VIVEKANAND EDUCATION SOCIETY'S
College of Arts, Science and Commerce
(AUTONOMOUS)
NAAC Re-accredited 'A' Grade (2017)
Best College Award (Urban Area: Year 2012-13) University of Mumbai
Recipient of FIST Grant (DST) ** Recipient of STAR College Grant (DBT)**
Recipient of Pradhan Mantri Uchchatar Siksha Abhiyan (PM-USHA) Grant

NEP HOLISTIC DEVELOPMENT BASED CURRICULUM FRAMEWORK

for

T. Y. B. Sc. MICROBIOLOGY SEMESTER V

PROGRAM CODE: UMB

Undergraduate Programme

From

Academic year

2025 - 2026

(Under NEP)

Program Outcomes (PO)

Upon completion of **B.Sc. Programme**, the graduates will have:

PO1. The required analytical skills to apply appropriate scientific principles and methodologies to solve real world problems

PO2. The ability to design, carry out experiments and analyze results while accounting for uncertainties in different quantities measured using various scientific instruments.

PO3. The ability to communicate scientific concepts, experimental results and analytical arguments clearly and concisely, both verbally and in writing.

PO4. Understand the need for scientific solutions to problems of the environment and society, keeping in mind their sustainable development.

PO5. Imbibed ethical, moral and social values in personal and social life leading to a cultured and civilized personality.

Program Specific Outcomes (PSO)

Upon completion of **B.Sc. Microbiology Programme**, the graduates will:

PSO1. Be well-versed with the fundamentals of Microbiology, which in turn will enable them to comprehend the latest developments in Life Sciences.

PSO2. Be able to apply the acquired conceptual knowledge in real life situations to solve problems as well as create new technologies.

PSO3. Have acquired knowledge and skills in various fields of Microbiology enabling their application in the Pharmaceutical, Health, Food and Biotechnology industries, as well as in protecting the environment

PSO4. Have acquired the basic skills and knowledge required for pursuing a career in Research

SEMESTER V TYBSC MICROBIOLOGY

Summary Table

COURSE CODES SEM V	Mode	Credits/ Semester	Hours/ Semester	SEMESTER V
Core Subject: **Major I** UMMMBS5-301	Theory	02	30	Flow Of Genetic Information
Core Subject: **Major II** UMMMBS5-302	Theory	02	30	Medical Microbiology
Core Subject: **Major III** UMMMBS5-303	Theory	02	30	Fundamentals Of Prokaryotic Biochemistry
Core Subject: **Major IV** UMMMBS5-304	Practical	04	60	Practicals Based on UMMMBS5-301, UMMMBS5-302 & UMMMBS5-303
Major Elective* UMEMBS5-311 UMEMBS5-313 UMEMBS5-315	Theory	02	30	1. Industrial Microbiology: Principles & Applications 2. Applications of Biotechnology 3. Bioinformatics & Biostatistics
Major Elective UMEMBS5-312 UMEMBS5-314 UMEMBS5-316	Practical	02	30	1. Practicals Based on UMEMBS5-311 2. Practicals Based on UMEMBS5-313 3. Practicals Based on UMEMBS5-315
VSC UVSMBS5-326	Theory	02	30	Techniques in Molecular Biology and Tissue Culture
Minor UMNMBS5-316	Theory	02	30	Biomolecules
Minor UMNMBS5-317	Practical	02	30	Practicals Based on UMNMBS5-316
FP UFPMBS5-371/ **CEP** UCEMBS5-372	-	02	30	Field Project or Community Engagement Program
TOTAL		**22**		

***Any one Major Elective and corresponding practicals**

MAJOR / CORE COURSE - I
COURSE TITLE: FLOW OF GENETIC INFORMATION

COURSE CODE: UMMMBS5-301
[CREDITS - 02: LECTURES - 30 hours: LEC/WEEK - 02]

Course Learning Objective
The objectives of this course are: 1. *To make the students appreciate the flow of genetic information from DNA to RNA to protein* 2. *To explain the molecular details of the processes of DNA replication, transcription and translation* 3. *To demonstrate the overall similarity of molecular processes in different biological systems while throwing light on the differences in the details*

Course Learning Outcomes
After completion of this course, the learner will be able to: 1. *Explain in detail the processes of DNA replication, transcription and translation* 2. *Enlist the various proteins and enzymes involved in the processes and explain their significance* 3. *Compare and contrast between the processes in prokaryotic and eukaryotic cells*

Unit I	DNA Replication	[15 L]
I.1	**Nature of DNA replication:** a) Semi-conservative (Meselson and Stahl experiment) b) Bidirectional c) Semi-discontinuous	**02**
I.2	**Modes of replication in:** a) Circular chromosomes (prokaryotic genomes, mitochondrial and chloroplast DNA, viral DNA) - theta mode and sigma mode b) Linear chromosomes (eukaryotic genome)	**03**
I.3	**Enzymes and proteins associated with DNA replication:** a) DNA polymerases b) Reverse transcriptase c) Topoisomerases d) Primase e) Helicases f) SSB g) Ligases h) Termination proteins	**05**
I.4	**Steps in prokaryotic and eukaryotic DNA replication:** a) Initiation b) Elongation c) Termination	**04**
I.5	**Telomerase activity and its significance**	**01**

References

1. Russell, iGenetics- A Molecular Approach, 3rd edition

2. Snustad and Simmons, Genetics, 6th edition, John Wiley and Sons, Inc.
3. Benjamin A. Pierce, Genetics - a conceptual approach, 4th edition, 2012, W.H. Freeman and Company
4. Teri Shors.(2009), Understanding viruses, Jones and Bartlett publishersAlan J. Cann (2005), Principles of Molecular Virology, 4th edition, Elsevier Academic Press
5. Nicholas H. Acheson (2011), Fundamentals of Molecular Virology, 2nd edition, John Wiley and Sons, Inc.

Unit II	Gene Expression	[15 L]
II.1	**Transcription** a) RNA polymerases of: i) Prokaryotes ii) Eukaryotes iii) Viruses b) Steps and molecular details of transcription in prokaryotes and eukaryotes: i. Initiation ii. Elongation iii. Termination c) Processing of eukaryotic mRNA- capping, tailing and intron removal	**07**
II.2	**Translation** a) The Translation machinery (Revision of SY topics) b) The steps and molecular details of translation in prokaryotes and eukaryotes i. Initiation ii. Elongation iii. Termination b) Post-translational modifications	**08**

References

1. Russell, iGenetics- A Molecular Approach, 3rd edition
2. Snustad and Simmons, Genetics, 6th edition, John Wiley and Sons, Inc.
3. Benjamin A. Pierce, Genetics - a conceptual approach, 4th edition, 2012, W.H. Freeman and Company
4. Prescott, Harley and Klein, Microbiology, 4th edition, WCB/McGraw-Hill

MAJOR / CORE COURSE - II
COURSE TITLE: MEDICAL MICROBIOLOGY

COURSE CODE: UMMMBS5-302
[CREDITS - 02: LECTURES - 30 hours: LEC/WEEK - 02]

Course Learning Objective

The objective of this course is:

1. *Understand the mechanisms of host-pathogen interactions, infection cycles, and virulence factors that contribute to microbial pathogenicity.*
2. *Study the morphology, cultural characteristics, pathogenesis, clinical features, laboratory diagnosis, treatment, and prevention of key bacterial and fungal pathogens.*
3. *Understand viral properties, replication cycles, pathogenesis, clinical features, laboratory diagnosis, treatment, and prevention of significant human viruses.*
4. *Study the characteristics, developmental stages, life cycles, pathogenesis, clinical features, laboratory diagnosis, treatment, and prevention of major protozoan pathogens.*
5. *Understand the attributes of an ideal antibiotic, classification based on target sites, and mechanisms of action of key antibiotic classes.*

Course Learning Outcomes

After completion of this course learner will be able to:

1. *Analyze and explain how pathogens establish infections, evade host defenses, and cause disease, relating virulence factors to clinical outcomes.*
2. *Identify bacterial and fungal pathogens based on morphology and culture, correlate them with clinical manifestations, and recommend appropriate diagnostic and therapeutic measures.*
3. *Explain viral replication strategies, associate them with pathogenic mechanisms, and apply knowledge to clinical diagnosis, treatment, and prevention of viral infections.*
4. *Illustrate protozoan life cycles, correlate them with disease transmission and pathogenesis, and recommend effective diagnostic and therapeutic strategies.*
5. *Classify antibiotics based on their targets, explain their mechanisms of action, and justify their selection for different infections.*

Unit I	Understanding Common Bacterial Diseases	[15 L]
II.1	**Host - pathogen interaction, infection cycle, virulence factors** (Revision from SY)	02
II.2	**Study of common bacterial pathogens:** (Morphology and cultural characteristics, pathogenesis & clinical features, laboratory diagnosis, treatment and prevention) a) *Streptococcus* spp b) *Staphylococcus aureus* c) *Mycobacterium tuberculosis* d) *E. coli* *e) Klebsiella pneumoniae* f) *Salmonella* spp g) *Vibrio cholerae* h) *Proteus* spp	13

	i) *Pseudomonas aeruginosa*	
Unit II	**Common Fungal, Viral & Protozoal Pathogens of humans**	**[15 L]**
II.1	**Pathogenic Fungi:** **(**Morphology and cultural characteristics, pathogenesis & clinical features, laboratory diagnosis, treatment and prevention) a) *Candida albicans* b) *Trichophyton*	**03**
II.2	**Viruses:** **(**Properties of virus, pathogenesis & clinical features, laboratory diagnosis, treatment and prevention) a. Influenza b. Dengue c. Herpes d. Hepatitis e. HIV f. Covid-19	**06**
II.3	**Protozoa:** **(**Characteristics, developmental stages, life cycle, pathogenesis & clinical features, laboratory diagnosis, treatment and prevention) a) *Entamoeba histolytica* *b) Plasmodium spp.*	**03**
II.4	**Antibiotics:** a) Attributes of an ideal antibiotic b) Classification of antibiotics based on target site: i) Cell wall (Penicillin and Cephalosporins) ii) Cell Membrane (Polymyxin) iii) Protein Synthesis (Streptomycin and Tetracycline) iv) Nucleic acid (Nalidixic acid) v) Enzyme inhibitors (Trimethoprim)	**03**

References

1. Jawetz, Melnick, & Adelberg's (2019). Medical Microbiology (27th ed.). McGraw-Hill Education.
2. Procop, G. W., & Koneman, E. W. (2017). Koneman's Color Atlas and Textbook of Diagnostic Microbiology (7th ed.). Wolters Kluwer Health.
3. Goering, R. V., Dockrell, H. M., Zuckerman, M., Wakelin, D., Chiodini, P. L., & Mims, C. (2013). Mims' Medical Microbiology (5th ed.). Elsevier/Saunders.
4. Ananthanarayan, R., & Paniker, C. K. J. (2017). Ananthanarayan and Paniker's Textbook of Microbiology (10th ed.). Orient BlackSwan.

MAJOR / CORE COURSE - III
COURSE TITLE: FUNDAMENTALS OF PROKARYOTIC BIOCHEMISTRY

COURSE CODE: UMMMBS5-303
[CREDITS - 02: LECTURES - 30 hours: LEC/WEEK - 02]

Course Learning Objective
The objective of this course to: 1. *To make the students acquainted with nutrient transport mechanisms in bacteria* 2. *To make the students understand the architecture of the membrane and how solute is transported inside the cell.* 3. *To describe the electron transport chain and understand the mechanism of ATP synthesis* 4. *To make the students appreciate the various pathways of Carbohydrate catabolism and generation of ATP by SLP* 5. *To make the students understand the anabolic processes .*
Course Learning Outcomes
After completion of this course learner will be able to: 1. *Recall the architecture of the membrane and the mechanism of solute transport into the cell* 2. *Explain the electron transport chains* 3. *Explain the mechanism of ATP synthesis.* 4. *Recall various pathways which produce ATP by SLP* 5. *Describe anabolic reactions in carbohydrate synthesis.*

Unit I	Nutrient transport and Electron transport chain	[15 L]
I.1	**Biological Membranes:** Lipids and properties of membranes	**01**
I.2	**Methods of studying solute transport** a) Vesicles and Protoplasts b) Liposomes and Proteoliposomes	**01**
I.3	**Solute transport across the membrane** a) Comparison between Passive transport, Facilitated diffusion, and Active transport by membrane proteins b) Co-transport across plasma membrane - Uniport, Antiport, Symport c) Active transport-Na-K ATPase d) Electrochemical gradient-Lactose transport e) Shock sensitive system: Role of binding proteins-Maltose and Histidine uptake f) Phosphotransferase system	**04**
I.4	**Electron transport chain** a) Universal Electron acceptors that transfer electrons to E.T.C b) Hydrogen carriers – Flavoproteins, Quinones c) Electron carriers – Iron Sulphur proteins, Cytochromes d) Inhibitors of ETC and ATPase	**02**

I.5	**Mitochondrial ETC** a) Complexes in Mitochondrial ETC b) Schematic representation of Mitochondrial ETC and electron-proton flow	**02**
I.6	**Prokaryotic ETC** a) Organization of electron carriers in bacteria b) Branched bacterial ETC c) The pattern of electron flow in *E. coli* - aerobic and anaerobic	**02**
I.7	**ATP synthesis** a) Explanation of terms – Proton motive force, Proton pump, Coupling sites, P:O ratio, Redox potential b) Experiments to prove the Chemiosmotic theory c) Structure & function of Mitochondrial and bacterial ATP synthase d) Mechanism by Rotational catalysis.	**03**
Unit II	**Metabolism of Carbohydrates**	**[15 L]**
II.1	**Catabolism of Carbohydrates** a) EMP and ED pathway, Radiorespirometry, Amphibolic role of EMP b) HMP Pathway c) TCA cycle-Anaplerotic reactions Glyoxylate bypass, Amphibolic role of TCA d) Breakdown of polysaccharides – Glycogen, Starch, Cellulose e) Breakdown of oligosaccharides - Lactose, Maltose, Sucrose, Cellobiose. f) Utilization of monosaccharides - Fructose, Galactose	**07**
II.2	**Energetics of Glycolysis, TCA and ED pathway**	**01**
II.3	**Fermentative pathways (with structures and enzymes)** a) Lactic acid fermentation- Homofermentation, Heterofermentation, Bifidum pathway b) Alcohol fermentation in bacteria and yeasts c) Mixed acid and Butanediol	**04**
II.4	**Anabolism of Carbohydrates** a) Gluconeogenesis b) Biosynthesis of glycogen	**3**

References

1. Conn, E.E., P. K .Stumpf, G. Bruening and R. Y. Doi. 1987. Outlines of Biochemistry,5th edition, 1987. John Wiley &Sons. New York
2. Nelson, D. L. and M.M. Cox (2005), Lehninger, Principles of biochemistry. 4th Edition, W. H. Freeman and Company
3. Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag
4. White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rd edition,Oxford University Press
5. Nelson, D. L. and M.M. Cox (2005), Lehninger, Principles of biochemistry. 4th Edition, W. H. Freeman and Company
6. Zubay, G. L (1996), Biochemistry, 4th edition, W. C. Brown publishers

MAJOR / CORE COURSE - IV
COURSE TITLE: PRACTICALS BASED ON UMMMBS5-301, UMMMBS5-302 & UMMMBS5-303

COURSE CODE: UMMMBS5-304
[CREDITS - 04: PRACTICALS - 120 hours , Practicals /week - 08]

Practicals based on UMMMBS5 - 301, UMMMBS5 - 302 & UMMMBS5 - 303	[120 L]

1. Isolation of genomic DNA of *E. coli*
2. Isolation of plasmid DNA
3. Gel electrophoresis of genomic and plasmid DNA
4. Measurement of DNA concentration by UV-VIS Spectrophotometer
5. Pure Culture studies (morphological, cultural and biochemical characteristics) of:
    a. *Streptococcus* spp
    b. *Staphylococcus aureus*
    c. *E. coli*
    d. Klebsiella pneumoniae
    e. *Salmonella* spp
    f. Shigella
    g. *Proteus* spp
    h. *Pseudomonas aeruginosa*
6. Cultural and biochemical identification of pathogens
    a. Identification of isolates causing infections of Skin
    b. Identification of isolates causing infections of the Respiratory tract
    c. Identification of isolates causing infections of the Gastrointestinal. tract
    d. Identification of isolates causing infections of the urinary tract.
7. Antibiotic susceptibility test by the Kirby-Bauer method
8. Detection of *Mycobacterium tuberculosis* by Acid-fast staining
9. Identification of *Candida* species by the germ tube test
10. Identification of Candida species on Chromagar
11. Observation of malarial parasites in blood films
12. Study of glucose transport in yeast using a solute transport inhibitor
13. Isolation of mitochondria and detection of succinate dehydrogenase activity
14. Study of homofermentation and heterofermentation by lactic acid bacteria
15. Study of Starch degradation by DNSA method
16. Comparison of growth of *E.coli* in aerobic and anaerobic conditions with respect to:
    a. Growth
    b. Acid production (pH changes)
    c. BNM,./ Redox potential (methylene blue reduction test)

VOCATIONAL SKILL COURSE (VSC)
TECHNIQUES IN MOLECULAR BIOLOGY AND TISSUE CULTURE

COURSE CODE: UVSMBS5-326
[CREDITS - 02: THEORY - 30 hours , Lecture /week - 02]

Course Learning Objective

The objectives of this course are to:

1. *Describe restriction enzymes and their significance in molecular biology*
2. *Explain the principle of PCR and its applications.*
3. *Describe the principles and procedures of Southern, Northern, and Western blotting.*
4. *Explain the principles and applications of Enzyme-Linked Immunosorbent Assay (ELISA), Radioimmunoassay (RIA) and Fluorescent in situ hybridization technique (FISH)*
5. *To elucidate the key steps in gene cloning, including isolation of genes, insertion into vectors, and transformation into hosts*
6. *Illustrate the concepts and applications of animal cell culture.*
7. *Elaborate on plant tissue culture techniques and their applications.*

Course Learning Outcomes

After completion of this course learner will be able to:

1. *Explain the mode of action and classification of restriction enzymes.*
2. *Understand the principle and mechanism of PCR.*
3. *Explain the principles and procedures of Southern, Northern, and Western blotting.*
4. *Compare the applications of ELISA and RIA in molecular biology and diagnostics.*
5. *Describe the various types of cloning vectors and explain the steps in gene cloning*
6. *Explain the basic principles, types and applications of animal cell cultures.*
7. *Describe the methods and applications of plant tissue culture*

Unit I	Molecular Biology techniques	[15 L]
I.1	**Restriction Digestion** a. Restricticton enzymes - Types, Characteristics, Naming convention b. Recognition sequences and cleavage sites, Sticky vs. blunt ends, Star activity c. DNA methylation and its effect on restriction enzyme activity	**03**
I.2	**Polymerase Chain Reaction (PCR)** a. Principle and key requirements b. Steps in PCR c. Types of PCR	**02**
I.3	**Blotting techniques** a. Southern blotting b. Northern blotting c. Western blotting	**02**
I.4	**Fluorescent in situ hybridisation assay (FISH)**	**01**
I.5	**Immunoassays** a. ELISA b. RIA	**01**

I.6	**Steps in Gene cloning:** a. Insertion of DNA fragments into cloning vectors Properties of Vectors: Origin of replication, selection markers, multiple cloning sites, and promoters, Types of Vectors: Plasmids, bacteriophages, cosmids b. Ligation Role of DNA ligases in joining DNA fragments c. Transformation Methods: Chemical transformation, heat shock, electroporation d. Screening for Successful Transformation: Antibiotic resistance, blue/white screening	**06**
Unit II	**Tissue Culture Techniques**	**[15 L]**
II.1	**Animal Tissue Culture** a. Basic concepts of mammalian cell culture b. Types of cell cultures - primary cell culture, secondary cell cultures, finite cell lines, continuous cell lines c. Steps in preparation of a primary cell culture, passaging d. Cell culture media and reagents e. Equipment for cultivation of mammalian cells f. Applications of cell culture: i. Cytotoxicity assays ii. Production of recombinant proteins iii. Cultivation of viruses and antiviral vaccine production iv. Hybridoma technology	**08**
II.2	**Plant Tissue Culture** a. Introduction to Plant tissue culture: Key principles b. Culture Media, Reagents and equipments c. Types of plant tissue culture: Callus Culture, Organ Culture, Embryo Culture, Protoplast Culture, Somatic Embryogenesis, Seed Culture, Meristem Culture, Anther Culture, Suspension Culture d. Applications of plant tissue culture: i. Micropropagation ii. Genetic engineering of plants iii. Production of secondary metabolites	**07**

References

1. Molecular Cloning: A Laboratory Manual by Sambrook & Russell
2. Bernard R Glick and Jack J Pasternak. Molecular Biotechnology: Principles and Applications of recombinant DNA. 3rd Edition.
3. R. C. Dubey. A Textbook of Biotechnology. 2006 S. Chand and Company Ltd.
4. B. D. Singh. Biotechnology. Kalyani Publishers.
5. S. N. Jogdand. Advances in Biotechnology. 2005. 5t Edition.
6. S. B. Primrose. Modern Biotechnology 1989. Blackwell Scientific Publ. Primrose and others. Principles of Gene manipulations. 6th edition. 2004 Blackwell Science.
7. Aluizino Borent and others. Understanding Biotechnology. 2004 Pearson Education.
8. James Watson and Others. Recombinant DNA. 2001. Scientific American Books.

COURSE TITLE: MAJOR ELECTIVE - 1
INDUSTRIAL MICROBIOLOGY: PRINCIPLES AND APPLICATIONS

COURSE CODE: UMEMBS5-311
[CREDITS - 02: THEORY - 30 hours , Lecture /week - 02]

Course Learning Objective
The objective of this course is: 1. *Understand the basics of industrial microbiology and its significance.* 2. *Learn methods for screening and improving industrial microbes.* 3. *Understand fermentation media composition and formulation.* 4. *Explore fermenter design, operation, and control.* 5. *Study industrial applications such as in brewing, antibiotics, enzymes, and organic acids.*

Course Learning Outcomes
After completion of this course learner will be able to: 1. *Describe the principles and importance of industrial microbiology.* 2. *Apply techniques for microbial screening and strain improvement.* 3. *Formulate fermentation media for optimal microbial growth.* 4. *Explain fermenter design, types, and operational control.* 5. *Analyze industrial microbial applications and their role in product development*

Unit I	Fundamentals of Industrial Microbiology	[15 L]
I.1	**Introduction to Industrial Microbiology**	01
I.2	**Industrial Microorganisms:** Screening and isolation of industrially useful microbes and strain improvement	03
I.3	**Fermentation media:** a) Water b) Carbon sources c) Nitrogen sources d) Other media ingredients e) Media formulation	03
I.4	**Fermentation systems:** a) Fermenter design and construction b) Fermenter control and monitoring c) Sterilization in fermenter operations	06
I.5	**Fermentation types:** a) Submerged b) Solid-State Fermentation c) Batch d) Fed-batch e) Continuous	02

Unit II	Industrial Processes and Products	[15 L]
II.1	**Downstream processing**	07
II.2	**Industrial fermentations:** a) Beverage fermentations i. Beer brewing ii. Wine production b) Microbial biomass production - Manufacture of baker's yeast c) Commercial production of health-care products i. Antibiotic - Penicillin ii. Vitamin - Vitamin B12 d) Commercial production of organic acid - Citric acid e) Commercial production of enzyme - Protease	08

References

1. Waites, M. J., Morgan, N. L., Rockey, J. S., & Higton, G. (2001). *Industrial microbiology: An introduction*. Wiley-Blackwell.
2. Crueger, W., Crueger, A., & Aneja, K. R. (2017). *Biotechnology: A Textbook of Industrial Microbiology* (3rd ed.). Medtech.
3. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3rd ed.). Butterworth-Heinemann.
4. Casida, L. E. (2016). *Industrial Microbiology* (2nd ed.). New Age International.

COURSE TITLE: MAJOR ELECTIVE - 1
PRACTICALS BASED ON UMEMBS5 - 311

COURSE CODE: UMEMBS5-312
[CREDITS - 02: PRACTICAL - 60 hours , Lecture /week - 04]

Practicals based on Industrial Microbiology	[60 L]

1. Primary screening for antibiotic producers using Wilkins agar overlay method
2. Production of antibiotic in broth culture, extraction of antibiotic by solvent extraction and detection of activity by agar cup method
3. Chemical estimation of Penicillin
4. Bioassay of Penicillin
5. Bioassay of Cyanocobalamin
6. Qualitative assay of Protease
7. Quantitative assay of Protease by Lowry's method
8. Alcohol Fermentation
    a. Preparation and standardization of yeast inoculum for alcohol fermentation
    b. Preparation of alcohol fermentation medium using jaggery and checking sugar content using Refractometer
    c. Alcohol fermentation using jaggery medium
    d. Distillation of Alcohol
    e. Chemical estimation of alcohol by Dichromate method
    f. Calculation of efficiency of fermentation.

COURSE TITLE: MAJOR ELECTIVE - 2
APPLICATIONS OF BIOTECHNOLOGY

COURSE CODE: UMEMBS5-313
[CREDITS - 02: THEORY - 30 hours , Lecture /week - 02]

Course Learning Objective
The objective of this course is: 1. *To equip students with a comprehensive understanding of how biotechnology impacts various fields* 2. *To demonstrate the use of genetic engineering in creating novel products which have robust applications* 3. *To demonstrate the application of transgenic animals and plants* 4. *To illustrate the role of biotechnology in healthcare through use of recombinant proteins, vaccines, gene therapy, and molecular diagnostics*
Course Learning Outcomes
After completion of this course learner will be able to: 1. *Explain antibiotic synthesis techniques and the production process of SCP using yeast, Spirulina, and mushrooms.* 2. *Evaluate bioremediation methods and the role of GEM and phytoremediation in environmental restoration.* 3. *Elaborate on the versatility of marine ecosystem in providing us with unique bioactive compounds* 4. *Describe the production and benefits of genetically modified animals and crops* 5. *Discuss the production of recombinant proteins and vaccines, gene therapy techniques and its challenges, and the impact of personalized medicine and nanomedicine in modern healthcare.*

Unit I	**Industrial, Environmental and Marine Biotechnology**	**15 L**
I.1	**Industrial Biotechnology** - Synthesis of Novel Antibiotics – Engineering polyketide antibiotics, peptide antibiotics - Production of SCP – Yeast, Spirulina, Mushroom - Production of Biopolymers – Biogums, Biopolysaccharides, Bioplastic. - Enzyme Immobilization Techniques and applications	**05**
I.2	**Environmental Biotechnology** - Introduction and Types of reaction in Bioremediation. - Biodegradation of pesticides and herbicide - Bioremediation of contaminated soil and waste water. - Bioremediation using genetically engineered microbes (GEM) - Higher plants in Bioremediation : Phytoremediation - Bioenergy & Biofuels - Biosensors	**05**
I.3	**Marine Biotechnology** - Marine Microbial Habitats and their biotechnologically relevant microorganisms - Methods for Microbial Bioprospecting in Marine Environments. - Bioactive compounds from other Marine Organisms: fungi, Microalgae, Seaweeds, Actinomycetes, sponges - Marine Bio-resources: Marine Secondary Metabolites, Marine Proteins, Marine Lipids, Cosmetics from Marine Sources, Marine Drugs, Marine Microbial Enzymes	**05**

Unit II	Animal, Plant and Healthcare Biotechnology	15 L
II.1	**Animal Biotechnology** a) Transgenic disease models: Alzheimer disease b) Transgenic Cattle c) Transgenic Fish	**04**
II.2	**Plant Biotechnology** a) Biofertilizers and Biopesticides a) Genetically Modified Crops: Resistance to pests, herbicides and environmental stress (e.g., Bt crops, Roundup Ready,). b) Genetically modified foods - Golden rice, Flavr Savr tomatoes	**04**
II.3	**Healthcare Biotechnology** a) Recombinant Vaccines: Hepatitis B, HPV b) Molecular diagnostics: PCR-based genetic testing and infectious disease diagnosis (e.g., HIV, tuberculosis, Covid-19), ELISA, Western blot, Monoclonal antibodies c) Production of Recombinant Therapeutic Proteins: Insulin, growth hormones, interferons, and clotting factors. d) Gene Therapy: Principles, types (somatic vs. germline), current challenges, and ethical considerations. e) Personalized Medicine f) Nanoparticles and nanomedicine	**07**

References

1. Bernard R Glick and Jack J Pasternak. Molecular Biotechnology: Principles and Applications of recombinant DNA. 3rd Edition.
2. Alexander N. Glazer, Hiroshi Nikaido (2007). Microbial Biotechnology: Fundamentals of Applied Microbiology. Cambridge University Press
3. Se-Kwon Kim (2015). Springer Handbook of Marine Biotechnology. Springer Berlin, Heidelberg
4. P.K. Mohapatra (2006). Textbook of Environmental Biotechnology.I K International Publishing House Pvt. Ltd.
5. Satyanarayana, U. (2005). Biotechnology. Books and Allied (P) Ltd.
6. R. C. Dubey. (2006) A Textbook of Biotechnology. S. Chand and Company Ltd

COURSE TITLE: MAJOR ELECTIVE - 2
PRACTICALS BASED ON UMEMBS5-313

COURSE CODE: UMEMBS5-314
[CREDITS - 02: PRACTICAL - 60 hours , Lecture /week - 04]

Practicals based on Biotechnology	[60 L]

1. Restriction digestion of plasmid DNA and study of restriction gene map
2. Native PAGE of bacterial/yeast cell homogenate
3. SDS PAGE of bacterial/yeast cell homogenate
4. Preparation of animal cell culture media
5. Cell viability - Trypan Blue Method
6. Preparation of plant cell culture media
7. Seed surface sterilization
8. Western Blotting (Demonstration)
9. ELISA (Demonstration)
10. Perform immobilization of yeast cells for invertase activity - making of alginate beads
11. Determination of Immobilized yeast activity
12. Polysaccharide extraction from Azotobacter and its detection
13. Production of SCP using yeast and protein estimation by Lowry's method
14. Isolation of cellulose degraders and production of alcohol from cellulolytic waste
15. Enrichment and Isolation of Phenol degraders and estimation of phenol by 4 AAP method
16. Biosynthesis of nanoparticles
17. Isolation and Cultivation of Marine Microorganisms

COURSE TITLE: MAJOR ELECTIVE - 3
BIOINFORMATICS AND BIOSTATISTICS

COURSE CODE: UMEMBS5-315
[CREDITS - 02: THEORY - 30 hours , Lecture /week - 02]

Course Learning Objective

The objective of this course is:

1. *To explain the definition, scope, aims, tasks and applications of bioinformatics in modern biology*
2. *To demonstrate the structure, purpose, and usage of various biological databases related to nucleic acids, proteins and molecular biology*
3. *To explain how bioinformatics can be applied to real-world biological questions, including drug discovery and evolutionary biology*
4. *To compute and interpret central tendency, dispersion, and correlation/regression analysis*
5. *To gain proficiency in performing hypothesis tests, understanding errors, p-values, and significance levels.*
6. *To develop the ability to perform and interpret chi-square tests, F-tests, and ANOVA for data analysis*

Course Learning Outcomes

After completion of this course learner will be able to:

1. *Explain the concept, goals and scope of bioinformatics.*
2. *Critically evaluate the strengths and limitations of different bioinformatics databases and tools for specific biological research questions.*
3. *Interpret alignment results to infer homology and evolutionary relationships.*
4. *Calculate and interpret central tendency, dispersion measures, and perform correlation and regression analysis on datasets.*
5. *Formulate hypotheses and conduct hypothesis tests, including understanding p-values, Type-I & Type-II errors, and significance levels.*
6. *Apply advanced statistical tests like chi-square, F-tests, and ANOVA to analyze complex data and interpret results.*

Unit 1	BIOINFORMATICS	[15 L]
I.1	**Introduction to Bioinformatics -** Goals, Scope, Applications and Limitations	01
I.2	**Introduction to Biological Database - Types and Pitfalls** - Types - Relational and Object-oriented - Biological Database - Primary, Secondary, Specialized - Nucleic acid sequence databases - EMBL, DDBJ, GenBank, GSDB, Ensembl and specialized Genomic resources - Protein sequence databases - PIR, SWISS-PROT, TrEMBL NRL-3D - Protein structure databases - SCOP, CATH, PROSITE, PRINTS BLOCKS & KEGG - Databases for - Restriction enzymes, Vectors, Primer selection	03

I.3	**Sequence alignment**
	- Sequence Homology versus Sequence similarity
	- Sequence similarity versus Sequence identity
	- Methods - Global and Local
	- Alignment Algorithms - Dot Matrix, Dynamic Programming
	- Scoring Matrices - PAM, BLOSUM
	- Statistical significance of Sequence Alignment
	- Database Similarity Searches - Pairwise alignment
	  - Heuristics Database Searching - BLAST and FASTA
	- Database Similarity Searches - Multiple sequence alignment
	  - Heuristic algorithms - progressive, iterative and block-based
		06

I.4	**Phylogenetics** - Molecular evolution and molecular phylogenetics - Terminologies - Gene phylogeny versus species phylogeny - Forms of Tree representation - Phylogenetic tree construction methods - Distance-based and clustering based	**03**
I.5	**Protein visualization tool - RasMol**	**02**
Unit 2	**BIOSTATISTICS**	**[15 L]**
II.1	**Descriptive Statistics:** - Review: Measures of central tendency - Mean, Median, Mode, Geometric mean - Review: Measures of dispersion - Range, Q.D and MD, Variance, Standard deviation - Correlation and Regression analysis: Relation between two variables, Scatter diagram, Karl Pearson's coefficient of correlation, Spearman's coefficient of correlation, Equations of regression lines, Principle of least squares, Interpretation of regression coefficients	**04**
II.2	**Inferential Statistics:** - Estimation - Hypothesis testing - Null and alternative hypothesis, Sampling Distributions, Type-I & Type-II errors, Level of significance, Power of test, P-value	**03**

II.3	**Parametric tests:**
	- Large sample Tests
	  i. Testing significance of single population mean
	  ii. Testing significance of two population mean
	- Small sample Tests
	  i. Testing significance of single population mean
	  ii. Testing difference between two independent normal population mean
	  iii. Testing difference between two correlated normal population mean
	  iv. Testing significance of correlation coefficient
		03

II.4	**Chi-Square test:** - Testing single population variance - Testing Goodness of fit	**02**
II.5	**F-test- Testing equality of variance:** a) ANOVA i. One-way classification ii. Two-way classification	**03**

References

1. Bioinformatics methods and applications - S.C. Rastogi
2. Baxevanis, A. D., & Ouellette, B. F. Francis. (2005). Bioinformatics : a practical guide to the analysis of genes and proteins. 3rd ed. Hoboken (N.J.): Wiley.
3. Xiong, J. (2006) Essential Bioinformatics. Cambridge University Press, Cambridge.
4. Daniel, W. W., & Cross, C. L. (2019). Biostatistics : A foundation for analysis in the health sciences (Eleventh edition). Wiley.
5. Paulson, D. S. (2009). Biostatistics and microbiology: A survival manual. Springer.
6. McDonald, J.H. (2014) Handbook of Biological Statistics. 3rd Edition, Sparky House Publishing, Baltimore.
7. http://www.rasmol.org/software/RasMol_2.7.5_Manual.html

COURSE TITLE: MAJOR ELECTIVE - 3
Practicals based on UMEMBS5-315

COURSE CODE: UMEMBS5-316
[CREDITS - 02: PRACTICAL - 60 hours , Lecture /week - 04]

Practicals based on UMEMBS5-315	[60 L]

1. Visiting NCBI and EMBL websites & list services available, software tools available and database maintained
2. Using BLAST and FASTA for sequence analysis
3. Pairwise alignment and multiple alignment of a given protein sequences
4. Primer Designing using open online source NCBI-BLAST
5. Formation of phylogenetic tree
6. Visualization PDB molecules using Rasmol
7. Calculation and Interpretation of the Mean, Determining the Median of a Dataset Identifying the Mode in a Dataset, Computing the Geometric Mean for Proportional Data
8. Determining the Range of a Dataset, Calculating Quartile Deviation (Q.D) and Mean Deviation (M.D), Calculation of Variance in a Dataset, Measuring Dispersion Using Standard Deviation
9. Exploring the Relationship Between Two Variables, Constructing and Analyzing Scatter Diagrams, Calculating Karl Pearson's Coefficient of Correlation, Computing Spearman's Rank Correlation Coefficient, Deriving and Interpreting Equations of Regression Lines, Application of the Principle of Least Squares, Interpreting Regression Coefficients for Predictive Models
10. Estimation Techniques and Hypothesis Testing: Null and Alternative Hypotheses
11. Testing the Significance of Single and Two Population Means Using Large Samples
12. Small Sample Hypothesis Tests: Single and Two-Sample Mean Comparisons
13. Chi-Square Test, F-Test, and ANOVA for Testing Variance and Group Differences

Reference

1. Baxevanis, A. D., & Ouellette, B. F. Francis. (2005). Bioinformatics : a practical guide to the analysis of genes and proteins. 3rd ed. Hoboken (N.J.): Wiley.
2. Xiong, J. (2006) Essential Bioinformatics. Cambridge University Press, Cambridge.
3. Daniel, W. W., & Cross, C. L. (2019). Biostatistics : A foundation for analysis in the health sciences (Eleventh edition). Wiley.
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5. McDonald, J.H. (2014) Handbook of Biological Statistics. 3rd Edition, Sparky House Publishing, Baltimore.

Modality of Assessment

Students appearing for the NEP BSc Microbiology will be evaluated as per the **60:40 scheme** wherein the term end exam will be of 60 marks while 40 marks will be through internal evaluation.

Theory Examination Pattern:

A. Internal assessment - 40%

Continuous internal evaluation: 30 marks

Sr No	Evaluation type	Marks
1.	Evaluation modalities: 1. Assignments that can include a. Essay Writing b. Solving Subjective Questions c. Problem Solving d. Report on lab/industry visit e. Any other subject/content specific assignments 2. Project based learning activities a. Group Discussion b. Research/Case studies c. Seminar Presentations d. Skits e. Poster Presentation f. Debate 3. Self-study/Class test	15
2	a. Active participation in routine class instructional deliveries b. Overall conduct as a responsible student, wrt manners, skill in articulation, leadership qualities demonstrated through organizing co-curricular activities, etc.	05

B. External examination - 60%

Semester End Theory Assessment: 30 marks

- The duration of this exam will be of 1 Hrs and 15 min (75 minutes)
- The theory question paper will have 2 questions of 15 marks each
- For each unit there will be one main question, with sub-questions within
- All questions will be compulsory with internal choice within the questions such that each question will be set out of 25-30 marks with options.

II. Practical Examination pattern

Practical Course	Medical identification + AST	Technique I	Technique II	Quiz	Viva	Journal	Total
Major Mandatory Practical	40	15	15	10	10	10	100 Marks

Practical Course	Bioassay	Chemical assay	Viva	Journal	Total
Major Elective 1 (Industrial Micro) Practical	25	15	5	5	50

Practical Course	Major	Minor	Quiz	Viva	Journal	Total
Major Elective 2 (Mol bio and Tissue culture) Practical	20	15	05	05	05	50 Marks

Practical Course	Major I	Major II	Minor I	Minor II	Journal	Total
Major Elective 3 (Bioinfo and Biostats) Practical	15	15	5	5	10	50 Marks

Overall Examination pattern
Semester V

	Course	Theory		Practical		Total	Credits
		Internal	External	Internal	External		
Major-Mandatory Theory	UMMMBS5-301	20	30	-	-	**50**	**02**
Major-Mandatory Theory	UMMMBS5-302	20	30	-	-	**50**	**02**
Major-Mandatory Theory	UMMMBS5-303	20	30	-	-	**50**	**02**
Major-Mandatory Practical	UMMMBS5-304	-	-	-	100	**100**	**04**
Major-Elective Theory	UMEMBS5-311	20	30	-	-	**50**	**02**
Major-Elective Practical	UMEMBS5-312	-	-	-	50	**50**	**02**
Minor-Theory	UMNXXS5-316	20	30	-	-	**50**	**02**
Minor-Practical	UMNXXS5-317	-	-	-	50	**50**	**02**
VSC - Theory	UVSMBS5-326	20	30	-	-	**50**	**02**
Field Project	UFPMBS5-371	50	-	-	-	**50**	**02**
	Total	**140**	**210**		**200**	**550**	**22**