Department of Microbiology
OSMANIA UNIVERSITY
HYDERABAD, TELANGANA STATE.
M.Sc Fermentation Technology

Program Outcomes (PO):

PO1: Graduates will be able to understand concepts about the microbial world, learn the fundamental techniques and their use in industry

PO2: Graduates will be able to apply essential perceptions about the microbial physiology, cell metabolic engineering and gene editing procedures in prokaryotic and eukaryotic system

PO3: Graduates will be able to demonstrate effective communication skills in both written and oral forms.

PO4:. Graduates will be able to impart technical skills and knowledge in research methodologies, computational data and its use to manage automated fermentation process.

PO5: Graduates will learn about design of fermenter, strains of industrial importance, media optimization, growth kinetics to manage the fermentation process at small scale to pilot scale.

PO6: Graduates will be able to apply knowledge and skills from microbial sciences, fermentation based concepts to interdisciplinary sciences to address real-world challenges.

PO7: Graduates will be able to demonstrate knowledge and understanding of global perspectives and challenges faced due to climate change, antimicrobial resistance.

PO8: Graduates will be able to engage in lifelong learning to take up activities, enhance their skills for meeting the Sustainable Development Goals (SDGs) and circular bioeconomy.

PO9: Graduates will be able to use current and emerging technologies to solve problems and create innovative solutions such as novel antibiotics, vaccines and novel biomolecules

PO10: Graduates will undergo industrial training and internship programs and be Bioferment-tech savvy's at industries.

Program Specific Outcome (PSO):

PSO1: Graduates will be able to understand about the importance of microbial world and their use in different arenas of agriculture, environment, food, medical and pharma

PSO2: Graduates will be able to learn about microbial, plant and mammalian system as bio factories for natural and recombinant products,

PSO3: Graduates will be able use different instrumentation techniques for bio-physio-chemical and molecular characterization of microorganisms and bio ferments.

PSO4: Graduates will be able to analyze data using statistical methods and software tools to corelate research on microorganisms, metabolites, optimized conditions for fermentation process

PSO5: Graduates will be able to take up scientific writing, trained to maintain documentation at QC and QA levels at various industries

Program Educational Objectives (PEOs):

PEO1: Graduates will learn fundamentals and apply basic principles of life sciences to ideate a solution, initialize prototyping and develop product road map.

.

PEO2: Graduates will combine principles of chemistry and biological sciences (molecular and cellular biology, genetics and immunology and technological disciplines (process engineering, computational parameters) and understand how cells can be used as bio-factories

PEO3: Graduates will be fortified with communication skills, ethical and professional principles, patent writing, entrepreneurial skills and knowledge required to pursue advanced studies in their field of study.

DEPARTMENT OF MICROBIOLOGY, OSMANIA UNIVERSITY
MSc Fermentation Technology, 2023
I Semester - CHOICE BASED CREDIT SYSTEM (CBCS)
Schedule for Instruction and Examination
(Proposed Scheme for Academic year 2023onwards)

SEMESTER – I						
Paper code	**Paper titles**	**Credits**	**Teaching Hours**	**Marks**		
				Internal Assessment	**Semester Exam**	**Total**
THEORY						
FT 101	Fundamentals of biology (Core)	3	3	50	50	100
FT 102	Instrumentation and Analytical Techniques (Core)	3	3	50	50	100
FT 103	Microbiology and fermentation (Core)	3	3	50	50	100
FT 104	Basics calculations in biology (Core)	3	3	50	50	100
PRACTICALS						
FT 151	Basic biology and Instrumentation	4	8	--	100	100
FT 152	Fermentation and calculations	4	8	--	100	100
	Total	**20**	**28**	**200**	**400**	**600**

Continuous and Comprehensive Evaluation (CCE)
Internal Assessment Pattern

<table>
<tr><th>1st Internal Assessment (10 Marks)</th><th>2nd Internal Assessment (10 Marks)</th><th>3rd Internal Assessment (10 Marks)</th><th>4th Internal Assessment (10 Marks)</th><th>% Attendance (10 Marks)</th><th>Total 50 Marks</th></tr>
<tr><td rowspan="6">1.) 10 Questions - ½ Mark each
MCQ-5 Marks

2.) 10 Questions – ½ Mark each
Fill in the blanks – 5 Marks</td><td rowspan="6">Short Answer Questions –

10 Questions
1 Mark each</td><td rowspan="6">Report writing –

2 Paraphrasing
5 Marks each</td><td rowspan="6">1. Assignment - 5 Marks

2. Seminar Presentation – 5 Marks</td><td>95-100%
10 Marks</td><td rowspan="6"></td></tr>
<tr><td>86 ≤ 95%
08 Marks</td></tr>
<tr><td>81 ≤86%
06 Marks</td></tr>
<tr><td>75 ≤81%
05 Marks</td></tr>
<tr><td>65 ≤75%
04 Marks</td></tr>
<tr><td>≤65%
(Detained)</td></tr>
<tr><td>10 M</td><td>10 M</td><td>10 M</td><td>10 M</td><td>10 M</td><td>50 Marks</td></tr>
</table>

Semester end Examination: 50M

M.Sc. (Previous) I Semester (CBCS)
Paper I FT 101 Fundamentals of Biology (Core)
(7 Hrs per week = 5 credits)

Course Objectives:

i. The students will learn about fundamentals of biology, structure of cell and membrane
ii. The students will understand about different biomolecules, structural and functional parameters
iii. The students will obtain information about biological reactions and metabolic pathways

Unit – I

Chemical basis of life. Miller-Urey experiment. Composition of living matter; Carbohydrates, proteins, organic compounds, hydrogen bonds, Water – properties of water, essential role of water for life. hydrogen bonding, solvent properties of water, ionization of water. pH optima of different enzymes, buffer. preparation and storage of solutions. pH, Buffers, Electrodes and Biosensors Stabilizing interactions: Vander waals, electrostatic, hydrogen bonding, Hydrophobic interactions. Interactions between cells and their Environment: Cell wall. Ultra structure of plasmamembrane: Membrane asymmetry, Dynamic nature of the plasma membrane. Movement of substances across cell membranes: Diffusion, Facilitated Diffusion & active transport.

Unit-II

Chemical composition of lipids, Fatty acid metabolism elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation. Carbohydrates, derivatives of monosaccharides, and polysaccharides (starch, glycogen, cellulose, dextrins), sugars of bacterial cell wall. Concept of isomerism in biomolecules. Proteins, Enzymes and proteins. Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation.Nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure

Unit –III

Bioenergetics-basic principles; equilibria and concept of free energy; glycolysis and gluconeogenesis;; Citric acid cycle, TCA as source of biosynthetic precursors; role of vitamins and cofactors in metabolism. Oxidative phosphorylation; Electron transfer in oxidative phosphorylation; Photosynthesis – Two photosystems; Calvin cycle
Microbial Metabolism: Glycolysis, Entner-Doundroff pathway, Aerobic respiration- Cellular respiration. Tricarboxylic acid cycle, The Electron Transport chain. Anerobic respiration.

Recommended Textbooks and References:

1. Stryer, L. (2015). *Biochemistry*. (8th ed.) New York: Freeman.
2. Lehninger, A. L. (2012). *Principles of Biochemistry* (6th ed.). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2016). *Biochemistry* (5th ed.). Hoboken, NJ: J. Wiley & Sons.
4. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology* (5th ed.). New York: McGraw-Hill.
5. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's Microbiology*. New York: McGraw-Hill.

I Semester FT 151 Fundamentals of biology (CBCS)- Paper I

1. Qualitative analysis of Simple sugars and Carbohydrates.
2. Qualitative analysis of Amino acids
3. Isolation / Extraction of biochemical metabolites (Carbohydrates, Protein and Lipids) from various sources
4. Estimation of glucose by DNS method
5. Estimation of protein by Lowry's/Bradford's method.
6. Estimation of cholesterol by Zak's method.
7. Buffer Preparation: Determination of *pKa*
8. pH optima
9. Effect of pH, Temperature, Substrates, Inhibitor on enzyme activity
10. Enzyme kinetics – Km, Vmax, Specific activity

M.Sc. (Previous) I Semester (CBCS)

Paper II FT 102 Instrumentation and analytical techniques (Core)

(7 Hrs per week = 5 credits)

Course Objectives:

i. The students will learn about instrumentation used in biological research
ii. The students will understand about principles and operating protocols of different spectrophotometric, electrophoretic techniques
iii. The students will obtain information about SOPs and safety precautions

Unit –I

Bioseparation and Scope - General laboratory procedures: lab safety, note books and reports, cleaning of glasswares. Microscopy:Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence microscopy: Advanced Microscopy:Confocal microscope. Scanning electron microscope. Diffusion, dialysis, cell disruption methods. Solid removal operations Centrifugation techniques – Principle, methodology and application of analytical centrifugation, differential centrifugation, density gradient centrifugation, ultracentrifuge.Principles and applications of lyophilization.

Unit –II

Spectrophotometry- Basic principles, instrumentation and applications of UV, Visible, IR spectrophotometers and Mass Spectrometry. Flame Photometry - Principles and applications Chromatography – Principle, operative technique and applications of Paper, TLC, adsorption chromatography, HPLC Ion-Exchange, molecular sieve. Ionization techniques; mass analyzers/overview MS; FT-IR and Orbitrap, fragmentation of peptides; proteomics, LC-MS; mass spectroscopy in structural biology; imaging mass spectrometry. Optical rotation. Circular dichroism, NMR, ESR. X-Ray diffraction, crystals and detectors, quantitative analysis and applications.

Unit -III

Electrophoretic techniques - Principle and technique of horizontal and vertical gel electrophoresis, Protein and DNA separation by electrophoresis, Isoelectric focusing, Pulsed field gel electrophoresis, immunodiffusion and immuno electrophoresis methods capillary electrophoresis. Serodiagnostic studies and their applications. Radio isotopes – detection and measurement of radioactivity – scintillation counters, autoradiography, stable isotopes and their use. Safety precautions. Calibration of balance, vortex, orbital shaker etc, based on industrial Standard operating procedures.

Recommended Textbooks and References:

1. Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: a Laboratory Manual*. Benjamin-Cummings Publishing Company.
2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). *Collins and Lyne's Microbiological Methods* (8th ed.). Arnolds.
3. Tille, P. M., & Forbes, B. A. *Bailey & Scott's Diagnostic Microbiology.*
4. Biophysical chemistry principles and techniques by Upadyay, Upadyay and Nath (Himalaya publishing).
5. Principles and techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker, Cambridge University Press
6. Instrumental methods of chemical analysis by Dr. G.R. Chatwal and Sham Anand, Himalaya Publishing House

I Semester FT 151 Instrumentation and analytical techniques (CBCS)- Paper I

1. To study Principle and applications of instruments: Autoclave, Hot-air oven, Centrifuge, pH meter, Incubator, Refrigerator, Distillation apparatus, Laminar Air-flow system, Water-bath.
2. Use of microscope and calibration.
3. Spectrophotometric determination of λmax for proteins, nucleic acids, vitamins
4. TLC and separation of pigments, aminoacids, carbohydrates, lipids
5. Use of HPLC for separation of aminoacids
6. Demonstration and tutorial mode for GC MS
7. Separation of DNA by agarose gel electrophoresis and molecular weight determination
8. Separation of proteins by SDS PAGE
9. Calibration demonstration of the different equipments and machinery used in fermentation industry
10. Calibration of balance, vortex, orbital shaker etc, based on industrial SoPs

M.Sc. (Previous) I Semester (CBCS)
Paper III FT 103 Microbiology and Fermentation (Core)
(7 Hrs per week = 5 credits)

Course Objectives:

i. The students will learn about the exploration of microorganisms in fermentation process
ii. The students will understand about sterilization and disinfection methods followed in different bio and pharma labs
iii. The students will obtain information about cell banks and broad array of metabolic pathways for production of primary and secondary metabolites

Unit -I

History & scope of microbiology. Microbes in fermentation., Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for bacterial classification; Morphology, structure, growth and nutrition of bacteria. Bacterial growth curve, bacterial culture and purification methods. Enrichment culture techniques: Isolation and selection of specific groups such as chemoheterotrophs, chemoautotrophs and photosynthetic microbes, Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria. Identification of bacteria and fungi by biochemical and molecular methods (16s rRNA and ITS). Microbial transformations and Carbon, Nitrogen, Phosphorous and Sulphur cycles.

;

Unit – II

Sterilization and Disinfection – principle, methods and mechanism of action – Physical Agents – Incineration, dry heat, moist heat, filtration, Radiation – (uv and ionising). Chemical agents – disinfectants – phenol, aldehydes, halogens, hypochlorites. Testing of disinfectants – phenol coefficient test, Rideal Walker test. Plasma sterilization, Principles, functioning and types of Biosafety cabinets.

Sterilization process in fermentation industry. Air and media sterilization. Strategies for bulk sterilization of fermentation media, in situ steam injection and steam sterilization.. Strategies of sugar sterilization and avoidance of undesired products. Initial bioburden and precautionary steps. Fermentor sterilization., Batch sterilization, Continuous sterilization. Membrane filtration and Deep bed filteration. Maintenance of filter catridges. Sterilization for decontamination of solid waste materials. Biosafety contained work areas.

Unit –III

Fermentation as co-evolutionary force. Fermentation Science. Chronology of fermentation process.Fermented traditional foods: Microorganisms and enzymes as key tools of fermentation. Isolation, preservation and improvement of industrially important microorganisms, Media for industrial fermentations – media formulation, Development of inoculum for industrial use. Inoculum preservation and storage. Cell banks: Working cell back and Mater cell bank. Broad array of metabolic pathways employed for the production of primary and secondary metabolites, as well as biopharmaceuticals. Fermented foods: nutrition and human health

Books for References:

1. Emt.el-Mansi & CFA. Bryce Fermentation Microbiology & Biotechnology, Taylor & Francis Ltd. (2004).
2. Stanbury, P.F., A. Whitaker & S.J. Hall. Principles of fermentation technology Oxford Press. (1997).
3. Microorganisms and Fermentation of Traditional Foods . 2015. Edited By Ramesh C. Ray, Didier Montet

4. Madigan, MT, Martinko, JM, Parker J. Brock Biology of Microorganisms. 10th Ed., Prentice-Hall, 2003.
5. Matthai,W, Berg, CY, Black, JG. Microbiology, Principles & Explorations. John Wiley&Sons, 2005.
6. Black, JG.Microbiology. 8th Edition, Wiley John Wily & Sons, Inc. Singapore, 2013.

I Semester FT 152Microbiology and Fermentation (CBCS)

Paper II

1. Introduction to Microbiology laboratory – GLP, Biosafety
2 Preparation and sterilization of culture media
3 Aseptic Transfer Techniques
4 Assessment of sterility of glassware and nutritional media (Hot air oven and Autoclave)
5 Sterilization by membrane filtration and sterility assessment Fermentation
6. Rideal walker test
6. Measurement of microbial growth
7. Turbidometric studies for bacterial growth
8. Determination of viable count and CFU
9. Isolation of industrially important microorganisms
10. Characterization of metabolites of industrial purpose, qualitative and quantitative assays.

.

M.Sc. (Previous) I Semester (CBCS)
Paper IV FT 104 Basic calculations in biology (Core)
(7 Hrs per week = 5 credits)

Course Objectives:

i. The students will be trained in calculations used in different biological process
ii. The students will understand about basics of physical quantities and their approach to use in fermentor process
iii. The students will learn fundamentals of physics / chemistry and their use in bioprocess.

Unit-I

Mathematical calculations and models in biology. Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems . Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology.
Statistical tools: Hypothesis. Hypothesis testing. Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design.

Unit –II

Basics to Physics: Physical quantities and their dynamics: definitions and dimensions; springs & Hookes laws; elastic and inelastic collisions; Newton's law of motions (centripetal and centrifugal forces *etc.*); simple harmonic motions, mechanical waves, Doppler effect, Directed motions in biological systems; low Reynolds number - buoyant forces, Bernoulli's equation, viscosity, turbulence, surface tension, adhesion; laws of thermodynamics: Maxwell Boltzmann distribution, conduction, convection and radiation, internal energy, electrolyte conductivity, capacitors and capacitance, dielectrics; various machines in biology *i.e.* enzymes, allostery and molecular motors (molecules to cells and organisms).

Unit-III

Basics to chemistry - elements, atoms, isotopes, atomic weights, atomic numbers, molecules, Avogadro number, molarity, gas constant, molecular weights, structural and molecular formulae, ions and polyatomicions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate-determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); chemical bonds (ionic, covalent, Van der Walls forces); electronegativity, polarity; states of matter - vapor pressure, phase diagrams, surface tension, boiling and melting points, solubility, capillary action, suspensions, colloids and solutions; Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; Newman projections, conformational analysis..

Recommended Textbooks and References:

1. Baaquie, B. E. (2000). *Laws of Physics: a Primer*. Singapore: National University of Singapore.
2. Matthews, C. P., & Shearer, J. S. (1897). *Problems and Questions in Physics*. New York: Macmillan Company.
3. Halliday, D., Resnick, R., & Walker, J. (1993). *Fundamentals of Physics.* New York: Wiley.
4. Ebbing, D. D., & Wrighton, M. S. (1990). *General Chemistry*. Boston: Houghton Mifflin.
5. Averill, B., & Eldredge, P. (2007). *Chemistry: Principles, Patterns, and Applications*. San Francisco: Benjamin Cummings.
6. Mahan, B. H. (1965). *University Chemistry*. Reading, MA: Addison-Wesley Pub.
7. Cantor, C. R., & Schimmel, P. R. (2004). *Biophysical Chemistry*. San Francisco: W.H. Freeman

8.. Hussain.I. et.al. Mathematics, A text book for class XI, NCERT.
9. Joshi, D.D. et.al. Mathematics, A text book for class XII, NCERT.
10.Batschelet, Mathematics for life Sciences
11.S. Sokal, R. and James F. Introduction to Biostatistics.

I Semester FT 152Basics calculations in biology(CBCS)- Paper II

1. Preparing various stock solutions and working solutions that will be needed for the course.
2. To prepare buffers and validate the Henderson-Hasselbach equation.
3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino Acids.
5. Problems on molarity, normality
6. Calculation of surface tension in biological experiments
7. Tutorial mode of practicals for calculation of heat liberated in fermentation process
8. Calculation of percentage composition
9. Calculation of molecular formulae
10. Problems on correlation analysis
11. Problems on ANOVA, DMRT

Semester – I : Course Outcomes

By the end of this Semester, the students will be able to:

1. Understand about the fundamentals of biological processes.
2. Understand the different principles and protocols on use of instrumentation in biological labs.
3. Get the significance of microbial world and their use in different metabolite production at fermentation industry
4. Work on calculations using statistics, physics and chemical parameters in different systems and various biochemical reactions.
5. Trained to work on different equipment's and tools used in microbiology lab
6. Design experiments to enumerate and cultivate bacteria
7. Perform the staining techniques and methods to identify microorganisms
8. Calculate problems related to molarity, normality, molecular formulae.

DEPARTMENT OF MICROBIOLOGY, OSMANIA UNIVERSITY
MSc Fermentation Technology, 2023
II Semester - CHOICE BASED CREDIT SYSTEM (CBCS)
Schedule for Instruction and Examination
(Proposed Scheme for Academic year 2023 onwards)

SEMESTER – II						
Paper code	**Paper Titles**	**Credits**	**Teaching Hours**	**Marks**		
				Internal Assessment	**Semester Exam**	**Total**
THEORY						
FT 201	Fermentation and Growth kinetics (Core)	3	3	50	50	100
FT 202	Bioprocess Technology and Economics (Core)	3	3	50	50	100
FT 203	Molecular Biology and Genetic Engineering (Core)	3	3	50	50	100
FT 204	IPR, Biosafety &Regulations (Core)	3	3	50	50	100
PRACTICALS						
FT 251	Fermentation & growth kinetics and Bioprocess technology& Economics	4	8	--	100	100
FT 252	Molecular Biology, &Genetic engineering and IPR, Biosafety & Regulations	4	8	--	100	100
	Total	**20**	**28**	**200**	**400**	**600**

M.Sc. (Previous) II Semester (CBCS)
Paper I FT 201 Fermentation and growth kinetics (Core)
(7 Hrs per week = 5 credits)

Course Objectives:

i. The students will learn about fermentation process parameters
ii. The students will understand about growth kinetics and models
iii. The students will obtain information about media formulation, calculation of C/N ratio.

Unit – I

Basics of fermentation. Isolation, screening, selection and improvement of microbial cultures involved in fermentation process. Design of a fermentor, aseptic operation and containment. Fermentor body construction. Design aspects of stirred tank reactors. Working volume, use of baffles and impellers and their configuration. Fermentors for microbial and animal cell culture, micropropagation of plants. Alternative vessel design, common measurements and control systems. Design of batch, fed batch, continuous bioreactors. Immobilized cell reactors and air□lift reactors. Sensors and Biosensors used in fermentation moniotring. Solid state and Submerged Fermentations. Merits and Demerits. Dual and multiple types of fermentation.

.

Unit –II

Media for industrial fermentations –Kinetics of media sterilization, D time, Z-value and F-value, calculation of Del-factor and holding time.Richard's rapid methods of design of sterilization process.Development of inoculum for industrial fermentations, preparation of seed bank, growth and library parameters. Fermentation: modeling-simulation, Microbial growth and metabolic process. Microbial growth kinetics. Structured and unstructured growth models. Monod's Growth kinetics, Specific growth rate, yield, production. Yield equations: Yg, YATP, Saturation constant, maintenance energy.

Unit –III

Typical medium, water, energy sources, carbon sources, nitrogen sources, C/N ratio and its importance in biomass and metabolite production. Use pf minerals, growth factors, nutrients, buffers, addition of precursors and metabolic regulators to media, oxygen requirement.Determination of the oxygen consumption rates during fermentation and evaluation of the oxygen solubility and transfer rates. Determination of K_La values,Fluid rheology. Methods of measuring variables in fermentation (aeration, agitation, valves, flow of fluids, pH, temperature, foam, pressure, redox). Introduction to software sensor models in fermentation process.

Recommended Textbooks and References:

1. Shuler, M. L., &Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering.*New York: M. Dekker.
4. Bailey, J. E., &Ollis, D. F. (1986). *Biochemical Engineering Fundamentals*. New York: McGraw-Hill.
5. Aiba and Hemphery Biochemical Engineering:.
6. S John Pirt Principles of Microbes and Cell Cultivation:.
7. Pauline M Doran. Bioprocess Engineering Principles

II Semester, FT 251

Fermentation& Growth Kinetics Practicals - Paper I

1. Isolation, screening, selection of industrially important microorganisms and their preservation.
2. Strain improvement using different mutagenic agents.
3. Indigenous assemblage and materials formaking a fermentor
4. Demonstration of working of various fermentors
5. Stoichiometric calculations and demonstrate specific models for bacterial growth
6. Monitoring microbial growth and biomass determination
7. Problems related to microbial growth kinetics
8. Problems related to Monod model for microbial growth kinetics
9. Carbon, nitrogen calculations of batch and fed batch fermentation process
10. Calculate the need for oxygen and oxygen transfer
11. Study of bacterial growth kinetics of Batch operation in a bioreactor
12. Measurement of different variables, calculations using sensors in fermentation process
13. Demonstration and comparison of solid state and submerged fermentation process for any product used at industry

M.Sc. (Previous) II Semester (CBCS)

Paper II FT 202 Bioprocess Technology and Economics (Core)

(7 Hrs per week = 5 credits)

Course Objectives:

i. The students will learn about upstream strategies and theoretical yield in bioprocess
ii. The students will get the glimpse of down stream process and product recovery
iii. The students will obtain information about circular bioeconomy, life cycle assessment, biorefinery process

Unit – I

Upstream strategies: media formulation and optimization; heat transfer in bioprocess; scale up and scale down; various process parameters affecting cellular environment. Elemental balance equations, metabolic coupling – ATP and NAD. Theoretical predictions of yield coefficients of bioprocess. Microorganisms involved in making of Primary and secondary metabolites, Use of bakers yeast and production of different metabolites; organic acids,antibiotics, bioethanol, biofuels, biosurfactants.

Unit –II

Down-stream strategies: Removal of microbial cells and other solid matter, Formation of foam. Separation and removal. Estimationof products fromfoam. Downtream operations: cell disruption, filtration, precipitation, centrifugation, liquid-liquid extraction, solvent recovery, Two phases extraction, Reversed micelle extraction, supercritical fluid extraction, final purification: drying; crystallization; storage and packaging. Different analytical studies for product detection.

Unit –III

Bioprocess economics and calculations involved in different fermentation steps. Biomass resources, renewable feed stocks, agro- lignocellulosic residual material for valorization. Circular economy and targets to meet the Sustainable Development Goals (SDGs). Life cycle assessment (LCA) of bioethanol, biofuel, biosurfactant production from microorganisms.. Effluent management and recovery of byproducts. Disposal of effluents and dissolved oxygen concentration as an indicator of water quality.

References

- Doran Pauline (1995) Bioprocess Engineering Principles, Academic Press.
- Lydersen B., N. a. D' Elia and K. M. Nelson (Eds.) (1993) Bioprocess Engineering: Systems, Equipment and Facilities, John Wiley andSons Inc.
- .Ratledge C and Kristiansen B eds. (2001) Basic Biotechnology 2ndEd. Cambridge Univ. Press.
- Operational Modes of Bioreactors, (1992) BIOTOL series, Butterworths Heinemann.
- Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts*. Upper
- Saddle River, NJ: Prentice Hall.
- Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*.
- Oxford: Pergamon Press.

- Blanch, H. W., & Clark, D. S. (1997). B*iochemical Engineering*. New York:
- M. Dekker.
- Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals.* New York:
- McGraw-Hill.
- El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology*.
- Boca Raton: CRC/Taylor & Francis.

II Semester, FT 251

Bioprocess Technology & Economics Practicals - Paper I

1. Isolation of yeast from different fermented samples
2. Production of wine and bioethanol using yeast
3. Estimation of ethanol and calculation of fermentation efficiency
4. Calculation of bioprocess economics for making of wine
5. Role of yeast in dough leavening
6. Isolation of microorganisms for organic acid production
7. Isolation of microorganisms for biosurfactant production
8. Isolation of microorganisms for antibiotic production
9. Downstream processing of different primary metabolites (organic acid/biosurfactant)
10. Downstream processing of secondary metabolites (antibiotics)
11. Detection methods for organic acids, biosurfactants, antibiotics
12. Demonstration and calculation of Life cycle assessment in biotech industry for different products
13. Site survey to understand the effluent / waste treatment
14. Water quality assessment of industrial effluents by different methods

M.Sc. (Previous) II Semester (CBCS)
Paper III FT 203 Molecular Biology and Genetic Engineering (Core)
(7 Hrs per week = 5 credits)

Course Objectives:

i. The students will learn about the genetic material, DNA, RNA and operon concept
ii. The students will understand about microbial genetics and cloning strategies
iii. The students will obtain information about recombinant technology and different products

Unit -I

Chromosomes: their structure, functions, replication and recombination. Nucleic acids: structure of DNA, RNA. Types of RNA. Transcription, Translation; components involved, t-RNA as adapter, genetic code and its salient features, gene expression; inducible and repressible operon (account of lac and trp operon). Gene regulation.Mutations and site directed mutagenesis. DNA damage and repair. Isolation of DNA, Sequencing of DNA, principle and methods. Cell signaling and metabolism. Signal transduction in response to nutrient, temperature and light and its role. Engineering signal transduction pathways for new functionalities and applications.

Unit -II

Genetics of bacteria and viruses. Recombination methods: Transformation, Transduction, Conjugation, Transfection, Molecular cloning; techniques and their importance, cloning vectors; properties and uses of phage vectors, plasmids, cosmids and phagemids., Restriction enzymes and their use in gene manipulation, cloning strategies; Preparation of genomic DNA, cDNA. Transposons, joining of DNA molecules. recombinant selection and characterization of clones, gene probes, labeling. Gene identification by chromosome walking and jumping. PCR principle, methodology and applications. Design of primers. Hybridization techniques: Northern and, Southern. Colony hybridization, fluorescence *in situ* hybridization. Western Blotting. Protein-protein interactive cloning and Yeast two hybrid system; Phage display.

Unit –III

Gene transfer technologies- Protoplast Fusion methods, gene transfer using cloning vector, Use of microbes in genetic engineering. Gene electroporation techniques, Microinjection method. Biolistic method for DNA transfer. Use of liposome for gene transfer, Tools for studying DNA / genes, A brief outline of structural and functional genomics. An overview of genetic engineering / recombinant DNA technology for different industrial products.

Books Recommended:

- Friefelder, D. 1987. Microbial Genetics. Narosa Publication.
- Friefelder, D., Maloy, S.R. and Cronana, J.E. 1994, Microbial Genetics, IInd edition, Jones and Barlett Publishers.
- Malacinski, G.M. &Friefelder, D. 1993. Essentials of Molecular Biology, IInd Edition. Jones and Bartlett Publishers.
- . Synder, L. and Champness, W., 1997. Molecular Genetics of Bacteria, ASM Press.
- Stryer, L. (2015). *Biochemistry*. (8th ed.) New York: Freeman.
- Lehninger, A. L. (2012). *Principles of Biochemistry* (6th ed.). New York, NY: Worth.
- Voet, D., &Voet, J. G. (2016). *Biochemistry* (5th ed.). Hoboken, NJ: J. Wiley & Sons.
- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).
- *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science.
- Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman.
- Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). *Lewin's Genes XI*. Burlington, MA: Jones & Bartlett Learning.

II Semester, FT 252

Molecular Biology and Genetic Engineering Practicals - Paper II

1. Preparation of competent cells
2. Isolation of plasmid DNA
3. Isolation of genomic DNA
4. Transformation experiment
5. Restriction digestion analysis
6. Calculations of vector and insert size using restriction enzymes
7. Cloning demonstration and explanation with gene of interest
8. Cloning for enhanced metabolite production and gene expression studies using manual or kit method.
9. Mutagenic agents and demonstration of Ames test
10. Demonstration of Recombinant technology used for different industrial products
11. Demonstration of protoplast fusion
12. Demonstration of transfection method

M.Sc. (Previous) II Semester (CBCS)
Paper IV FT 204IPR, Biosafety and Regulations(Core)
(7 Hrs per week = 5 credits)

Course Objectives:

i. The students will learn about Intellectual property rights, trademarks and copyright
ii. The students will understand patent filing process and treaties involved
iii. The students will obtain information about biosafety, bioethics and other regulatory bodies

Unit –I

Introduction to intellectual property rights (IPR); types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act. Concept of 'prior art': Patent databases - country-wise patent searches (India, USPTO, EPO); analysis and report.

Unit-II

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application.Precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; International patenting-requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents-gazette Patent infringement; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules.

Unit – III

Biosafety, Biosecurity and Bioethics - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs. principles of safety assessment of transgenic plants –environmental, food and feed safety assessment; Products derived from RNAi, genome editing tools. International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius. Indian regulations – EPA act and rules, guidance documents, regulatory framework – RDAC, RCGM, IBSC. Containments – biosafety levels, Category of rDNA experiments and field trails. Standard operating procedures (SoPs) - guidelines of state governments; GM labeling – Food Safety and

Standards Authority of India (FSSAI).Bioethics Concepts; Philosophical considerations; Ethics and the Law Issues associated with Genetic Engineering and other advanced research.

Recommended Textbooks and References:

1. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy.* New Delhi: Tata McGraw-Hill Pub.
2. *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. *Complete Reference to Intellectual Property Rights Laws*. (2007). Snow White Publication Oct.
4. Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.
5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
6. Karen F. Greif and Jon F. Merz, *Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies*, MIT Press
7. World Trade Organisation. http://www.wto.org
8. World Intellectual Property Organisation. http://www.wipo.int
9. International Union for the Protection of New Varieties of Plants. http://www.upov.int
10. National Portal of India. http://www.archive.india.gov.in
11. National Biodiversity Authority. http://www.nbaindia.org

II Semester, FT 252

IPR, Biosafety and RegulationsPracticals - Paper II

1. IPR and regulatory issues in relation to microorganisms and / or products/processes
2. Architecture of a typical patent application.
3. Documentation of Regulations of National Biodiversity authority (NBA) and Features of Biological Diversity Act 2002.
4. Information about different culture collection centers in India and Globally
5. Documentation and deposition of potential microbial strains at culture collection centers for patent application.
6. Typical stages in commercialization aspects of biotechnology processes / products;.
7. Documentation on TRIPS (Trade – Related Aspects of Intellectual Propery Rights) agreement; Alternative models of technology transfer and licensing
8. Documentation on integrity issues and Bio safety principles
9. Demonstration of ethical design for animal and clinical studies
10. Information and documentation of Bio ethics, law issues pertaining to biotech industrial process

Semester – II : Course Outcomes

By the end of this Semester, the students will be able to:

1. Understand about the fermentation process basics and operating parameters
2. Learn about microbial growth kinetics and calculations.
3. Understand about the molecular level of genetic material, cloning and recombinant studies
4. Write claims and file patent, understand the bioethics involved in animal and clinical studies.
5. Work on use of fermenter, small scale level and operational parameters
6. Frame upstream and downstream strategies and get the concept of circular economy, work towards Sustainable Development Goals (SDGs).
7. Design process parameters for production of novel metabolites and biosimilars using genetic engineering process
8. Scale up strategies from flask level to laboratory level fermenter

DEPARTMENT OF MICROBIOLOGY, OSMANIA UNIVERSITY
MSc Fermentation Technology, 2023
III Semester - CHOICE BASED CREDIT SYSTEM (CBCS)
Schedule for Instruction and Examination
(Proposed Scheme for Academic year 2023onwards)

SEMESTER – III						
Paper code	**Paper Titles**	**Credits**	**Teach -ing Hours**	**Marks**		
				Internal Asses	**Semester Exam**	**Total**
THEORY						
FT 301	Bio-Entrepreneurship Management (Core)	3	3	50	50	100
FT 302	Computational Biology and Bioinformatics (Core)	3	3	50	50	100
FT 303	**Electives:** IA: Microbial Fermentation Technology **OR** IB: Medical and Agricultural Biotechnology	3	3	50	50	100
FT 304	**Electives:** IIA: Emerging technologies and Precision fermentation **OR** IIB: Drug discovery, Nanotechnology and Protein Engineering	3	3	50	50	100
FT 305	Seminar / Review or Research article presentation	1	2	-	25	25
FT 306	Report writing of **one week Internship** at Industry / or any institute #	1	-		25	25
PRACTICALS						
FT 351	Bio-Entrepreneurship Management and Computational Biology and Bioinformatics	4	8	--	100	100
FT 352A*	**Electives:** Microbial Fermentation Technology, Emerging technologies and Precision fermentation **OR**	2	4	--	50	50
352B*	Microbial Fermentation Technology, Drug discovery, Nanotechnology and Protein Engineering**OR**					
352C*	Medical and Agricultural Biotechnology, Emerging technologies and Precision fermentation**OR**					
352D*	Medical and Agricultural Biotechnology, Drug discovery, Nanotechnology and Protein Engineering					
	Total	**20**	**26**	**200**	**400**	**600**

Training done after Semester II will be valued for award of credit

*Based on the elective selected (choice based) in theory, paper title of practical's need to be considered.

M**.Sc. (Final) III Semester (CBCS)**

Paper III B FT 301 Bioentrepreneurship Management (core)

(7 Hrs per week =5 credits)

Course Objectives:

i. The students will learn about entrepreneur skills
ii. The students will understand about development of different bioproducts, bioprocess and commercialization strategies
iii. The students will obtain information about Standard operating procedures for setting up diagnostic lab.

Unit -I

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech: Food and beverages), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Start–ups), strategic dimensions of patenting & commercialization strategies.

Unit -II

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills. Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

Unit-III

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP). Setting up of Medical diagnostic lab. Serological studies and regulatory measures. Handling of samples: Serological, Microbial, Urine and stool. PCR and other diagnostic procedures. Documentation and report analysis of hematology. Accreditation and permission protocols

Recommended Textbooks and References:

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. 3. Onetti, A., & Zucchella, A. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge*. Routledge.
4. 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.

III Semester, FT 351 Bioentrepreneurship Management Practicals Paper I

1. Visit to industry for making biofertilizers and report writing
2. Visit to food industry and report writing
3. Visit to dairy industry and report writing
4. Visit to pharma sector and report writing
5. Visit of drinking water plant and checking for sources of contamination and report writing
6. Visit to waste water treatment plant and report writing
7. Visit to Medical Diagnostic lab and report writing
8. Accreditation procedures and documentation
9. License documentation of existing fermented products
10. PoC of the project idea

M.Sc. (Final) III Semester (CBCS)

Paper III B FT 302 Computational Biology and Bioinformatics (core)

(7 Hrs per week =5 credits)

Course Objectives:

i. The students will learn about use of computers and programs for its use in automation of fermentation process
ii. The students will understand about the different bioinformatic tools
iii. The students will obtain information aboutArtificial intelligence, IoT and use in biological studies

Unit -I

Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; NCBI,EMBL-EBI; Database mining tools. Submission of DNA sequences to databases and database searching; sequence alignment , methods of phylogenetic analysis, pairwise alignment techniques; motif discovery and gene prediction.

Unit -II

Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX. Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.

Unit –III

Introduction to Python. Machine learning, Deep learning and AI tools in biology. IoT of fermentation process. Automation of fermentation process. Management of inconsistency in parameters during fermentation and product formation. Biosensors/Software sensor used in fermentation. Measurable parameters and comparison with computational levels. Offline /Online measurements- PID Controller in fermentation

Recommended Textbooks and References:

1. Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Bourne, P. E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.
3. Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics*. Oxford: Oxford University Press.
4. Campbell, M & Heyer, L. J. (2006), *Discovering Genomics, Proteomics and Bioinformatics*, Pearson Education.
5. Oprea, T. (2005). C*hemoinformatics in Drug Discovery,* Volume 23. Wiley Online Library.

6. Gasteiger, J. & Engel,T. (2003), *Chemoinformatics: a Textbook*, Wiley Online Library.

III Semester, FT 351 Computational Biology and Bioinformatics Practicals Paper I

1. MS Windows basics, UNIX basics,
2. File Management, E-mail (PINE, EUDORA, Internet mail),
3. File Transfer (ftp, WSftp).
4. Introduction and use of various genome databases.
5. Similarity searches using tools like BLAST and interpretation of results
6. Multiple Sequence alignment using ClustalW
7. Phylogenetic analysis of protein and nucleotide (16S) sequences
8. IoT to understand fermentation kinetics, process
9. Computational methods for fermentation
10. Software sensors in fermentation to monitor biomass, growth rate etc.

M.Sc. (Final) III Semester (CBCS)
Paper III FT 303 Microbial Fermentation Technology

(Elective I A)
(7 Hrs per week = 4 credits)

Course Objectives:

i. The students will learn about different fermentation process using microorganisms
ii. The students will understand about development of different bioproducts, bioprocess and bottle necks of fermentation industry
iii. The students will obtain information about how metagenomics can contribute to novel microbial products

Unit –I

Application of microbes and microbial processes in food and healthcare industries - food processing and food preservation. Different Fermented foods and nutraceuticals, Sensory evaluation. Antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Non-recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS) microbes to be used in food (*e.g.*, Lactic acid bacteria, Yeast) –. Process of spoilage and preservation. Rapid methods for detection food borne pathogens. Microorganisms in agriculture applications: PGPR, Bioinoculants, Biostimulants, Biofertilizers (Rhizobium and Mycorrhizae); Bioinsecticides *(Bacillus thuringiensis*, Baculoviruses) Biofungicides: (*Trichoderma, Pseudomonas fluorescens*);

Unit-II

Recombinant protein and pharmaceuticals production in microbes – common bottlenecks and issues (technical/operational, commercial and ethical); Attributes required in industrial microbes (*Streptomyces* sp., Yeast) to be used as efficient cloning and expression hosts (biologicals production); Generating diversity and introduction of desirable properties in industrially important microbes (*Streptomyces*/Yeast); Microbial cell factories; Bacteria, *Streptomyces* sp., Yeast, Algae for. fermentation of ethanol, bioethanol, biofuel, etc

Unit –III

Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Limits of microbial genomics with respect to use in human welfare; Metagenomics and metatranscriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, metagenomic library construction and functional screening in suitable hosts – tools and techniques for discovery/identification of novel enzymes, drugs (*e.g.*, protease, antibiotic).

Recommended Textbooks and References:

1. Lee, Y. K. (2013). *Microbial Biotechnology: Principles and Applications*. Hackensack, NJ: World Scientific.
2. Moo-Young, M. (2011). *Comprehensive Biotechnology*. Amsterdam: Elsevier.
3. Nelson, K. E. (2015). Encyclopedia of Metagenomics. *Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools*. Boston, MA: Springer US.
4. *The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet*. (2007). Washington, D.C.: National Academies Press.
5. Journals: (a) Nature, (b) Nature Biotechnology, (c) Applied microbiology and biotechnology, (d) Trends in Biotechnology, (e) Trends in Microbiology, (f) Current opinion in Microbiology, (g) Biotechnology Advances, (h) Genome Research)
6. Websites: http://jgi.doe.gov/our-science/

III Semester, FT 352 Microbial Fermentation Technology Practicals Paper I

1. To isolate bacteria and characterize for plant health
2. Isolation, characterization and production of *Bacillus thuringiensis* and Trichoderma at small scale level
3. To screen bacteria against phytopathogens
4. To evaluate the production of alcohol from molasses & lignocelluloses from different microorganisms
5. To compare production of citric acid using sucrose and molasses as carbon source.
6. Production of lactic acid using cheese whey as substrate.
7. To isolate and characterize yeast for production of industrially important products
8. Production of extracellular enzymes (pectinase and xylanase) by thermophilic and mesophilic fungal culture.
9. To isolate rare genera of microorganisms for novel antibioticproduction, and to evaluate the potential of different media for antibiotic production.

M.Sc. (Final) III Semester (CBCS)

Paper III FT 303 Agriculture and Medical Biotechnology

(Elective I B)

(7 Hrs per week = 4 credits)

Course Objectives:

i. The students will learn plant as bioreactor and its use in production of different secondary metabolites
ii. The students will understand about animal cell line techniques and transgenic animals
iii. The students will obtain information about development of vaccines, edible vaccines and antibody engineering etc

Unit –I

Plant cell culture, introduction, culture media. Plant growth regulators, Culture initiation, callus culture initiation, Concept of plants as bio factories, Plants as Bioreactors and scale up. Production of β – carotene and marketing prospects of carotenoids. Production of Lycopene and other pigments. Plant secondary metabolite production. Regeneration, Micropropagation, Plant transformation technology: *Agrobacterium*-plant interaction; virulence; Ti and Ri plasmids. *Agrobacterium*-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment Characterization of transgenics; chloroplast transformation; marker-free methodologies, advanced methodologies - cisgenesis, intragenesis

Unit –II

Introduction to mammalian cell culture, Growth kinetics, bioreactors for mammalian cell culture, process. Growth medium, role of CO_2 and supplements, serum and protein defined media. Animal biotechnology, transgenic manipulation of animal embryos; cryopreservation methods. Nuclear transplantation, transfection methods- lipofection, electroporation, microinjection, targeted gene transfer. Applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species.

Unit –III

Vaccinology: history of development of vaccines, introduction to the concept of vaccines, Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering, Making of insulin and monoclonal antibodies, catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T

cell based vaccine, edible vaccines, Stem cells-embryonic and adult stem cells and applications

Recommended Textbooks and References:

1. Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. Enfield, NH: Science.
2. Razdan, M. K. (2003). *Introduction to Plant Tissue Culture*. Enfield, NH: Science.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). *Plant Biotechnology: an Introduction to Genetic Engineering*. Oxford: Oxford University Press.
4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons.
5. Umesha, S. (2013). *Plant Biotechnology.* The Energy And Resources.
6. Glick, B. R., & Pasternak, J. J. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, D.C.: ASM Press.
7. Brown, T. A. (2006). *Gene Cloning and DNA Analysis: an Introduction.* Oxford: Blackwell Pub.
8. Primrose, S. B., & Twyman, R. M. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
9. Bernard R. Glick and Jack J. Pasternak. Molecular Biotechnology Panima Publishing House, New Delhi. (2002).
10. Bhojwani, S.S. and M.K. Razdan. Plant Tissue culture: theory and practice a revised edition Elsevier science. (2004).
11.. Goding, J.W. Monoclonal Antibodies: Principles and Practice Academic Press. (1983).
12.. Masters, J.R.W. Animal Cell culture Oxford University Press. (2000).

III Semester, FT 352 Agriculture and Medical Biotechnology

Practicals Paper II

1. Prepare culture media with various supplements for plant tissue culture.
2. Study of aseptic techniques in plant tissue culture laboratory
3. Preparation of media for plant tissue culture
4. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material).
5. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
6. Isolation of plant DNA
7. Count cells of an animal tissue and check their viability.
8. Prepare culture media for animal tissue culture.
9. Monitor and measure doubling time of animal cells.
10. Demonstration to Attempt animal cell fusion using PEG

M.Sc. (Final) III Semester (CBCS)

Paper IV FT 304 Emerging technologies and Precision fermentation

(Elective II A)

(7 Hrs per week = 4 credits)

Course Objectives:

i. The students will learn about new areas of fermentation process
ii. The students will understand about gene editing techniques, CRISPR/Cas9
iii. The students will obtain information about sustainable solutions and precision fermentation.

Unit I

Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Advanced genome and epigenome editing tools (*e.g.*, engineered zinc finger proteins, TALEs/TALENs, and the CRISPR/Cas9 system as nucleases for genome editing, transcription factors for epigenome editing, and other emerging tools) for manipulation of useful microbes/strains and their applications; Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies Different types of PCR techniques Gene manipulation and protein-DNA Interaction .

Unit –II

Predictive engineering and metabolic pathway optimization. Use of untapped variety of yeasts, fungi, mycelium, and microalgae as hosts to produce ingredients identical to animal proteins, for example egg whites (Clara Foods) or dairy (Perfect Day). Precision fermentation for the production of major food components (protein, lipids, carbohydrates). Precision fermentation using natural and genetically engineered microbes to produced different food, personal care products, colorants (food), textiles (dyes) etc.

Unit –III

New avenues in precision fermentation. Agriculture 2. 0. Sustainable solutions and ethical food system. Concept of Sustainable development goals (SDGs). Regulatory parameters in novel food products. Target of specific molecule. Use of live cultures for precision fermented products. Innovations in precisionfermentation and advancement of synthetic biology. Scaleup Technologies, market size and growth. Advantages and disadvantages of precision fermentation.

. **Recommended Textbooks and References:**

- Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*. Oxford:
  Pergamon Press.

- BBauman, RW, Microbiology. 2nd edition. Pearson Benjamin Cummings, 2009.
- Prescott, LM. Prescott, Harley and Klein's Microbiology. 6thEdition, McGraw-Hill, 2007.
- Tortora GJ, Funke BR, Case CL. Microbiology: An introduction 8th Edition. San Francisco: Pearson, 2004.
- Joan L. Slonczewski and John W. Foster. Microbiology: An evolving science. W. W. Norton & Company, 2013.
- New research articles and information of companies making food products through precision fermentation

III Semester FT 352 Emerging Technologies and Precision fermentation

Practicals Paper II

1. Demonstrations of evolving brewing process
2. CRISPR based strategies used at industries
3. New precision fermented products
4. Demonstration of making of meat using microbes
5. Demonstration of making of egg protein using bacteria, yeast
6. Making of fermented dairy products
7. Visit to industry making precision fermented products
8. PoC for novel precision fermented metabolites using microorganisms

M.Sc. (Final) III Semester (CBCS)

Paper IV FT 304 Drug discovery, Nanotechnology and Protein Engineering

(Elective II B)

(7 Hrs per week = 4 credits)

Course Objectives:

i. The students will learn about drug discovery and *In silico* studies
ii. The students will understand about nano technology and its application
iii. The students will obtain information about purification of enzymes, process parameters and protein engineering

Unit-I

Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three-dimensional structures and physicochemical properties of drugs and receptors; Modelling drug/receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases.

Unit –II

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials. Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules, Nanostructured fluids and their characterization. Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers. Silica nanoparticles for analytical microbial biofilms structure and applications.

Unit –III

Large scale production and purification of enzyme; Cofactors and their role in enzyme activity; Immobilization of enzyme and whole cells; Process design and operation strategies

for immobilized enzyme reactors; External and diffusional mass transfer limitation, Effectiveness factor and modulus; Stabilization of enzyme, Immobilization of multiple enzyme system; Protein engineering; Application of enzyme - Industrial, Analytical and Medical.

Recommended Textbooks and References:

1. Protein Engineering: Principles and Practice by Jeffrey L. Cleland and Charles S. Craik

2. Engineering the Genetic Code: Expanding the Amino Acid Repertoire for the Design of Novel Proteins by Nediljko Budisa

3. Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson and Michael M. Cox

4. A Laboratory Course in Nanoscience and Nanotechnology (2014). Ed. Gerrard Eddy Jai Poinern. CRC Press, USA.

5. Nanobiotechnology Protocols (2005). Eds. Rosenthal, Sandra J, Wright, David. Springer's Humana Press, USA.

6. Nanobiotechnology: Concepts and Applications in Health, Agriculture, and Environment (2019). Eds. Rajesh Singh Tomar, Anurag Jyoti and Shuchi Kaushik. CRC Press, USA

7. Protein Engineering For Industrial Biotechnology by Lilia Alberghina 5) Molecular Biology of the Cell by Bruce Alberts

III Semester, FT 352 Drug discovery, Nanotechnology and Protein Engineering Practicals Paper II

1. Principles of drug absorption studies
2. Drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions,
3. Plasma protein binding assays
4. Metabolite profile studies
5. Biofabrication of nanoparticles,
6. Demonstration of nanoparticles for drug delivery
7. Synthesis of nanoparticles using fungus/bacterium/plant extract.
8. Characterization of nanoparticles using UV-vis spectroscopy/X-ray diffraction (XRD), Transmission electron microscopy (TEM)/Scanning electron microscopy (SEM)/Selected-area electron diffraction (SAED)/Energy dispersive x-ray analysis (EDAX) .
9. Production of nanocomposites

Semester – III : Course Outcomes

By the end of this Semester, the students will be able to:

1. Get the concept of startups, funding opportunities available and how to take over entrepreneur skills
2. Take up computer aided tools, bioinformatics for different *in silico* studies
3. Do the automation process needed for operational parameters of fermentor.
4. Focus towards commercialization studies of different primary and secondary metabolites using microorganisms.
5. Focus to work on plant and animal based products and scale up strategies at fermentor level.
6. Design experiments for understanding the novel drugs, nano technology and engineering processes.
7. Take up emerging technologies to work on novel products and process parameters and trained to work on cellular agriculture and precision fermentation.
8. Take up literature reading, group presentations, individual communication skills and internship at industry.

DEPARTMENT OF MICROBIOLOGY, OSMANIA UNIVERSITY
MSc Fermentation Technology, 2023
IV Semester - CHOICE BASED CREDIT SYSTEM (CBCS)
Schedule for Instruction and Examination
(Proposed Scheme for Academic year 2023onwards)

Semester –IV : Industrial training with Dissertation / Project work - 20 credits
Course Objectives:

i. The students will be sent to different industries and / or where the Department has MoU for the training program.
ii. The students will work at industry for completion of the work related to fermentation or production process.
iii. The students will take up Industrial training along with dissertation / Project work.

SEMESTER-IV					
Paper code	**Title**	**Credits**	**Marks**		
FT 401	**Industrial training with Dissertation / Project work**		**Internal Assessment**	**Semester end Evaluation**	**Total**
Evaluation criteria					
	Design of Research project proposal, Research Design Seminar, Objectives and work frame	05	50	100	150
	-Instrumentation, Statistical Data and Computational analysis used in Research work *Certificate course / Training should be done as mentioned below	05	50	100	150
	Project Work / Dissertation	05	50	100	150
	-Scientific Writing, Making of Manuscript, Paper submission /acceptance/ publication Presentation and Final Viva voce	05	50	100	150
	Total	**20**	**200**	**400**	**600**

* Certificates from any authentic online portal or offline at any institute should be submitted to award credits (Duration of one week=1 credit; Duration of three day=0.5 credit). Its **mandate** to do one week certificate course. 9If any student does three day course, then they need to take up **two such certificate courses of three day each**.)Any certificate course done after Semester I will be valued for award of credits. Maximum of **two credits** (only) will be given through submission of certificate based training programs.

* Certificate based Training should be done on different instruments and techniques (HPLC, GC-MS, NGS, Fermenter, cell culture, etc) computational and statistical tools [Protein modelling, Genomics, Genome editing tools (CRISPR), computational tools: Biopython, Statistical tools: R programs, SAS software etc.]

Semester – IV : Course Outcomes

By the end of theSemester, the students will be able to:

1. Understand the SOPs at any pharma and bio sector
2. Get the clarity of process parameters and scale up strategies used in fermentation industry
3. Get trained in working of industrial level fermenter
4. Get the vision of working in QA/QC and R & D at industries
5. Work on different equipment's, tools and statistical parameters
6. Develop good communication, writing skills
7. Ready for setting up their own start-up with proper support.
8. Take up higher education at any academic / research institute