

Indian Institute of Technology Kanpur

Department of Chemistry

Proposal for a New Course

Course Title	Advances in Chemical Biology and Medicinal Chemistry
Course No.:	CHM665
Credits:	3-0-0-0 [9]

Course Contents

1: Fundamentals and Modern Strategies in Drug Discovery (8 lectures)

- Introduction to Medicinal Chemistry & Chemical Biology – Evolution, key principles, and current challenges
- Chemical Space and Molecular Design – Lipinski's rule, beyond Rule-of-5, and privileged scaffolds
- High-Throughput Screening (HTS) and Fragment-Based Drug Discovery (FBDD)
- Structure-Based and Ligand-Based Drug Design (SBDD, LBDD) – Virtual screening, docking, and scoring functions
- Artificial Intelligence and Machine Learning in Drug Discovery – Deep learning, generative models, and de novo drug design
- Hit-to-Lead Optimization: Medicinal Chemistry Strategies – SAR, ADME, and toxicity considerations
- Emerging Concepts: Click Chemistry and Bioorthogonal Reactions in Drug Development

2: State-of-the-Art Drug Discovery Technologies (8 lectures)

- Proximity inducers: PROTACs, Molecular Glues, LYTACs, AUTACs and RIPTACs. Degradation Design Principles: E3 Ligases, Linker Chemistry, and Protein-Protein Interactions
- Covalent Inhibitors: Mechanisms, Design Strategies and advancements – Warheads, selectivity, and resistance
- mRNA and RNA-Targeted Drug Discovery – Small molecules targeting RNA and RNA-protein interactions
- Antibody-Drug Conjugates (ADCs) and Peptide-Drug Conjugates (PDCs)
- Stapled Peptides, Macrocycles, and Protein-Protein Interaction Inhibitors (PPIIs)

- Next-Generation Therapeutics: CRISPR-Based Gene Editing and Epigenetic Modulators

3: Chemical Biology Approaches in Drug Discovery (8 lectures)

- Multiomics: Metabolomics and Lipidomics in Drug Discovery. Chemical Proteomics for Target Identification – Activity-based protein profiling (ABPP), covalent probes. Photoaffinity Labeling and Chemoproteomics in Target Deconvolution
- Basics of drug-target interactions: Target Engagement and Cellular Thermal Shift Assay (CETSA), surface plasmon resonance (SPR), isothermal calorimetry (ITC), nuclear magnetic resonance (NMR) spectroscopy .
- Metabolic Labeling and Bioorthogonal Chemistry in Cellular Profiling. Organelle-Targeted Therapeutics – Mitochondria, lysosomes, and autophagy modulators

4: Basics of AI, Computational, and Biophysical Tools for Drug Discovery (8 lectures)

- Computational Approaches: Molecular Docking and Molecular Dynamics Simulations
- AI-Driven Drug Discovery: AlphaFold, DeepMind, and Predictive Modeling. Generative AI for Drug Design: Graph-Based Deep Learning Approaches
- Machine Learning for ADME-Tox Prediction and PK/PD Modeling
- Basics of Cryo-EM, X-ray Crystallography, and NMR for Drug Discovery. Single-Cell and Spatial Proteomics in Drug Mechanism of Action Studies.

5: Case Studies and Translational Strategies (8 lectures)

- Success Stories of First-in-Class Drugs – Lessons from FDA approvals. Clinical Translation of Novel Drug Modalities – PROTACs, ADCs, and mRNA therapeutics.
- Personalized and Precision Medicine: Small Molecule and Biologic Therapeutics
- Industry vs. Academia: Drug Discovery Pipelines and Collaborations. IP, Patents, and Regulatory Challenges in Drug Development
- Ethics in Medicinal Chemistry and Chemical Biology – Dual-use research concerns
- AI-Discovered Drugs in Clinical Trials: Hype vs. Reality. Future Perspectives: Next-Generation Therapeutics and Unmet Challenges

Reference/Textbooks:

1. Essentials of Chemical Biology by Andrew D. Miller (2008/updated)
2. Burger's Medicinal Chemistry, Drug Discovery, and Development (8th ed., 2021)

3. An Introduction to Medicinal Chemistry by Graham L. Patrick (6th ed., 2017)
4. The Practice of Medicinal Chemistry by Camille G. Wermuth (5th ed., 2015)
5. Antibody-Drug Conjugates: Fundamentals, Drug Development, and Clinical Outcomes (Wiley, 2017/updated)
6. Multi-Omics Technology in Human Health and Diseases (Elsevier, 2025) by Macha et al
7. Molecular Docking for Computer-Aided Drug Design by S. G. Coumar (Academic Press, 2021)
8. Artificial Intelligence in Drug Discovery (RSC, 2020/updated)
9. Latest Research papers will be discussed