# Research Statement

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## Background

My research over the past year brought together three exciting thrusts at the intersection of Gen AI: AI-generated code assurance, computational biology, and quantum-LLM reasoning. Each has the potential to be highly impactful in AI for science and engineering.

However, I have just received rejections of the GENESIS and Q-STEER Cat A grant proposals, while the IIE MDGF CodeAssure and Cat A AI-Driven Code Assurance for Enterprises were awarded, hence I will shift my focus in 2026 towards software engineering applications of AI. The genomics application may proceed as well, depending on the outcome of the NRF CRP proposal.

## Research Areas

These are ***new*** research directions, borne out of discussions with my SMU colleagues and students and colleagues at NTU and Imperial College. As such, I do not yet have papers in these areas.

### 1. AI-Driven Code Assurance for Enterprises

With the rise of AI-generated code—now approaching 30% of enterprise production—organizations face new risks in security, maintainability, and functional correctness. Through the CodeAssure project, we aim to develop a contamination-resistant evaluation framework for AI-generated code. This methodology goes beyond static analysis, analyzing business logic, multi-file coordination, and enterprise-specific requirements using novel metrics: Boundary Coverage, File Completeness, and Dependency Sequencing. By embedding proprietary codebases in secure sandboxes and integrating automated, LLM-enhanced test synthesis ("Code2QA"), we will enable robust reporting for CTOs, compliance, and product teams. Unlike competitors (SonarQube, CodeAnt), this approach will quantify code quality and alignment to business specs, setting new standards for safe and effective AI coding adoption in regulated industries. I have secured interest from 2 companies in this work: IBM and Smartly.

**This work has two parallel instantiations both of which were awarded in 2025: a cat A Research grant proposal, with JIANG LingXiao as co-PI, and an IIE Gap Fund proposal with a former MITB student.**

## 2. Generative AI for Synthetic Biology

This line of research places Gen AI in the service of multi-component biological design, moving beyond single-protein prediction to full gene cluster engineering. Using multi-agent frameworks and the latest open-weight protein/DNA LLMs, I aim to develop a methodology for the automated generation and validation of synthetic gene systems, targeting applications from novel enzymes to bio-upcycling.

The AI4Prot (GENESIS.AI) project was a Cat A research grant I proposed with NTU microbiologist Dr. Sierin LIM as collaborator but was rejected by SCIS..

However, in parallel, Dr. Sierin Lim submitted a 2025 NRF CRP grant proposal for which I am co-PI, in collaboration with A*STAR, U Washington (David Baker, Nobel chemistry 2024) and MIT. The CRP project aims to lay the foundation for closed-loop Design-Build-Test-Learn cycles in synthetic biology, with direct industrial and scientific impact.

## 3. Quantum-Enabled Reasoning for Large Language Models

AI reasoning via chain-of-thought (CoT) prompting requires control over exponential search spaces. In the Quantum-LLM Reasoning Cat A grant proposal (Q-Steer), Paul Griffin and I aimed to develop a hybrid quantum-classical optimization method, mapping the generation of reasoning traces to a quantum variational algorithm. This framework aimed to steer LLMs (e.g. DeepSeek, Qwen) along paths maximizing factuality, logic, and diversity, opening new possibilities for auditable, verifiable, and robust AI explanations. We were interested in showing that quantum approaches can outperform classical tree search on hard reasoning tasks, marking a potential paradigm shift in AI transparency and reliability.  An IBM Research quantum computing researcher would have collaborated with us if this grant had been awarded.

However, as the Cat A proposal was rejected, this thread is presently on HOLD.

**Selected Publications and Outputs**

This year, in addition to developing entirely new courses and teaching them on my own, I have developed new research collaborations and proposals.

It is expected that these efforts will lead to publications and commercialization outputs in 2026.