

B.Tech. Biotechnology (2025-26) onwards

THIRD SEMESTER

BIT2104

Microbiology

[3-1-0-4]

Introduction - History -Spontaneous generation; Germ theory of diseases; Cell theory; Microbial cell structure and function, Classification, brief account of viruses; mycoplasma, eukaryotic microbes. Microbial taxonomy: principles and its types; classical approach: numerical, chemical, serological and genetic - Microscopy- Nutrition, growth, and culturing: selective and differential media; growth curve, growth kinetics, overview estimation of microbes - Sterilization and Disinfection. Microbial genetics: DNA replication in bacteria, plasmids, transformation, conjugation, transduction; Fundamentals of microbial genomics and metagenomics. Applications of microbes: Applications in agriculture, environment, industry, health, and disease - microbe interactions; mechanisms of pathogenicity.

References

1. J. M. Willey, K. M. Sandman, and D. H. Wood, *Prescott's Microbiology*, 12th ed. New York, NY, USA: McGraw-Hill, 2023.
2. G. J. Tortora, B. R. Funke, and C. L. Case, *Microbiology: An Introduction*, 8th ed. Upper Saddle River, NJ, USA: Pearson Education, 2003.
3. M. T. Madigan, J. M. Martinko, and J. Parker, *Biology of Microorganisms*, 10th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2002.
4. R. Y. Stanier, J. L. Ingraham, M. L. Wheelis, and P. R. Painter, *General Microbiology*, 5th ed. London, U.K.: Macmillan Press, 1987.
5. M. J. Pelczar, E. C. S. Chan, and N. R. Krieg, *Microbiology*, New York, NY, USA: McGraw-Hill, 1986.

BIT2105

Cell and Molecular Biology

[3-1-0-4]

Introduction and Applications of cell and molecular biology, Cells and cellular structure, Properties of cells and cell membrane, Prokaryotic versus Eukaryotic, Cellular Reproduction, Mitosis and Meiosis, Cellular Activities and Checkpoints, DNA and the Flow of Molecular Information, DNA and RNA, Replication: DNA replication- Semi conservative replication - Replication in prokaryotes and eukaryotes, Mutation and its types, DNA repair systems - Post-transcriptional modifications, post-translational modifications. Regulation of gene expression in prokaryotes and eukaryotes, Positive Control and significance of Protein Synthesis, Cell Signaling: Receptors for Cell Signals, Signaling Pathways, Mis-regulation of Signaling Pathways, case studies.

References

1. H. F. Lodish *et al.*, *Molecular Cell Biology*, 9th ed. New York, NY, USA: W. H. Freeman, 2021.
2. G. Karp, *Cell and Molecular Biology: Concepts and Experiments*, 9th ed. Hoboken, NJ, USA: John Wiley & Sons, 2020.

3. G. M. Cooper and R. E. Hausman, *The Cell: A Molecular Approach*, 8th ed. New York, NY, USA: Oxford Univ. Press, 2018.
4. B. Alberts *et al.*, *Molecular Biology of the Cell*, 5th ed. New York, NY, USA: Garland Science, 2008.

BIT2106

Biochemistry

[3-1-0-4]

Introduction to Biochemistry: Definition and Scope of Biochemistry, Biomolecules and their role in living organisms, techniques for quantification of biomolecules. Carbohydrate Biosynthesis pathways, their regulation, and metabolism: Gluconeogenesis, Glyoxylate, Glycolysis, Pentose phosphate pathway, Citric acid cycle, Oxidative Phosphorylation and Photophosphorylation, Photosynthesis, Respiration, and Electron transport chain. Lipid Biosynthesis pathways, their regulation and metabolism: Fatty acids, Hormones, Neurotransmitters, Oxidation of Fatty acids, Transport of fatty acid, beta-oxidation, Ketone bodies Protein Biosynthesis pathways, their regulation, and metabolism: Amino Acids, Structure of Protein, Protein folding, Amino acid oxidation and production of Urea - Metabolic fates of amino groups, Nitrogen excretion, and the urea cycle, Amino acid degradation, Nitrogen metabolism, Biosynthesis of amino acids Nucleic acid Biosynthesis pathways, their regulation, and metabolism: Structure of DNA and RNA, Nucleotides Biosynthesis, and Nucleotides degradation. Biomolecules associated with different disorders and their possible treatment. Lab experiments related to quantification of biomolecules, enzymes, spectrophotometry, and chromatography

References

1. D. L. Nelson and M. M. Cox, *Lehninger Principles of Biochemistry*, 8th ed. New York, NY, USA: W. H. Freeman & Co Ltd, 2021.
2. J. M. Berg, G. J. Gatto, J. K. Hines, J. L. Tymoczko, and L. Stryer, *Biochemistry*, 10th ed. New York, NY, USA: W. H. Freeman & Co Ltd, 2023.
3. E. Conn, P. K. Stumpf, G. Bruening, and R. H. Doi, *Outlines of Biochemistry*, 5th ed. Hoboken, NJ, USA: Wiley, 2009.
4. D. J. Voet, J. G. Voet, and C. W. Pratt, *Principles of Biochemistry*, 4th ed. Hoboken, NJ, USA: Wiley, 2012.

BIT2107

Thermodynamics

[3-1-0-4]

Introduction: First Law of Thermodynamics, Entropy, Second and Third Law of Thermodynamics, Gibbs energy, governing equations for Mass, Energy and Entropy in closed and open systems, Interrelation between thermodynamic properties of ideal and real gases; Equation of state, intensive and extensive properties, Interrelation between thermodynamic properties of water, Multi-phase systems, Steam table, Thermodynamic properties of mixture, phase equilibrium, Gibb's phase rule. Thermodynamic aspects of biological processes: Heat generation and energy dissipation of live cell growth process, thermodynamic prediction of kinetic parameters (e.g., yield coefficients, growth rate,

specific rates, affinity constants), metabolic heat production, Gibbs energy dissipation for aerobic, fermentative, and autotrophic cell growth, Biocalorimetry and its applications. Thermodynamics of Metabolism: Black box thermodynamic analysis of Dicarboxylic acid production (e.g., Fumaric acid, succinic acid), maximum theoretical product yield, alkali consumption, osmotic stress and ionic strength, ATP synthesis for growth, thermodynamic feasibility analysis of metabolic pathways.

References

1. Y. A. Çengel and M. A. Boles, Thermodynamics: An Engineering Approach, 9th ed. New York, NY, USA: McGraw-Hill, 2019.
2. M. J. Moran, H. N. Shapiro, D. D. Boettner, and M. B. Bailey, Fundamentals of Engineering Thermodynamics, 9th ed. Hoboken, NJ, USA: Wiley, 2018.
3. J. M. Smith, H. C. Van Ness, and M. M. Abbott, Introduction to Chemical Engineering Thermodynamics, 8th ed. New York, NY, USA: McGraw-Hill, 2017.
4. S. I. Sandler, Chemical, Biochemical, and Engineering Thermodynamics, 5th ed. Hoboken, NJ, USA: Wiley, 2017.

BIT2108

Process calculations

[3-1-0-4]

Review of Basic concepts - Process variables & properties, Degree of Freedom, Material balances: Steady State Material Balances - in non-reacting systems and reacting system, Recycle & purge, elemental vs. species balance, combustion of fossil fuels. Multiphase equilibrium: Single component and multicomponent phase equilibrium, Steady State Material balances in Multiphase systems. Energy Balances: Steady State Energy Balances - in non-reacting & reacting systems, De-Coupled & coupled mass & energy balances, Calculations for network of units with recycle & bypass, Process Flow sheeting with sequential modular calculations, Unsteady State Balances. Humidification: Terminology of humidity, Humidity charts, heating and cooling problems of moist air.

References

1. D. M. Himmelblau and J. B. Riggs, Basic Principles and Calculations in Chemical Engineering, 8th ed. Nashville, TN, USA: Pearson, 2015.
2. R. M. Felder and R. W. Rousseau, Elementary Principles of Chemical Processes, 3rd ed. Hoboken, NJ, USA: Wiley, 2004.
3. B. I. Bhatt and S. B. Thakore, Stoichiometry, 5th ed. New York, NY, USA: McGraw-Hill, 2010.

BIT2132

Simulation lab

[0-0-2-1]

Introduction to Excel, functions, data organization, visualization, and process calculations. Basics of ASPEN simulation software, thermodynamic property selection, and estimation. Simulation of simple and multiunit systems with/without reactions. Case studies on process modeling and analysis.

BIT2134 Microbiology Lab

[0-0-2-1]

Introduction to microbiology laboratory practices and instruments. Microscopy-based studies of cells and mitosis, isolation of mitochondria and chloroplasts. Media preparation, sterilization, microbial isolation and culture techniques. Bacterial staining, motility, growth, preservation, antibiotic sensitivity, milk microbiology, and cell counting.

FOURTH SEMESTER

BIT2203

Genetic Engineering

[3-1-0-4]

Gene interaction, and linkage, extra-chromosomal inheritance, Sex determination, sex-linked, sex-limited, and sex-influenced inheritance, Molecular mapping, molecular markers, chromosome mapping, Pedigree analysis, case studies of genetic disorders. Introduction to Genetic Engineering and DNA Structure, Gene Cloning and Vectors: Principles of gene cloning, types of vectors, Cloning strategies and techniques, Modern vector systems: CRISPR-Cas9 delivery systems and viral vectors. cDNA Library and cDNA Synthesis, DNA Analysis and Sequencing: PCR and DNA amplification, DNA sequencing methods, Next-generation sequencing (NGS), Basics of Gene Expressions: hybridization techniques, blotting techniques, Nucleic acid microarrays, Recombinant DNA Technology and Applications, Case Studies and Ethical Considerations. Current Trends and Future Directions.

References

1. T. A. Brown, *Gene Cloning and DNA Analysis: An Introduction*, 8th ed. Hoboken, NJ: Wiley-Blackwell, 2021.
2. S. B. Primrose and R. M. Twyman, *Principles of Gene Manipulation and Genomics*, 7th ed. Malden, MA: Wiley-Blackwell, 2006.
3. B. Lewin, *Lewin's Genes XII*. Burlington, MA: Jones & Bartlett Learning, 2017.
4. J. Sambrook and D. W. Russell, *Molecular Cloning: A Laboratory Manual*, 4th ed. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2012.
5. D. P. Snustad and M. J. Simmons, *Principles of Genetics*, 7th ed. Hoboken, NJ: Wiley, 2015.

BIT2204

Transport Processes in Biological Systems

[3-0-0-3]

Introduction to transport phenomena in biological systems, diffusion and convection, forces and fluid statics, Newtonian fluids, and shear/strain relationships. Fluid transport: Principles of fluid mechanics, conservation equations, Fluidic applications: parallel-plate, rectangular and cylindrical channels, Differential forms of the conservation of mass and momentum: Navier Stokes, Integral forms of the conservation of mass and momentum. Heat transfer: Principles of heat transfer, heat transfer coefficients, heat transfer equipment - double pipe heat exchanger, shell and tube heat exchanger. Concept of evaporation and condensation. Mass transport: Principles of mass transfer, Steady diffusion and boundary conditions, Steady state diffusion from variable geometries, Unsteady diffusion, Adsorption, Absorption, Extraction, Drying, Distillation, Transport in porous media. Case studies pertaining to biological systems.

References

1. R. B. Bird, W. E. Stewart, and E. N. Lightfoot, *Transport Phenomena*, 2nd ed. Hoboken, NJ, USA: Wiley, 2006.
2. C. J. Geankoplis, *Transport Processes and Separation Process Principles*, 5th ed. Upper Saddle River, NJ, USA: Pearson, 2018.
3. P. M. Doran, *Bioprocess Engineering Principles*, 2nd ed. Amsterdam, Netherlands: Elsevier, 2012.
4. J. E. Bailey and D. F. Ollis, *Biochemical Engineering Fundamentals*, 2nd ed. New York, NY, USA: McGraw-Hill Education, 2017.
5. G. Truskey, F. Yuan, and D. Katz, *Transport Phenomena in Biological Systems*, 2nd ed. Upper Saddle River, NJ, USA: Pearson, 2009.

BIT2205

Bioreaction Engineering

[3-0-0-3]

Basics of Reaction Engineering: Law of mass action and rate equation, definitions and examples of elementary and nonelementary reactions, theories of reaction rate and temperature dependency, analysis of experimental reactor data - evaluation of rate equation by integral and differential analysis for a constant volume system. Ideal and non-ideal reactors. RTD.

References

1. O. Levenspiel, *Chemical Reaction Engineering*, 3rd ed. Hoboken, NJ, USA: Wiley, 2021.
2. H. S. Fogler, *Elements of Chemical Reaction Engineering*, 6th ed. Harlow, U.K.: Pearson Education Limited, 2022.
3. M. Ozilgen and E. Sorguven, *Bio-Thermodynamics Principles and Applications*, 1st ed. Boca Raton, FL, USA: CRC Press, 2016.
4. D. L. Nelson and M. M. Cox, *Lehninger Principles of Biochemistry*, 8th ed. New York, NY, USA: W.H. Freeman and Co., 2021.
5. J. M. Smith, H. C. Van Ness, and M. M. Abbott, *Introduction to Chemical Engineering Thermodynamics*, 7th ed. New York, NY, USA: McGraw-Hill, 2012.

BIT2232

Genetic Engineering Lab

[0-0-4-2]

Preparation of reagents and extraction of genomic DNA, plasmid DNA, and RNA. Gene manipulation techniques including transformation, mutation, PCR, restriction digestion, electrophoresis, SDS-PAGE, and Western blotting. Quantification of nucleic acids, study of DNA/RNA models, and analysis of genetic linkage, probability, and statistics.

BIT3103 Bioprocess Engineering**[3-1-0-4]**

Media preparation and sterilization: Introduction on Media formulation, media for bacterial and animal cell culture, Media optimization methods, media sterilization, Design of batch and continuous sterilization processes. Culture preservation, inoculum development, Microbial growth kinetics: Preservation of industrially important cell cultures, Development of inocula for animal cell processes, Criteria for inoculum transfer, Yeast processes, Unicellular bacterial processes, Mycelial processes, Vegetative fungi. Batch culture, continuous culture, fed-batch culture, multistage systems, comparison of batch and continuous culture in industrial processes, Chemostat with cell recycle, Stability analysis. Stoichiometry of microbial growth and product formation, Mass transfer in bioprocessing, Heat generation by microbial growth.

References

1. M. L. Shuler and K. Kargi, Bioprocess Engineering: Basic Concepts, 2nd ed. New Delhi, India: Pearson Education India, 2015.
2. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd ed. New York, NY, USA: McGraw-Hill, 2017.
3. P. Doran, Bioprocess Engineering Principles, 2nd ed. Amsterdam, Netherlands: Elsevier, 2012.
4. H. W. Blanch and D. S. Clark, Biochemical Engineering, 2nd ed. New York, NY, USA: CRC Press, 1997.
5. P. F. Stanbury, A. Whitaker, and S. J. Hall, Principles of Fermentation Technology, 3rd ed. Oxford, UK: Butterworth-Heinemann, 2016.

BIT3104 Immunology**[3-1-0-4]**

Introduction to Immunology, Types of Immunity, Cells of the Immune System and their roles and interactions, Mechanisms of lymphocyte movement and activation. Antigens, Antibodies, Genetic Mechanisms of Immunity, Regulation of antibody production. Monoclonal and Polyclonal Antibodies, Components of the complement system, Complement activation and regulation. Cytokines, Interleukins, and interferons production and their biological functions. Antigen-presenting cells; Major histocompatibility complex structure and function - Antigen processing and presentation, HLA typing. Immune Tolerance: Transplantation Immunology: Hypersensitivity: Case Study, Vaccines, immunodiagnostic Techniques, Antibody Engineering, Immunotherapy.

References

References

1. D. Baxevanis and B. F. Ouellette, *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, 3rd ed. Hoboken, NJ, USA: John Wiley & Sons, 2023.
2. T. K. Attwood and D. J. Parry-Smith, *Introduction to Bioinformatics*, 1st ed. Harlow, U.K.: Pearson Education, 2005.
3. M. Zvelebil and J. O. Baum, *Understanding Bioinformatics*, 1st ed. New York, NY, USA: Garland Science, 2007.
4. D. W. Mount, *Bioinformatics: Sequence and Genome Analysis*, 2nd ed. Cold Spring Harbor, NY, USA: Cold Spring Harbor Laboratory Press, 2004.
5. P. E. Bourne, *Structural Bioinformatics*, 2nd ed. Hoboken, NJ, USA: Wiley-Blackwell, 2011.
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BIT3134

Bioprocess Engineering Lab

[0-0-3-1]

Experimental methods for measuring microbial growth (turbidity, dry weight, growth kinetics in shake flasks) and studying factors influencing growth. Screening and production of industrial enzymes, estimation of enzyme activity, and enzyme kinetics. Effect of pH and temperature on enzymes, and techniques of cell and enzyme immobilization with kinetic studies of immobilized systems.

BIT3135

Bioinformatics Lab

[0-0-3-1]

Retrieval and analysis of nucleotide, protein, gene, and structural data using biological databases (Entrez, PDB, PROSITE, TAIR). Sequence analysis through alignment, BLAST/FASTA, CLUSTAL, and phylogenetic tools. Protein structure prediction, analysis, docking, and molecular dynamics using PyMol, AutoDock, GROMACS, and AI-based modeling. Study of protein-protein interactions, active sites, and pathway analysis through STRING and KEGG.

by SDS-PAGE and zymography. Unit operations in downstream processing including crystallization, sedimentation, flocculation, drying, mass transfer studies in wetted wall column, and liquid-liquid extraction.

PROGRAM ELECTIVES

BIT3xxx Bioprocess Modeling and Simulation [3-0-0-3]

Introduction: Fundamentals and industrial applications of process modeling and simulation, macroscopic mass, and energy balances, Problem formulation, 7-step modeling procedure, development of mathematical models for batch, semi-batch, and continuous bioreactors. Simulation techniques: Numerical methods to solve and analyze the developed models.

References

1. I. J. Dunn, E. Heinzle, J. Ingham, and J. E. Prenosil, *Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples*, 2nd ed. Weinheim, Germany: Wiley-VCH GmbH & Co. KGaA, 2003.
2. K. Hangos and I. T. Cameron, *Process Modeling and Model Analysis*. San Diego, CA, USA: Academic Press, 2001.
3. J. Ingham, I. J. Dunn, E. Heinzle, J. E. Prenosil, and J. B. Snape, *Chemical Engineering Dynamics: An Introduction to Modelling and Computer Simulation*, 3rd ed. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA, 2007.
4. S. S. Sastry, *Introductory Methods for Numerical Analysis*, 5th ed. New Delhi, India: PHI Learning Pvt. Ltd., 2012.

BIT3xxx Bioreactor design and Analysis [3-0-0-3]

Introduction to Bioreactors- classification of bioreactors based on factors like oxygen availability, mode of operation, and type of biological agent - Components of a bioreactor and their functions (vessel, impeller, sparger, baffles, etc.) - bioreactor Operation and scale-up - Bioreactor Design Principles - Case Studies and Applications - Specific bioreactor designs for different applications (e.g., microbial fermentation, cell culture) - analysis of bioreactor performance - Optimization of bioreactor operation for productivity and cost-effectiveness -bioreactor control systems and automation.

References

1. J. M. Doran, *Bioprocess Engineering Principles*, 2nd ed. Cambridge, MA, USA: Academic Press, 2013.
2. P. M. Doran, *Principles of Fermentation Technology*, 3rd ed. Oxford, U.K.: Butterworth-Heinemann, 2020.
3. M. L. Shuler and F. Kargi, *Bioprocess Engineering: Basic Concepts*, 2nd ed. Upper Saddle River, NJ, USA: Prentice Hall, 2017.
4. A. L. Demain and J. E. Davies, *Manual of Industrial Microbiology and Biotechnology*, 3rd ed. Washington, DC, USA: ASM Press, 2010.

5. H. C. Vogel and C. D. Todaro, *Fermentation and Biochemical Engineering Handbook*, 3rd ed. Norwich, NY, USA: William Andrew Publishing, 2014.

BIT3xxx

Bioprocess Plant Design

[3-0-0-3]

Plant Design: Fermentor design, vessels for Biotechnology, piping and valves for biotechnology, Pressure relief system. Materials of construction and properties. Utilities for plant and their design introduction. Process Economics: General fermentation process economics, materials usage and cost, capital investment estimate, and production cost estimate. Two case studies - one traditional product and one recombinant product. Pharmaceutical Water System: Grades of water, sanitary design, water treatment system, Water distribution system, validation. Validation Of Biopharmaceutical Facilities: Introduction, why validation, when does validation occur, validation structure, resources for validation, validation of systems and processes, including SIP and CIP. Good Manufacturing Practices: Structure - quality management, personnel, premises and equipment, documentation, production, quality control, contract manufacturing and analysis, complaints and product recall, self-inspection. GLP and its principles.

References

1. 1G. Vidya Sagar, *Pharmaceutical Industrial Management*, 2nd ed. Hyderabad, India: Pharma Med Press/BSP Books, 2023.
2. M. S. Peters and K. D. Timmerhaus, *Plant Design and Economics for Chemical Engineers*, 4th ed. New York, NY, USA: McGraw Hill, 1991.
3. J. P. Seiler, *Good Laboratory Practice: The Why and How?* Berlin, Germany: Springer, 2001.
4. B. K. Lydersen, *Bioprocess Engineering: Systems, Equipment and Facilities*. Hoboken, NJ, USA: John Wiley & Sons, 2005.

BIT3xxx

Industrial Biotechnology

[3-0-0-3]

Introduction to microorganisms and industrial products - Primary screening (screening for amylase, organic acid, antibiotic, amino acid and vitamin producing microorganisms) and secondary screening - Process flow sheeting- Basic concepts of upstream and downstream processing in bioprocess - Methods of strain improvement - inoculum media and inoculum preparation- Medium requirements for fermentation process - Types of fermentation processes - Scale up of fermentations - Process economics - production of primary and secondary metabolites - production and application of industrial enzymes - microbial biopesticides and biofertilizers, biopolymers, biofuels, recombinant products- Case studies.

References

1. W. Cruger and A. Cruger, *A Textbook of Industrial Microbiology*, 2nd ed. New Delhi, India: CBS Publishers & Distributors, 2016.
2. A. H. Patel, *Industrial Microbiology*, 2nd ed. New Delhi, India: Laxmi Publications, 2016.
3. S. C. Prescott and C. G. Dunn, *Industrial Microbiology*, 4th ed. New Delhi, India: CBS Publishers, 2005.
4. P. F. Stanbury and A. Whitaker, *Principles of Fermentation Technology*, 3rd ed. Oxford, U.K.: Pergamon Press, 2016.

BITXXX

Bioremediation

[3-0-0-3]

Concept, principal and mechanism of bioremediation acclimatization, detoxification, transformation, degradation, mineralization, co-metabolism, metabolism, biostimulation, bioaugmentation, Factors affecting bioremediation, nature of pollutants, bioavailability of pollutants, production of bioremediation metabolites and intermediates, Growth kinetics of organisms, - In situ and Ex situ bioremediation technology detection of microbial community and metagenomics of polluted sites, Alpha, beta and gamma biodiversity, Phytoremediation, Bioventing, Biosparging. Restoration of ground water, oil spills, Commercialization of bioremediation technology, Bioremediation of metals , bioleaching, biosorption and bioaccumulation of metals from solid and liquid waste. Biodegradation and biotransformation of Xenobiotics including pesticides, chlorinated and nitrated aromatic compounds, phenolic compounds, polycyclic aromatic compounds. Enzymes and metabolic pathways of degradation of xenobiotic compounds.

References

1. A. Singh and O. P. Ward, Eds., *Biodegradation and Bioremediation*, 2nd ed. Berlin, Germany: Springer, 2004.
2. M. H. Fulekar, *Bioremediation Technology: Recent Advances*, 1st ed. Dordrecht, Netherlands: Springer, 2010.
3. R. M. Atlas and J. Philp, *Bioremediation: Applied Microbial Solutions for Real-World Environmental Cleanup*, 1st ed. Washington, DC: ASM Press, 2005.

BIT3xxx

Waste Management

[3-0-0-3]

An introduction to waste management covering the classification, sources, composition, and impacts of various types of wastes; municipal solid waste management including generation, collection, transportation, processing, and disposal methods such as composting, incineration, and landfilling; hazardous and biomedical waste management focusing on classification, treatment, disposal, and regulations related to hazardous, biomedical, and electronic wastes; wastewater and sludge management involving the characteristics of wastewater, treatment technologies, and sludge handling; waste-to-energy and resource recovery techniques such as anaerobic digestion, pyrolysis, gasification, and landfill gas recovery; and sustainable waste management practices encompassing the 3R approach (Reduce, Reuse, Recycle), zero waste concepts, circular economy, extended producer responsibility (EPR), public participation, and the use of smart technologies in waste monitoring and management.

References

1. H. Vesilind, W. Worrel, and D. Reinhart, *Solid Waste Engineering*, 2nd ed. Stamford, CT, USA: Cengage Learning, 2006.
2. M. H. Fulekar, *Environmental Biotechnology*, 1st ed. Boca Raton, FL, USA: CRC Press, 2010.
3. C. Visvanathan and R. Tränkler, *Municipal Solid Waste Management in Asia: A Comparative Analysis*, 1st ed. Bangkok, Thailand: Asian Institute of Technology (AIT), 2003.

BITXXX Renewable energy and sustainable engineering [3-0-0-3]

Introduction to Energy and Sustainability, Global energy demand and sources, Principles of sustainable development, Energy Efficiency and Conservation in industry, buildings, and transportation, Solar Energy - Thermal Systems, Solar thermal collectors and applications Solar water heaters and concentrating solar power (CSP), Photovoltaic Systems (PV) principles and materials, Wind Energy- Wind resource assessment, Wind turbine types, operation, and siting. Hydropower Run-of-river and reservoir systems, Small and micro hydropower, Environmental impacts and mitigation. Biomass and Bioenergy- Biomass resources and conversion technologies. Biofuels: ethanol, biodiesel, biogas. Sustainability concerns. Energy Storage Systems- Batteries, flywheels, supercapacitors, Hydrogen and fuel cells, Pumped hydro and thermal storage. Sustainable Building Design- Passive solar design, Green building materials. Environmental Impact and Policy, Emissions and carbon footprint, LEED/BREEAM certifications, Environmental regulations and energy policy, IPCC reports, Paris Agreement. Case Studies and Emerging Trends.

References

1. G. Boyle, *Renewable Energy: Power for a Sustainable Future*, 5th ed. Oxford, U.K.: Oxford Univ. Press, 2021.
2. J. W. Tester, E. M. Drake, M. J. Driscoll, M. W. Golay, and W. A. Peters, *Sustainable Energy: Choosing Among Options*, 3rd ed. Cambridge, MA, USA: MIT Press, 2021.
3. S. A. Kalogirou, *Solar Energy Engineering: Processes and Systems*, 2nd ed. Amsterdam, Netherlands: Academic Press, 2013.
4. C. J. Kibert, *Sustainable Construction: Green Building Design and Delivery*, 5th ed. Hoboken, NJ, USA: Wiley, 2022.

BIT3xxx Waste Water Treatment Technologies [3-0-0-3]

Introduction- treatment processes - wastewater characterization: physical, chemical, and biological parameters (BOD, COD, TOC, solids, etc.) - BOD kinetics modeling: Least Square, Fujimoto, Thomas, etc. - microbial metabolism in aerobic/anaerobic systems; energy and mass balances - anaerobic treatment: UASB and variants; biogas estimation via Buswell equation - nutrient removal: nitrification, denitrification, anammox, and phosphorus removal.

References

1. G. Tchobanoglous, F. L. Burton, H. D. Stensel, M. Abu-Orf, P. W. Bowden, and K. Tsuchihashi, *Wastewater Engineering: Treatment and Resource Recovery*, 5th ed. New York, NY, USA: McGraw-Hill Education, 2014.

2. C. S. Rao, *Environmental Pollution Control Engineering*, 2nd ed. New Delhi, India: New Age International (P) Ltd., 2006.

BIT3xxx

Stem Cell Engineering

[3-0-0-3]

Introduction to stem cells, their properties and types, regulators of Pluripotency and Differentiation of Stem Cell, Differences between Adult and Embryonic Stem Cells, stem cells and their potential sources Isolation and culture techniques for stem cells, Stem cells engineering and applications in therapy, Case study on cardiac repair using iPS. Case study on successful treatment of disease by using stem cells. Ethical concerns and controversy for stem cell research.

References

1. S. Sell, *Stem Cells Handbook*, 2nd ed. Totowa, NJ, USA: Humana Press, 2013.
2. R. L. Gardner, D. I. Gottlieb, and D. R. Marshak, *Stem Cell Biology*, 2nd ed. Cold Spring Harbor, NY, USA: Cold Spring Harbor Laboratory Press, 2013.
3. F. R. Almeder, *Stem Cell Research: Medical Applications and Ethical Controversy*, 2nd ed. Totowa, NJ, USA: Humana Press, 2007.
4. A. Y. Chiu and M. S. Rao, *Human Embryonic Stem Cells: An Introduction to the Science and Therapeutic Potential*, 2nd ed. Totowa, NJ, USA: Humana Press, 2004.

BIT3xxx

Tissue Engineering

[3-0-0-3]

Current scope of development; Use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, motility and functions. Measurement of tissue characteristics, appearance, cellular component, ECM, mechanical measurements and physical properties. Tissue types and Tissue components, Tissue repair, Engineering wound healing and sequence of events. Basic wound healing, Therapeutic applications of growth factors, Control of cell migration in tissue engineering. Hematopoietic differentiation pathway, Potency and plasticity of stem cells, sources, embryonic stem cells, hematopoietic and mesenchymal stem cells, Stem Cell markers, FACS analysis, Differentiation, Stem cell systems- Liver, neuronal stem cells, Types & sources of stem cell with characteristics. Properties of biomaterials. Scaffolds - 3D Bioprinting & tissue engineering, Types of biomaterials.

References

1. B. Basu, *Biomaterials Science and Tissue Engineering: Principles and Methods*, 1st ed. Cambridge, U.K.: Cambridge Univ. Press, 2017.
2. U. Meyer, Th. Meyer, J. Handschel, and H. P. Wiesmann, *Fundamentals of Tissue Engineering and Regenerative Medicine*, 1st ed. Berlin, Germany: Springer-Verlag, 2009.

BIT3xxx

Cancer Biology

[3-0-0-3]

Introduction to carcinogenesis. Pathology of Cancer: Defining a neoplasm and classification of cancers. Epidemiology: Identifying causes for human cancers. Genetic Basis of Cancer: Oncogenes; Tumour suppressor genes; Genetic instability in cancers. Chemical and Radiation Carcinogenesis: Chemical carcinogenesis; Radiation carcinogenesis; Predicting the type of

carcinogen by mutational spectrum analysis. Familial cancers; Connection with sporadic cancers. Growth of Cancers: Balancing cell proliferation, death and differentiation; Growth regulation and signal transduction; Interaction between cell and its environment. Invasion and metastasis: Invasion; Intravasation, Transport in the bloodstream, Extravasation; Angiogenesis, Genes involved in metastasis. Cancer therapy: Principles behind the treatment of cancer; Different treatment modalities. Cancer prevention: Various approaches to cancer prevention. Preventable causes in certain types of cancers.

References

1. R. J. B. King and W. R. Mike, *Cancer Biology*, 3rd ed. Harlow, England: Pearson Education, 2006.
2. L. P. Bignold, *Principles of Tumors*, 1st ed. London, U.K.: Academic Press, 2019.
3. R. Hesketh, *Introduction to Cancer Biology: A Concise Journey from Epidemiology Through Cell and Molecular Biology to Treatment and Prospects*, 3rd ed. Cambridge, U.K.: Cambridge University Press, 2023.

BIT3xxx

Biotherapeutics

[3-0-0-3]

Definition and scope of biotherapeutics, Historical perspective and evolution of biopharmaceuticals, Comparison of small molecules vs. biologics, Overview of different classes of biotherapeutics: proteins, peptides, antibodies, vaccines, gene therapy, cell therapy, nucleic acid therapeutics, Therapeutic antibodies, Monoclonal antibody technology: Hybridoma technology, phage display, Antibody engineering: Chimeric, humanized, and fully human antibodies, Clinical applications of therapeutic antibodies in cancer, autoimmune diseases, and infectious diseases, Gene therapy: Principles of gene therapy: Gene augmentation, gene silencing, gene editing (CRISPR/Cas9), Viral vectors (Adenovirus, AAV, Lentivirus) and non-viral vectors for gene delivery, Stem cell-based therapies: Embryonic stem cells, induced pluripotent stem cells (iPSCs), mesenchymal stem cells (MSCs), CAR T-cell therapy: Design, production, and clinical applications in oncology, Quality Control (QC) of Biotherapeutics, Regulatory Affairs: Good Manufacturing Practices (GMP), Good Laboratory Practices (GLP), Good Clinical Practices (GCP), Regulatory agencies (e.g., FDA, EMA, CDSCO), IND (Investigational New Drug) and BLA (Biologics License Application) processes, Biosimilars and biobetters, Clinical trials design and phases for biotherapeutics, Ethical considerations and IPR in biotherapeutics development.

References

1. J. A. L. Murray, *Therapeutic Proteins: Methods and Protocols*, 3rd ed. New York, NY, USA: Humana Press, 2017.
2. G. Walsh, *Pharmaceutical Biotechnology: Concepts and Applications*, 3rd ed. Chichester, UK: Wiley-Blackwell, 2014.

BIT3xxx

Biopharmaceutical Engineering

[3-0-0-3]

Introduction: Drug and Pharmaceutical Industry, Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP). Regulatory aspects of quality control, pharmacopeia. Pharmacokinetics: Routes of drug administration, Absorption of Drugs - Passive and facilitated transport, Influence of pH on transport of molecules across membranes, Bioavailability. Distribution and Redistribution of drugs - Tissue storage, placental & brain

transport. Biotransformation of drugs and types, Routes of excretion of drugs - Rate of Clearance and Plasma half-life. Pharmacodynamics: Principles and Mechanism of drug action on receptors, enzymes, ion channels and transporters. Transducer mechanism. DoseResponse Relationship, Therapeutic efficiency, Factors modifying drug action. Pharmacovigilance - Casualty assessment, Side, secondary and toxic effects of drugs, Accidental overdose of drugs and the treatment, Drug Intolerance and Drug allergy, Drug abuse and Treatment. Case studies on vaccine manufacturing.

References

1. L. L. Brunton, B. C. Knollmann, and R. Hilal-Dandan, Goodman & Gilman's The Pharmacological Basis of Therapeutics, 13th ed. New York, NY, USA: McGraw-Hill Education, 2018.
2. N. Ferrari and R. Seguin, Oligonucleotide-Based Drugs and Therapeutics: Preclinical and Clinical Considerations for Development, 1st ed. Hoboken, NJ, USA: John Wiley & Sons, 2018.

BIT3xxx

Molecular Modeling & Drug Design

[3-0-0-3]

Fundamentals of molecular modeling and drug design, covering coordinate systems, potential energy surfaces, quantum mechanics, and empirical force field models - non-bonded interactions - historical development and concepts of pharmacophores, ADME properties, Lipinski's rule, and QSAR - pharmacophore model generation, alignment techniques, scoring, and optimization using software tools - structure prediction: molecular modeling, homology modeling, protein validation, and molecular docking tools - molecular dynamics (MD) simulations: Newtonian dynamics, solvation models, periodic boundary conditions, and MD vs Monte Carlo methods.

References

1. A. R. Leach, *Molecular Modelling: Principles and Applications*, 2nd ed. Harlow, England: Prentice Hall, 2001.
2. S. P. Gupta, *QSAR and Molecular Modeling*, 1st ed. New Delhi, India: Anamaya Publishers; Dordrecht, Netherlands: Springer, 2008.

BIT3xxx

Molecular Diagnostics

[3-0-0-3]

Introduction, specimen types and uses, types of molecular diagnostics, Enzyme Immunoassays: Comparison of enzymes available for enzyme immunoassays, conjugation of enzymes. Solid phases used in enzyme immunoassays, Homogeneous and heterogeneous enzyme immunoassays, Enzyme immunoassays after immuno blotting, Enzyme immuno histochemical techniques: Use of polyclonal or monoclonal antibodies, diagnostic microbiology, Molecular methods in clinical microbiology, Laboratory tests in chemotherapy: Susceptibility tests, diffusion test procedures, Tests for bactericidal activity and automated procedures for antimicrobial susceptibility tests, Automation and rapid diagnostic approach: Automation in microbial diagnosis, rapid diagnostic approach, Idiotypes and immunodiagnostic: Concepts and methods in idiotypes, Anti-idiotypes and molecular

mimicry and receptors, Epitope design and applications, Immunodiagnostic tests, Diagnostic tools.

References

1. D. E. Bruns, E. R. Ashwood, and C. A. Burtis, *Fundamentals of Molecular Diagnostics*, 2nd ed. St. Louis, MO: Elsevier Health Sciences, 2015.
2. L. Buckingham and M. L. Flaws, *Molecular Diagnostics: Fundamentals, Methods and Clinical Applications*, 2nd ed. Philadelphia, PA: F. A. Davis Company, 2019.
3. W. B. Coleman and G. J. Tsongalis, *Molecular Diagnostics for the Clinical Laboratorian*, 3rd ed. New York, NY: Humana Press, 2016.

BIT3xxx

Bioethics and Biosafety

[3-0-0-03]

BIETHICS: Principles of bioethics, bioethics vs. business ethics, ethical dimensions of IPR, technology transfer and other global biotech issues. The legal, institutional and socioeconomic impacts of biotechnology; Awareness of bioethics about generating new forms of life for informed decision making - with case studies. Ethical conflicts in biotechnology, Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, Biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety. Biosafety management. Ethical implications of biotechnological products and techniques. Regulations: Biosafety assessment procedures in India and abroad. International dimensions in biosafety, bioterrorism and convention on biological weapons. Social and ethical implications of biological weapons. Biosafety regulations and national and international guidelines regarding recombinant DNA technology and transgenic plants. Good manufacturing practice and Good lab practices. National and international regulations for food and pharma products. IPR, PATENTS AND PATENT LAWS. Biodiversity and farmer rights. Objectives, system, Basic principles and general requirements of patent law. The patenting of living organisms

References

1. M. K. Sateesh, *Bioethics and Biosafety*, 2nd ed. New Delhi, India: IK International Publishing House Pvt Ltd, 2017.
2. D. O. Fleming and D. L. Hunt, *Biological Safety: Principles and Practices*, 4th ed. Washington, DC: ASM Press, 2006.

BIT3xxx

Enzyme Technology

[3-0-0-3]

Enzymes -Classification and types - Mechanisms of enzyme catalysis and action -Concepts of bioenergetics. Kinetics of single-substrate reactions and multi-substrate reactions, Mechanisms, and kinetics - Types of inhibition and Kinetic models - Allosteric regulation of enzymes. Extraction of enzymes from various sources like plant, animal, and microbial sources - Nature of extraction medium - Purification of enzyme - Criteria of purity - Determination of molecular weight of enzymes. Enzyme immobilization - applications of enzymes in food, pharmaceutical, and other industries for analytical and diagnostic applications, Biosensors applications in industry, healthcare, and the environment

References

1. M. L. Shuler and F. Kargi, *Bioprocess Engineering: Basic Concepts*, 3rd ed. Upper Saddle River, NJ, USA: Prentice Hall, 2017.
2. T. Palmer and P. L. Bonner, *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry*, 3rd ed. Cambridge, UK: Woodhead Publishing, 2021.
3. M. Chaplin and C. Bucke, *Enzyme Technology*, 1st ed. Cambridge, UK: Cambridge Univ. Press, 1990.
4. J. M. Lee, *Biochemical Engineering*, 5th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2021.

BIT3xxx Protein Engineering

[3-0-0-3]

Introduction to Protein Engineering: Protein folding, misfolding & aggregation, Protein expression & purification systems, Post translational modifications, Protein structure determination (x-ray crystallography, NMR, Cryo-electron microscopy), Protein stability (enzymatic, thermodynamic and kinetic), Basic concepts for design of a new protein/enzyme molecule. Combinatorial protein engineering: Directed evolution, Site directed mutagenesis, Rational engineering: Backbone reversal, Surface reengineering to prevent aggregation, Enzyme active site remodeling, De novo engineering: computational protein design methods, Case studies of protein engineering (e.g.: Dihydrofolate reductase, Subtilisin).

References:

1. S. J. Park and J. R. Cochran, *Protein Engineering and Design*, Boca Raton, FL, USA: CRC Press, 2010.
2. J. L. Cleland and C. S. Craik, *Protein Engineering: Principles and Practice*, New York, NY, USA: Wiley, 1996

BIT3xxx Metabolic Engineering

[3-0-0-3]

Basic concepts of Metabolic Engineering, Overview of cellular metabolism, Different models for cellular reactions, Metabolic regulation network at the enzyme level and the whole cell level, Examples of metabolic pathway manipulations, Metabolic pathway synthesis algorithms, Metabolic flux analysis and its applications, Methods for experimental determination of metabolic fluxes by isotope labelling, Analysis of metabolic control and the structure metabolic networks, Thermodynamics of cellular processes, New concepts for quantitative bioprocess research and development.

References

1. G. N. Stephanopoulos and A. A. Aristidou, *Metabolic Engineering: Principles and Methodologies*, 2nd ed., Cambridge, MA: MIT Press, 2024.
2. C. D. Smolke, *The Metabolic Pathway Engineering Handbook: Fundamentals and Applications*, 2nd ed., Boca Raton, FL: CRC Press, 2021.
3. S. Cortassa, M. A. Aon, A. A. Iglesias, and D. Lloyd, *An Introduction to Metabolic and Cellular Engineering*, 3rd ed., Singapore: World Scientific, 2019.

4. S. Y. Lee and E. T. Papoutsakis, *Metabolic Engineering: Concepts and Applications*, 2nd ed., Boca Raton, FL: CRC Press, 2022.

BIT3xxx

Genomics and Proteomics

[3-0-0-3]

Brief overview of prokaryotic and eukaryotic genome organization and methods of preparing genomic DNA. DNA sequence analysis methods, Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing; Gene variation and Single Nucleotide Polymorphisms (SNPs); Expressed sequenced tags (ESTs), Genetic and physical maps; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, Recombinant DNA technology: DNA cloning basics, Human genome project and the genetic map. Introduction and scope of proteomics; Aims, strategies and challenges in proteomics. Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; protein- protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.

References

1. T. A. Brown, *Gene Cloning and DNA Analysis: An Introduction*, 7th ed. Hoboken, NJ: Wiley-Blackwell, 2016.
2. S. B. Primrose and R. M. Twyman, *Principles of Gene Manipulation and Genomics*, 7th ed. Hoboken, NJ: Wiley-Blackwell, 2006.
3. D. C. Liebler, *Introduction to Proteomics: Tools for the New Biology*, 2nd ed. Totowa, NJ: Humana Press, 2014.
4. A. M. Campbell and L. J. Heyer, *Discovering Genomics, Proteomics, and Bioinformatics*, 2nd ed. San Francisco, CA: Benjamin Cummings, 2007.
5. R. W. Old, S. B. Primrose, and R. M. Twyman, *Principles of Gene Manipulation*, 6th ed. Hoboken, NJ: Wiley-Blackwell, 1995.

BIT3xxx

Biosensors

[3-0-0-3]

Definitions, types, target analytes, signal recognition methods, and historical development - enzyme sensors, affinity-based sensors (antibodies and oligonucleotides), surface plasmon resonance (SPR), quartz crystal microbalance, FRET, membrane protein sensors, and whole-cell biosensors - immobilization techniques such as adsorption, encapsulation (e.g., hydrogels, sol-gel), and covalent attachment, along with diffusion limitations in optical and planar sensors - micro- and nanoscale using BioMEMS, nanowires, quantum dots, and PEBBLE sensors for multi-analyte and continuous - reagentless detection - applications in agriculture, food safety, biomedical diagnostics, biosecurity, and environmental monitoring.

References

1. U. Bilitewski and A. P. F. Turner, *Biosensors for Environmental Monitoring*, 1st ed. Amsterdam, The Netherlands: Harwood Academic Publishers, 2000.
2. F. S. Ligler and C. A. Rowe Taitt, *Optical Biosensors: Present and Future*, 1st ed. Amsterdam, The Netherlands: Elsevier, 2002.
3. V. C. Yang and T. T. Ngo, *Biosensors and Their Applications*, 1st ed. New York, NY, USA: Kluwer Academic/Plenum Publishers, 2000.

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Biomaterials

[3-0-0-3]

Fundamental properties of materials. Structure of solids, Bonding in solids. Structure-property relationships of biological materials. Mechanical behaviour of biomaterials. Definition and classification of biomaterials. Overview of biocompatibility and tissue response to implant surfaces. Metallic implant materials, dental alloys, and degradation processes on metallic surfaces are used. Ceramic Implant Materials, Bioresorbable and bioactive ceramics. Polymeric Implant Materials: Inert polymers, Natural polymers, Bioactive polymers, Biodegradable polymers. Composite Implant Materials: Mechanics of composites, Different composite biomaterials, Application of composite biomaterials. Soft Tissue Replacement: Skin substitutes and wound healing materials, Sutures and surgical adhesives, Maxillofacial implants, Blood-interfacing implants (vascular grafts, stents). Hard Tissue Replacement: Long bone repair: Wires, Pins, Screws, Fracture plates, Intramedullary devices, Joint replacement, Dental restorations and Spinal implants. Characterisation of Biomaterials. Biocompatibility and Biological Testing. Infection and Sterilization: Microbial contamination in implants, Sterilisation techniques.

References

1. J. Y. Wong and J. D. Bronzino, *Biomaterials: Principles and Practices*, 2nd ed. Boca Raton, FL: CRC Press, 2022.
2. B. D. Ratner, A. S. Hoffman, F. J. Schoen, and J. E. Lemons, *Biomaterials Science: An Introduction to Materials in Medicine*, 4th ed. Amsterdam, Netherlands: Elsevier, 2020.
3. W. R. Wagner, S. E. Sakiyama-Elbert, G. Zhang, and M. J. Yaszemski, *Biomaterials Science: An Introduction to Materials in Medicine*, 4th ed. San Diego, CA: Academic Press, 2020.
4. J. O. Hollinger, *An Introduction to Biomaterials*, 2nd ed. Boca Raton, FL: CRC Press, 2012.

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Nano Biotechnology

[3-0-0-3]

Nanobiotechnology v/s Bionanotechnology, Bottom-Up versus Top-Down approaches; synthesis of nanoparticles and parameters affecting. Structure-property relationships in materials. Fabrication in Soft Materials for biological applications. Types of nanomaterials and their characterization. Nanomolecular Diagnostics: Rationale of Nanotechnology for molecular diagnostics, Bio-functionalization methods, Nanoparticles in diagnostics, Bio-nanohybrids-with relevant applications. Nanopore technology, Nano arrays. Nanobiosensors: cantilever, carbon nanotube, nanowires. Pathogen detection by magnetic nanoparticle-based techniques. Miniaturized devices in nanobiotechnology - types and applications, lab on a chip concept. Biomedical Applications: nanocapsules, nanorobots, and nanopharmacology. Use of micro needles and nanoparticles for local highly controlled drug delivery. Nanotechnology products in ocular, oncology, neurology and cardiology. Functions and applications of DNA based nanostructures, Biomimetic fabrication of DNA-based metallic nanowires and networks, Biomolecular nanomotors (ATP synthase complex and flagella). Ethical, legal and social implications of Nano medicine, and nano-bio-products, Safety concerns- Health Risks, and Challenges. Assessment of the nanoparticles toxic effects - Case studies. Environmental effects, public perceptions, Guidelines and regulatory aspects and

evaluation of Nanopharmaceuticals, challenges and risks associated with Markets for Nano medicine. Trends in Research and education.

References

1. T. Vo-Dinh, *Nanotechnology in Biology and Medicine: Methods, Devices, and Applications*, 2nd ed. Boca Raton, FL: CRC Press, 2017.
2. B. Bhushan, *Springer Handbook of Nanotechnology*, 4th ed. Berlin, Heidelberg: Springer, 2017.

BIT3xxx

Entrepreneurship in Biotechnology

[3-0-0-3]

Entrepreneurship: Concept and theories of Entrepreneurship, Entrepreneurial traits and motivation, Nature and importance of Entrepreneurs, types of Entrepreneurships, stages in the entrepreneurial process. Bio-innovation to bio-business case studies from Indian context; Indian Company act for Bio business; Regulatory affairs and Regulatory bodies (FDA, DSIR, AYUSH, FSSAI). Profiling the Bioentrepreneur; Entrepreneurial Opportunity; Entrepreneurial Planning; Commercialization Process & Strategy; Management of Intellectual Property Rights; Financial Management; Financial Statements; Human Resource Management; Marketing Strategy; Strategies for Partnering & Collaboration; Negotiation Skills; Managing Regulatory Requirements; Funding Opportunities & Incentives; Government Initiatives for Startups; Preparing Business Plan.

References

1. D. Hine and J. Kapeleris, *Innovation and Entrepreneurship in Biotechnology, An International Perspective*, 1st ed. Edward Elgar Publishing, 2006.
2. M. V. Jones, C. Wheeler, and P. Dimitratos, *International Entrepreneurship in the Life Sciences*, 1st ed. Edward Elgar Publishing, 2011.
3. F. Mermelstein, R. Prince, and C. Novina, *Biotechnology from Idea to Market*, 1st ed. Bethesda, MD: Pda; River Grove, IL, 2019.
4. J. Watal, *Intellectual Property Rights in the WTO and Developing Countries*, 1st ed. Springer, 2001.