Computer-Aided Drug Design (CADD), Docking, Drug Repurposing, & AI-Driven pharmacophore modeling

Introduction to Drug Discovery and CADD

Topics Covered

- Overview of drug discovery and development pipeline
- Limitations of traditional experimental drug discovery
- Introduction to Computer-Aided Drug Design (CADD)
- Structure-based vs ligand-based drug design
- Applications of CADD in academia and industry

Drug Repurposing and Target Selection

Topics Covered

- Concept and importance of drug repurposing
- Advantages of repurposing over de novo drug discovery
- Types of biological targets (enzymes, receptors, proteins)
- Criteria for selecting a suitable target for docking studies

Demonstration

- Overview of protein and drug databases
- Understanding target information and disease relevance

Databases, Molecular Formats, Visualization Tools, and Protein Preparation

Topics Covered

Databases

- Protein Data Bank (PDB)
- PubChem
- ChEMBL
- ZINC database

Molecular Formats

- SMILES
- SDF
- PDB

Visualization Tools

- Introduction to PyMOL / Chimera
- Basic structure visualization and navigation

Protein Preparation

- Importance of protein preparation
- Removal of water molecules and co-crystallized ligands
- Addition of hydrogens and charge assignment
- Saving prepared protein for docking

Hands-on Session

- Downloading protein structures
- Visualizing and cleaning protein structures

Ligand Preparation for Docking and Molecular Docking

Topics Covered

Ligand Preparation

- Importance of ligand preparation
- 2D to 3D structure conversion
- Protonation states
- Energy minimization

Molecular Docking

- Principle of molecular docking
- Binding energy and docking score
- Introduction to docking software (AutoDock Vina / SwissDock, CB Dock, Dock thor)
- Docking workflow overview

Hands-on Session

- Ligand preparation step-by-step
- Performing basic molecular docking

Interaction Analysis, ADMET, Virtual Screening, and AI-Driven pharmacophore modeling

Topics Covered

Interaction Analysis

- Hydrogen bonding
- Hydrophobic interactions
- π–π and electrostatic interactions
- 2D and 3D interaction diagrams

ADMET Analysis

- Drug-likeness concepts
- Lipinski's Rule of Five
- ADMET parameters and prediction tools

Virtual Screening

- Concept of virtual screening

- Library preparation
- Docking-based screening
- Ranking and selection of hits

Hands-on Session

- Interaction visualization and analysis
- ADMET filtering of docked compounds

Single Target Docking, Redocking, and RMSD Calculation

Topics Covered

- Concept of redocking and its importance
- Selection of a single protein target
- Extraction of co-crystallized ligand
- Grid box definition and parameter setup
- RMSD calculation and interpretation

Hands-on Session

- Redocking of known protein–ligand complex
- RMSD evaluation for docking validation
- Docking of selected ligands on the same target

Learning Outcome

Students understand how to validate docking protocols scientifically. Mini Project and Scientific Reporting

Mini Project

Students will perform a **complete CADD workflow** on a selected target:

- Target selection
- Ligand preparation
- Docking

- Redocking and RMSD validation
- Interaction analysis
- ADMET evaluation
- Pharmacophore modelling

Scientific Reporting

- Organizing computational results
- Writing essential sections of a CADD research article:
    - Methods
    - Results
    - Discussion

Course Outcomes

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

- Perform protein and ligand preparation
- Conduct molecular docking and redocking
- Calculate and interpret RMSD
- Analyze protein–ligand interactions
- AI-Driven pharmacophore modeling
- Perform virtual screening and ADMET analysis
- Prepare results suitable for academic reporting and publication