, nucleic acids, small molecular weight compounds and immuno precipitates (Immuno electrophoresis), IEF; Chromatography: Adsorption, affinity, Ion exchange, gel permeation, TLC, GLC, RPC, HPLC etc.

COURSE OUTCOMES:

At the end of the course student will be able to

CO1: Evaluate the Comprehensive understanding on microscopic techniques.
CO2: Understand Knowledge on spectroscopy and principles of Beer- Lamberts Law.
CO3:Assess the knowledge on radioactivity, measurement of radioactivity and different Radiolabelled and fluorescence labelled based techniques involved in Biotechnology.
CO4: Analyze the different techniques involved in sequencing of proteins and nucleic acids
CO5: Understand on different biomolecules separation techniques like chromatography, Electrophoresis sedimentation and centrifugation.

TEXTBOOKS:

1. Essentials of Molecular Biology, David Friefilder, Jones and Barllett Publications.
2. Proteins-Structure and Molecular Properties. TE Creighton, WH Freeman and company.
3. Genes VII, B. Lewin, Oxford University Press.
4. Introduction to Protein Structure, C. Branden and J. Tooze, Garland Publishing, New York.
5. Encyclopaedia of Molecular Biology, J. Kendrew, Blackwell Scientific Publications, Oxford.
6. Physical Chemistry of Macromolecules, Tanford, C., John Wiley and Sons.
7. Introduction to Biophysical Chemistry, RB Martin, McGraw Hill, New York.
8. Biophysical Chemistry, Cantoz, WH Freeman.
9. Protein Structure, by Max Perutz.

REFERENCE BOOKS:

1. Hobert H Willard D. L. Merritt & J. R. J. A. Dean, Instrumental Methods of Analysis, CBS Publishers & Distributors, 1992
2. Vogal, Text Book of Quantitative Inorganic Analysis, 1990
3. Ewing, Instrumental Methods of Analysis, 1992
4. PranbkumarBanerjee,Introduction to Biophysics, S.chand Publications,2008.
5. Instrumental methods of chemical analysis-GurudeepR.ChatwAL 7 Sham K.Anand,Himalaya Publishing house,ISBN.
6. Principles & Techniques of Practical Biochemistry 5th edition. K. Wilson &J.Walker, Cambridge University Press, 2000.

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PROGRAM ELECTIVE III

ii. RESEARCH METHODOLOGY & COMMUNICATION SKILLS

Course Objectives: - - To use the framework of these methodologies for understanding effective lab practices and scientific communication - To use the framework of these methodologies to understand and appreciate scientific ethics.

Unit-I: History of Science and Science Methodologies Empirical science; The scientific method; Interrogative perturbation experiments and controls; Deductive and inductive reasoning; Descriptive science; Reductionist Vs holistic biology.

Unit-II: Preparation for Research Choosing a mentor, lab and research question; maintaining a lab notebook with date-wise entry.

Unit-III: Process of Communication Concept of effective communication- Setting clear goals for communication; Determining outcomes and results; Initiating communication; Avoiding repetitions & breakdowns while communicating; Creating value in conversation; Barriers to effective communication; Non-verbal communication Interpreting non-verbal cues; Importance of body language, Power of effective listening; recognizing cultural differences.

Unit-IV Presentation skills - Formal presentation skills; Preparing and presenting using Over Head Projector, Power Point slides with clearly legible fonts without crowding the content; Defending Interrogation; Scientific poster preparation & presentation; Participating in group discussions Computing Skills for Scientific Research Web browsing for information search; search engines and their mechanism of searching; Hidden Web and its importance in Scientific research; Internet as a medium of interaction between scientists; Effective email strategy using the right tone and conciseness.

Unit-V: Scientific Communication Technical Writing Skills - Types of reports; Layout of a formal report; Scientific writing skills - Importance of communicating science; Problems while writing a scientific document; Plagiarism; Scientific publication writing: Elements of a scientific paper including Abstract, Introduction, Materials & Methods, Results, Discussion, References; Drafting titles and framing abstracts; Publishing scientific papers - the peer review process and problems, recent developments such as open access and non-blind review; Plagiarism; Characteristics of effective technical communication; Scientific presentations; Ethical issues; Scientific misconduct.

COURSE OUTCOMES:

At the end of the course students will be able to:

CO1. Understand the an awareness of methodologies used to do research
CO2. Analyze the methodology for proper initiation and execution of research
CO3. Understand the knowledge of effective communication methods
CO4. Evaluate the knowledge of proper presentation skills
CO5. Analyze to get good knowledge of scientific communication and technical writing

TEXTBOOKS & REFERENCES:

1. Valiela, I. (2001). Doing science: Design, analysis, and communication of scientific research. Oxford: Oxford University Press.
2. On being a scientist: A guide to responsible conduct in research. (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. (n.d.). The Science of Scientific Writing. American Scientist, 78(Nov-Dec 1990), 550-558.

REFERENCE BOOKS:

1. Mohan, K., & Singh, N. P. (2010). Speaking English effectively, Delhi: Macmillan India.
2. Movie: Naturally Obsessed, The Making of a Scientist.

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OPEN ELECTIVE III

i. **FOOD SCIENCE AND TECHNOLOGY**

COURSE OBJECTIVES: This course enables students to understand the food laws, food chemistry, food microbiology, preservation techniques and knowledge of food hygiene & food quality.

UNIT-I: INTRODUCTION TO FOOD SCIENCE & TECHNOLOGY: Fundamentals and aims of food science and technology. Interdisciplinary approach, Nutritive value of foods, Food as a source of energy, Food Health and disease. Food laws: Overview of Food Safety Standards Act 2006, Food Safety Standards Rules & Regulations, 2011. Overview of other relevant national bodies (e.g. APEDA, BIS EIC, MPEDA, Spice Board) Overview of Codex Alimentarius - development and issue of standards, Committees under Codex, role in maintaining harmony in food standards.

UNIT-II: FOOD CHEMISTRY Food chemistry-definition and importance, water in food, water activity and shelf life of food. Carbohydrates- functional properties of sugars and polysaccharides in foods. Lipids: use of lipids in foods, physical and chemical properties, effects of processing on functional properties and nutritive value. Protein and amino acids: physical and chemical properties, distribution, amount and functions of proteins in foods, functional properties, effect of processing. -Losses of vitamins and minerals due to processing.

UNIT-III: FOOD MICROBIOLOGY Microbial growth pattern, Types of micro-organism normally associated with food mold, yeast, and bacteria. Micro-organisms in natural food products. Contaminants of foods-stuffs, Fisheries, milk and meat during handling and processing. Biochemical changes caused by micro-organisms, deterioration of various types of food product. Food poisoning and microbial toxins, standards for different foods. Food borne intoxicants and mycotoxins.

UNIT-IV: FOOD PRESERVATION, PROCESSING AND PACKAGING: Physical chemical and biological methods of preservations. Bioprocessing of meat, Fisheries, vegetables, diary products. Irradiated foods. Overview of food packaging methods and principles including novel packaging materials/techniques.

UNIT-V: GENERAL PRINCIPLES OF FOOD HYGIENE AND FOOD QUALITY ASSURANCE: General principles of food safety management systems including traceability and recall – sanitation, HACCP, Good production and processing practices (GMP,GAP,GHP, GLP, BAP, Principles of Quality assurance and Quality control with reference to food analysis and testing

Course outcomes:

At the end of the course students will be able to:

CO1: Understand about food science and technology
CO2: To know the chemical properties of food
CO3: Identify the microbiology of food
CO4: Provide solution for pathogenic and spoilage microorganisms associated with different foods and their commercial importance.
Co5: Explain the various principles of food hygiene and food quality assurance

Text Books:

1. Jay J.M. 1986. Modern Food Microbiology, 3rd Edn. VNR, New York
2. Food processing and Preservation PHI private itd, New Delhi
3. Food Microbiology fourth edition William C.Frazier, Tata Mc Graw Hill
4. Food Microbiology 2nd Edition, Michael P. Doyle , ASM press
5. Fennema, O.R. Ed. 1976. Principles of Food Science: Part-I Food Chemistry Marcel Dekker, New York.
6. Mever. L.H. 1973. Food Chemistry. East-West Press Pvt. Ltd., New Delhi.
7. Charalambous, G. and Inglett, G. 1981. The Quality of Foods and Beverages, (2 vol. set). Academic Press, New York.
8. Krammer, A. and Twigg, B.A. 1970. Quality Control for the Food Industry. 3rd Edn. AVI, Westport.

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OPEN ELECTIVE III

ii. **PHARMACEUTICAL MICROBIOLOGY**

COURSE OBJECTIVES: This course enables students to understand the microorganisms in pharmaceutical industry, mechanism and action of antibiotics on microorganisms, Regulatory practices and quality assurances, GMP and GLP in pharmaceutical industry.

Unit- I: Prokaryotic and Eukaryotic Cells in Biosimilars Production:
Actinomycetes in Biosimilar Production, *Saccharomyces cerevisiae* and Other Fungi in Biosimilar Production, Plants in Biosimilar Production, Transgenic Plants as Functional Foods or Neutraceuticals Transgenic Plants and Plant Cell Culture as Bioreactors of Secondary Metabolites.

Unit-II: Antibiotics:
Antibiotics-definition, types of antibiotics and their classification. Mode of action of important drugs-cell wall inhibitors (betalactum- eg, penicillin) membrane inhibitors (polymyxin), macromolecular synthesis inhibitors (streptomycin), antifungal antibiotics (nystatin). Drug resistance- The phenomenon clinical basis of drug resistance, biochemistry of drug resistance, genetics of drug resistance in bacteria. Non-medical use of antibiotics.

Unit- III: Microbes in Pharmaceutical Products:
Microbial contamination and spoilage of pharmaceutical products (sterile injectibles, non injectibles, ophthalmic preparations and implants) and their sterilization. Manufacturing procedures and in process control of pharmaceuticals. Other pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase); Protein and DNA Vaccines.

Unit-IV: Regulatory Practices and Quality Assurance:
Regulatory aspects of quality control & Quality assurance; Quality assurance and Quality management in pharmaceuticals ISO, WHO and US certification; Financing R&D capital and market outlook; Pharmacopeias - IP, BP, USP. Government regulatory practices and policies - FDA perspective; USFDA, WHO and ICH Introduction to ISO series.

Unit- V: GMP & GLP:
Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry. Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization); Chemical and biological indicators; Design and layout of sterile product manufacturing unit (Designing of Microbiology laboratory); Safety Levels in microbiology laboratory.

Course outcomes:

At the end of the course students will be able to:

Co1: Understand about Microorganisms in Pharmaceutical industry
Co2: To know the mechanism and action of various antibiotics on microorganisms
Co3: Identify the microbes in pharmaceutical products
Co4: Evaluate the various regulatory practices and Quality assurance in pharma industry
Co5: Analyze the Good manufacturing and lab practices in pharmaceutical industries

SUGGESTED BOOKS:

1. W.B.Hugo & A.D.Russell *Pharmaceutical Microbiology*. Blackwell ScientificPublications.
2. Frederick Kavanagh *Analytical Microbiology* Academic Press New York.
3. David C. Hooper, John S. Wolfson *Quinolinone antimicrobial agents*. ASMWashington DC.
4. Murray S.Cooper *Quality control in the Pharmaceutical Industry*. AcademicPress New York.
5. H.J.Rehm & G.Reed, *Biotechnology*. VCH Publications, Germany.
6. S.P.Vyas & V.K.Dixit *Pharmaceutical Biotechnology*. CBS Publishers &Distributors, New Delhi.
7. Sydney H.Willig, Murray M.Tuckerman, William S. Hitchings, Mercel Dekker
   Good Manufacturing Practices for Pharmaceuticals New York.
8. Gregory Gregoriadis *Drug Carriers in biology & Medicine*. Academic Press New

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LAB V

r-DNA TECHNOLOGY & MEDICAL MICROBIOLOGY LAB

PART-A: r-DNA TECHNOLOGY LAB

Course Objective: This course intends to provide practical knowledge of different techniques involved in r-DNA technology.

LIST OF EXPERIMENTS:

1. Isolation of DNA
2. PCR-Amplification of DNA
3. Restriction digestion , Gel extraction
4. Ligation
5. Screening for recombinants

Course Outcome: By the end of this course student will acquire skill to perform techniques involved in isolation restriction digestion & ligation of DNA and screening of recombinants

PART- B: MEDICAL MICROBIOLOGY LAB

Course Objective: This course intends to provide the practical knowledge of different techniques used in medical microbiology lab.

LIST OF EXPERIMENTS:

1. Preparation of medically important media
2. Urea estimation
3. Glucose estimation
4. Acid-Fast staining
5. Bacteriological examination of blood, urine & pus
6. Determination of Hemoglobin
7. Erythrocyte Sedimentation Rate
8. Collection and culture of Nosocomial micro-organisms

Course Outcome: By the end of this course student will acquire skill to perform different methods used in medical field.

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LAB VI

BIOINFORMATICS & BIOANALYTICAL TECHNIQUES LAB

PART-A: BIOINFORMATICS LAB

Course Objective: The main objective of this course is to gain knowledge on different tools/software involved in Bioinformatics.

LIST OF EXPERIMENTS:

1. Data Retrieval Tools (Pub Med)
2. BLAST
3. Pair wise Alignment (EMBOSS)
4. Multiple Sequence Alignments & Phylogenetic Analysis (ClustalW)
5. Proteomic Analysis
   (a) Primary structure analysis,
   (b) Secondary structure prediction,
   (c) Tertiary structure Prediction (SPDBV),
   (d) Molecular Visualization tools (RASMOL, SPDBV).

Course Out comes: at the end of this course student gain practical training on different tools and softwares which were helpful in life sciences research.

PART- B: BIOANALYTICAL TECHNIQUES LAB

Course objective: The main objective of this course is to gain knowledge on different analytical techniques involved in microbiology.

LIST OF EXPERIMENTS:

1. Microscopy: Compound and Fluorescence Microscopy
2. Electrophoresis of Proteins - native and under denaturing conditions –silver staining, coomasive staining.
3. Determination of Tm of nucleic acid.
4. Separation techniques (HPLC, GPC, FPLC, Ion-Exchange).
5. IEF Demonstration

Course outcomes: at the end of this course student gain practical training on different analytical techniques like microscopy Electrophoresis and Different chromatographic techniques.

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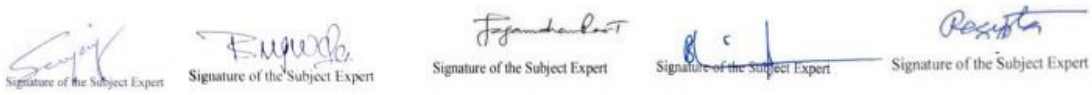
Signature of the Subject Expert | Signature of the Subject Expert | Signature of the Subject Expert | Signature of the Subject Expert | Signature of the Subject Expert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M.Sc. Microbiology	2022

THESIS TEMPLATE

TITLE NAME

(Capital letters only, Centre & Bold, Bookman Old style -14)

A THESIS

(Centre & Bold, Bookman Old style - 12)

Submitted

(Italic, Centre & Bold, Bookman Old style - 12)

in the partial fulfillment of the requirements for
the award of degree

(Italic, Centre & Bookman Old style -12)

MASTER OF SCIENCE

IN

MICROBIOLOGY

(Centre & Bold, Bookman Old style -14, Space line 1.5)

By

Mr. or **Miss. SAI MANISHA MALLELA**

[Roll No.: 19031D03**]

(Centre & Bold, Bookman Old style -14 & 12, Space line 1.5)

Under the supervision of

(Italic, Centre & Bookman Old style - 12)

Dr. K. VENKATESHWAR REDDY

Assistant Professor (C)

(Centre & Bold, Bookman Old style -14 & 12, Space line 1.5)

CENTRE FOR BIOTECHNOLOGY

UNIVERSITY COLLEGE OF ENGINEERING SCIENCE AND TECHNOLOGY,

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD,

Kukatpally, Hyderabad – 500 085, Telangana State, India

DECEMBER – 2021 (Submitted Month & Year)

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ACCREDITED BY NAAC
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CENTRE FOR BIOTECHNOLOGY
UNIVERSITY COLLEGE OF ENGINEERING SCIENCE AND TECHNOLOGY
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
(Established by Govt. Act No. 30 of 2008)
Kukatpally, Hyderabad – 500 085, Telangana State (India)

Dr. L. SAIDA, Ph.D.
Associate Professor & Head

Hyderabad
Date:

CERTIFICATE

This is to certify that the dissertation entitled "**TITLE**" is being submitted by Mr./Miss. **Name** bearing Roll No.: ------ to the Centre of Biotechnology, University College of Engineering Science and Technology, Jawaharlal Nehru Technology University Hyderabad in partial fulfillment for the award of **Master of Science** in **Biotechnology/ Microbiology** is a record of bonafide work carried out under the supervision of **Dr. K.VENKATESWAR REDDY**, Assistant Professor (C), CBT, UCEST, JNTUH, Hyderabad.

Dr. L. Saida Naik
(Head of the Department)

If possible **Saida sir** students only write as:
is a record of bonafide work carried out by **him/her** at our organization/ institution. And remaining faculty members write as above format.

M.Sc. Microbiology	2022

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CENTRE FOR BIOTECHNOLOGY
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(Established by Govt. Act No. 30 of 2008)
Kukatpally, Hyderabad – 500 085, Telangana State (India)

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Assistant Professor (C)

Hyderabad
Date:

CERTIFICATE

This is to certify that the dissertation entitled "**TITLE**" is being submitted by Mr./Miss. **Name** bearing Roll No.: ------- to the Centre of Biotechnology, University College of Engineering Science and Technology, Jawaharlal Nehru Technology University Hyderabad in partial fulfillment for the award of **Master of Science** in **Biotechnology/ Microbiology** is a record of bonafide work carried out by **her/him** under my guidance and supervision.

The results embodied in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

Dr. K. Venkateswar Reddy
(Research Supervisor)

M.Sc. Microbiology	2022

Outside Project work students done by
Different Institutions Organization Certificates

With Letter Head/Letter Pad
(Soft/Hard copy, Taken/Collect in the department Office or Colour print)

M.Sc. Microbiology	2022

DECLARATION

I hereby declare that the project work embodied in the dissertation entitled "**TITLE**" is being submitted to CBT, IST, JNTUH was carried out by me at Centre for Biotechnology (CBT), University College of Engineering Science and Technology (UCEST), under the supervision of **Dr. K. Venkateswar Reddy**, Assistant Professor (C), Centre for Biotechnology, University College of Engineering Science and Technology, JNTUH. This report is submitted in partial fulfillment for the award of Master of Technology in Biotechnology at CBT, UCEST, Jawaharlal Nehru Technological University Hyderabad, Kukatpally – 500 085, Hyderabad, Telangana State, India.

This work is original and no part of this has been submitted to any other university or institute for the award of any degree or diploma.

Place: Hyderabad

Date:

Signature

(**Name**)

Reg. No.:------

ACKNOWLEDGEMENTS

(Acknowledge assistance from **advisors, sponsors, funding agencies, colleagues, technicians**, and so on.)

My sincere thanks to **Dr. L. SAIDA**, Associate Professor and Head of the Department for permitting me to carry out the project work at Centre for Biotechnology, UCEST, JNTUH.

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My heartfelt thanks to **Dr. A. UMA,** Associate Professor, Centre for Biotechnology, UCEST JNTUH for guiding and supporting me throughout my project work at Centre for Biotechnology Laboratory.

My thanks are owed to **Teaching Staffs**, **Non-teaching staff's** members and Colleagues in the Biotechnology department of UCEST, JNTUH.

I would like to express my sincere thanks to all the **Colleagues** and **Ph.D scholars** of Centre for Biotechnology, UCEST, JNTUH for their valuable suggestions and support.

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(**Name**)
Reg. No.: -----

ABSTRACT

- The abstract may not exceed **500 words** for a master's. In style, the abstract should be a miniature version of the thesis. It should be a briefly state the (1) Research problem, (2) Methodology, (3) Key summary of the results, (4) Conclusions or main arguments presented in the thesis.
- Abstract should be in minimum 3 to 5 paragraphs and **justify** with **1.5 space** lines**.**
- **Key words:** Minimum 5 key words**.**

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

Abbreviation	Signification
DNA	Deoxyribonucleic acid
RNA	Ribonucleic acid

UNITS OF MEASUREMENTS & SYMBOLS	
cm	: Centimetre
^{o}C	: Degree Celsius
gm	: Gram
h	: Hour
kg	: Kilogram
µg	: Microgram
mg	: Milligram
mM	: Millimolar
mm	: Millimeter

µm	: Micrometer
µl	: Microlitre
ml	: Millilitre
min	: Minutes
M	: Molar concentration

FULL THESIS FORMAT GUIDELINES IN DETAILS
(CBT, UCEST, JNTUH)
Thesis Templates

Some of our students have contributed thesis templates which you may find helpful as you begin your thesis writing. If you have developed a template that you would like to share, please let us know and we will add it to our department of CBT.

- **Thesis hard copy** should be in **A4 Size** format with **300 gsm Gray sheet** soft binding.
- The thesis document is to be **printed on single side of the executive bond-paper**.

Fonts Size & Spacing:

- All the text words should be in **Times new roman** and font size is **12**.
- All text words should be **Justified** with **1.5 space line**
- Only footnotes, long quotations, bibliography entries should be double spaced, table captions, and similar special material may be single spaced.
- Paragraph to paragraph **1.0 cm** distance.
- All **headings** should be same font and **bold**, size is **12**.

Margins:

- We recommend a **left margin of "1.5**" and a **top, bottom,** and **right margin of "1.0"**.
- **Page numbers** do not need to meet the "1.0" margin requirement.
- If you do not follow the appropriate margin guidelines that are included here, you might lose content if your thesis is bound. Some students may wish to extend their work beyond the margin requirement for aesthetic reasons, this is acceptable.
- Labels for the Tables, Figures and Structures should be **centred**.

Table of contents:

- List the key **subject headings** and **subheadings** of your thesis with their page numbers.

List of figures:

- Include the figure numbers, figure titles, and page numbers.

List of tables:

- Include the table numbers, table titles, and page numbers and all text words should be **justified** with **1.0 space line anywhere in complete thesis.**

Hyperlinks:

- **Hyperlinks are not to be used** as a substitute for complete bibliographic citations.

Page numbering:

- Page numbers should be placed in the upper/ lower right corner of the page. Only the number should appear, not "page 9" or the abbreviation "p. 9."
- On the first page of each chapter, the number may be placed at the centred bottom, one double space below the last line of type (the conventional placement), or at the top right corner.

Body:

In the thesis body, you provide the introduction, narrative, and analysis of your work. The body includes these elements/chapters:

- **1. Introduction:** State (1) the purpose of the investigation, (2) the problem being investigated, (3) the background (context and importance) of the problem and **Objectives**.
- **2. Review of Literature:** It should be written based on update previous literature/available related to your work.
- **3. Materials, apparatus, and procedures:** List and describe key materials and apparatus. Then describe the procedure in detail that others can duplicate it. For design studies, this section includes component design, fabrication, assembly, and testing procedures. Use illustrations.
- **4. Results:** Present the results, usually with accompanying tables and graphs. Characterize the patterns and quality of the results and estimate their accuracy and precision. Detailed data may be presented as an appendix. Use analytical graphics.
- **4. Discussion:** Discuss the results, stating clearly what their significance is over the earlier reports. Compare the results with theoretical expectations and account for anything unexpected.
- **5. Conclusions:** Review the results in relation to the original problem statement. Assess the success of the study in light of the criteria of success you gave in the introduction.
- **6. Bibliography:** List alphabetically any works referred to in your study. Follow the bibliographical and footnote formats of your department.
- **Recommendations:** If applicable, recommend directions for future work.

- **Appendixes:** Provide detailed calculations, procedures, and data in separate appendixes. Give each appendix a title, a letter (Appendix A, B, C), and an introductory paragraph.

Standard References order should be following format:

1) All **Authors Names** included followed by **Year** of publication.
2) **Title of the publication**.
3) **Journals Names/ Title of the book; Subtitle & Publisher Names** (this should be written in ***italics***).
4) **Volume, Issue** and **Page Number**.
5) **Digital object identifiers** (DOIs) are commonly featured in reference entries for journal articles, as well as in entries for other types of electronic resources, **if available**.

Examples:

One Author:

1. Binnall, **J.** M (2019). Jury diversity in the age of mass incarceration: An exploratory mock jury experiment examining felon-jurors' potential impacts on deliberations. *Psychology, Crime & Law*, 25(4): 345–363. **DOI:** 10.1080/1068316X.2018.1528359.

Two Authors:

1) Machado, M. M., & Swank, **J.** M (2019). Therapeutic gardening: A counselling approach for bereavement from suicide. *Death Studies*, 43(10): 629–633. **DOI:** 10.1080/07481187.2018.1509908.

Three to More Authors:

1) Prinzie, P., Stams, G. **J. J.** M., Deković, M., Reijntjes, A. H. A., & Belsky, **J** (2009). The relations between parents' Big Five personality factors and parenting: A meta-analytic review. *Journal of Personality and Social Psychology*, 97(2): 351–362. **DOI:** 10.1037/a0015823.

If Book Chapters/ Text Books like:

1) Bale, T., Webb, P., & Poletti, M (2020). Foot soldiers: Political party membership in the 21st century. Oxford University Press. Routledge.

- **Plagiarism Report** generated by original print copy of colour page, should be provided in the **last page of thesis**.
- The plagiarism should be **less than 30**, if it is **more** than can't accept the thesis.

Very Important NOTE: Letter Head Certificates – Reg.

M. Tech (Biotechnology) and M. Sc (Biotechnology & Microbiology) student **Research Supervisor** will be **only CBT faculty** (Permanent/Contract) members, remaining outside Professors/ Scientists/ Managers will be **Co-supervisors** only.

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