Advanced Protein Engineering and Directed Evolution Training Course

Professional Development Training Course Outline

Category	Biotechnology and Pharmaceutical Development	**Duration**	10 Days
Base Fee	$4,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

The ability to precisely tailor a protein?ÇÖs function is the bedrock of modern biotechnology and the key to unlocking next-generation solutions in medicine, sustainable chemistry, and materials science. This advanced course bridges the gap between traditional molecular biology and cutting-edge bioengineering. It focuses on two powerful, complementary strategies: Directed Evolution (DE), which accelerates natural selection in the lab to rapidly optimize protein traits like thermostability and catalytic efficiency, and Rational Protein Design, which uses structural and computational insights for targeted modifications. The field is undergoing a paradigm shift, moving beyond laborious trial-and-error to a data-driven approach. Master the technologies driving this revolution, from High-Throughput Screening (HTS) platforms to the integration of Artificial Intelligence (AI) and Protein Language Models, to effectively navigate the vast protein fitness landscape and engineer novel biological function.

Advanced Protein Engineering and Directed Evolution Training Course is engineered for scientific leaders, R&D professionals, and advanced researchers ready to implement industrial-scale protein optimization campaigns. Participants will gain practical expertise in designing complex mutagenesis libraries and deploying continuous evolution systems like PACE and CRISPR-assisted DE. A core emphasis is placed on leveraging Computational Protein Design (CPD) and Machine Learning workflows including Active Learning-assisted Directed Evolution (ALDE) to predict beneficial variants, dramatically reducing experimental cycles and accelerating time-to-market. By mastering these integrated strategies, attendees will be equipped to develop proprietary biocatalysts, next-generation protein therapeutics, and high-performance biosensors, securing a competitive edge in the rapidly evolving landscape of synthetic biology.

Programme Curriculum

Advanced Protein Engineering and Directed Evolution Training Course

Introduction

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Course Duration

10 days

Course Objectives

1. Design and execute a full-cycle Directed Evolution campaign for optimizing protein function
2. Apply Computational Protein Design (CPD) methods to rationally engineer binding sites and allosteric regulation.
3. Utilize Machine Learning (ML) models and Protein Language Models (PLMs) to predict beneficial mutations and navigate the Protein Fitness Landscape.
4. Master advanced Mutagenesis Library construction techniques, including Site-Saturation Mutagenesis (SSM) and DNA Shuffling.
5. Develop and implement robust High-Throughput Screening (HTS) and selection assays
6. Engineer Enzymes with enhanced Stereoselectivity and Substrate Promiscuity for industrial biotransformations.
7. Design and optimize multi-enzyme Biocatalytic Cascades for complex chemical synthesis.
8. Implement Continuous Directed Evolution systems, such as PACE and CRISPR-based methods.
9. Develop Protein Therapeutics with improved Pharmacokinetics and reduced immunogenicity.
10. Analyze and interpret complex Sequence-Function data using Bioinformatics tools for evolutionary guidance.
11. Design and evolve high-specificity Biosensors for diagnostic and environmental monitoring applications.
12. Formulate a mixed Rational-Random Design strategy to tackle novel protein engineering challenges.
13. Apply principles of Synthetic Biology to engineer entire pathways and Synthetic Regulatory Circuits using optimized proteins.

Target Audience

1. R&D Scientists and Team Leads in Biotechnology and Pharmaceutical Companies.
2. Chemical Engineers.
3. Advanced Graduate Students and Post-Doctoral Researchers in Bioengineering, Biochemistry, and Synthetic Biology.
4. Computational Biologists and Bioinformaticians.
5. Heads of Discovery/Innovation.
6. Bioprocess Engineers.
7. Scientists working in Agri-Biotech or Materials Science.
8. Venture Capital Analysts and Technical Consultants.

Course Modules

Module 1: Foundational Principles and The Fitness Landscape

- The Protein Engineering Duality.
- Understanding the Protein Fitness Landscape and Epistasis.
- Protein structure, folding, and the determinants of stability, activity and specificity.
- Key parameters for industrial enzyme optimization
- Case Study: The evolution of Subtilisin E for activity in organic solvents

Module 2: DNA Diversification

- Designing Smart Mutagenesis Libraries
- Error-Prone PCR and its bias/tuning for random mutation rate.
- DNA Shuffling and Recombination for multi-site optimization.
- CRISPR-Cas9-assisted genome diversification and base editing techniques.
- Case Study: Directed evolution of ??-Lactamase for increased antibiotic resistance

Module 3: Computational Protein Design (CPD)

- Introduction to computational force fields and energy minimization in design.
- Predicting optimal Amino Acid Substitutions
- Design of novel protein folds and scaffolds: De Novo Protein Design.
- Targeting protein-protein interfaces and designing Allosteric Modulators.
- Case Study: Computational redesign of an enzyme active site to flip Stereoselectivity

Module 4: High-Throughput Screening (HTS) and Selection

- Developing and validating robust, scalable screening assays
- Fluorescence-Activated Cell Sorting-based screening for libraries up to 108 variants.
- Droplet Microfluidics and in Vitro Compartmentalization for ultra-HTS.
- Designing powerful, automated selection systems.
- Case Study: Screening for novel antibodies using Yeast Surface Display and FACS.

Module 5: Machine Learning (ML) for Directed Evolution

- Fundamentals of ML in DE.
- Active Learning-assisted Directed Evolution (ALDE) workflows.
- Training predictive models on Protein Sequence and experimental fitness data.
- Using Gaussian Processes and Neural Networks to guide Library Design.

- Case Study: ML-guided engineering of a polymerase for improved fidelity and speed.

Module 6: Protein Language Models (PLMs) and Generative AI

- Introduction to Protein Language Models and their latent space.
- Generating novel, high-fitness Protein Sequences using Generative Adversarial Networks.
- Zero-shot and few-shot prediction of protein properties.
- Interpreting Attention Maps for identifying functional residues.
- Case Study: Using a PLM to design a synthetic enzyme that is highly stable and active.

Module 7: Biocatalysis and Industrial Enzyme Engineering

- Engineering for Non-Aqueous Solvents and extreme pH conditions.
- Optimizing enzyme kinetics and reducing product inhibition.
- Design of Fusion Proteins and enzyme immobilization strategies for process efficiency.
- Strategies for engineering Stereoselectivity and Substrate Promiscuity.
- Case Study: Engineering a PETase enzyme for efficient plastic degradation

Module 8: Next-Generation Protein Therapeutics

- Engineering Antibodies.
- Design and optimization of Non-Antibody Scaffolds
- Fusion proteins for prolonged Serum Half-Life
- Directed evolution of AAV Vectors for enhanced Gene Therapy Tropism.
- Case Study: Evolution of an anti-tumor necrosis factor (TNF) antibody with higher affinity.

Module 9: Biosensors and Diagnostics

- Designing Receptor Proteins for specific ligand binding
- Evolution of Switchable Proteins and Allosteric biosensors.
- Linking protein binding to a detectable output
- Engineering whole-cell biosensors for environmental or clinical monitoring.
- Case Study: Directed evolution of a fluorescent protein sensor for zinc ion detection.

Module 10: Continuous Directed Evolution Systems

- Fundamentals of Phage-Assisted Continuous Evolution (PACE).
- Evolution in a Test Tube
- CRISPR-Cas systems for rapid, continuous in Vivo diversification and selection.
- Designing the Selection Circuit and Muting Mutant Effects.
- Case Study: Use of PACE to rapidly evolve a viral polymerase with altered substrate specificity.

Module 11: Structural Biology and Design Visualization

- Using AlphaFold2 and structural prediction tools to inform Rational Design.
- Interpreting Cryo-EM and X-ray Crystallography data for mutagenesis targets.
- Predicting and validating Protein-Protein Interactions (PPIs) and complexes.
- Molecular Visualization and Scripting for residue analysis.
- Case Study: Analyzing the 3D structure of an enzyme to identify a loop region for thermal stabilization.

Module 12: Synthetic Biology and Metabolic Pathway Engineering

- Using engineered proteins to control Metabolic Flux in a cell.

- Designing Synthetic Regulatory Circuits using evolved protein switches.
- Optogenetics and light-activated protein engineering.
- Protein engineering for Synthetic Compartments and minimal cell design.
- Case Study: Engineering a multi-enzyme pathway for enhanced production of a biofuel or pharmaceutical intermediate.

Module 13: Data Analysis and Bioinformatics for DE

- Processing and statistical analysis of High-Throughput Sequencing data from libraries.
- Mapping Variant enrichment and depletion using Deep Mutational Scanning (DMS).
- Bioinformatics pipelines for visualizing the Fitness Landscape
- Predicting Immunogenicity and Off-Target effects for Therapeutic proteins.
- Case Study: Interpreting DMS data to determine all permissible mutations in a binding domain.

Module 14: Scale-Up and Commercialization

- Strategies for Expression Host Optimization
- Intellectual Property (IP) considerations and patent strategy in protein engineering.
- Regulatory pathways for Engineered Therapeutics and Biocatalysts.
- Cost-of-Goods (CoG) analysis and process economics for industrial scale-up.
- Case Study: Taking an Engineered Enzyme from the lab to a multi-ton chemical manufacturing process.

Module 15: Future Directions: Converging Technologies

- The convergence of Quantum Computing and Protein Folding Prediction.
- In Vivo Directed Evolution for tissue-specific therapeutics.
- Engineering Artificial Metalloenzymes and novel co-factor dependence.
- Designing Self-Assembling Protein Nanomaterials and Hydrogels.
- Case Study: Discussion on the current state of the art in De Novo Protein Design of novel enzymes with no natural homolog.

Training Methodology

The course employs an Integrated CPD and DE Workflow methodology, combining theoretical lectures with intensive hands-on, problem-based learning.

1. Interactive Lectures
2. Computational Workshops.
3. Simulated Lab Practical?ÇÖs.
4. Case Study Analysis.
5. Capstone Project.

Register as a group from 3 participants for a Discount

Send us an email: info@fineskilltrainingcenter.org or call +254769199797

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Tailor-Made Course

We also offer tailor-made courses based on your needs.

Key Notes

a. The participant must be conversant with English.

b. Upon completion of training the participant will be issued with an Authorized Training Certificate

c. Course duration is flexible and the contents can be modified to fit any number of days.

d. The course fee includes facilitation training materials, 2 coffee breaks, buffet lunch and A Certificate upon successful completion of Training.

e. One-year post-training support Consultation and Coaching provided after the course.

f. Payment should be done at least a week before commence of the training, to Fineskill Training Center account, as indicated in the invoice so as to enable us prepare better for you.

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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