

# Jinyeop Song

Ph.D. Candidate in Physics and Statistics ·

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## Education

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### Massachusetts Institute of Technology

Ph.D. Candidate in Physics and Statistics - GPA: 4.35/4.5

Supervisor : Jeff Gore

Cambridge, MA, USA

Aug 2020 - June 2026 (Expected)

### Korea Advanced Institute of Science and Technology

B.S. in Physics (Major) and Math (Minor) - GPA: 4.16/4.3 (Summa Cum Laude)

Daejeon, Korea

Mar 2014 - Jun 2020

## Research Interests

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With a strong expertise in ML, systems biology, and physics, I am interested in:

- **LLM Agents for Drug Discovery:** designing interpretable [6] and RL-tuned [2] LLM-agent systems to accelerate drug discovery workflows [4, 5].
- **Protein/Genomic Foundation Models:** building and fine-tuning AI foundation models (e.g., generative models) for biology and medicine (e.g., patient disease prediction or biomolecular representation learning) [8, 7].

## Professional Experience

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### MIT–IBM Watson AI Lab

Cambridge, MA, USA

Research Intern (Summer)

2025

- Developed a knowledge-graph-augmented RAG framework for LLMs using multi-turn reinforcement learning (RL), achieving state-of-the-art accuracy with 47% lower generation cost and 6% higher transferability compared with prior methods.

### Machine Learning Alignment and Theory Scholars

Berkeley, CA, USA

Research Fellow

2025

- Proposed a novel, goal-agnostic evaluation framework for LLM agents using the information-theoretic measure (i.e empowerment : mutual information between actions and future states).

### MIT

Cambridge, MA, USA

Graduate Research Assistant (PI: Prof. Jeff Gore)

Feb 2021 – Present

- Explored emergent phenomena (e.g., neural scaling behaviors, in-context learning) in LLMs, linking theories with empirical results.
- Developed a foundation model for human methylation data that predicts patient aging and chronic disease.
- Explored how interspecies interaction strength shapes the merging of two microbial communities using experiments and simulations.

### Samsung Electronics Research

Suwon, Korea

Research Intern (Summer)

2020

- Investigated post-quantum cryptography (lattice-based encryption methods) for use in DRAM products.

### Harvard–MIT Health Sciences and Technology

Boston, MA, USA

Research Intern (Summer)

2019

- Developed a neural connectome reconstruction algorithm that maps brain images into 3D space.

### KAIST

Daejeon, Korea

Undergraduate Research Assistant

Jul 2014 – Aug 2020

- Biomedical Optics (PI: Prof. YongKeun Park): developed deep-learning algorithms for 3D time-lapse tracking of CAR-T cells; built classification models using 3D refractive-index maps for rapid pathogen identification.
- Chromatin/Protein Engineering (PI: Prof. Wonki Cho): implemented thermodynamic simulation code for multivalent antibody binding.
- Quantum & Nanophotonics (PI: Prof. YongHoon Cho): investigated exciton–polariton coupling in GaN nanoporous DBR cavities.

# Publications

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\* indicates equal contributions.

## AI related

- [1] Liang, Q., **Song, J.**, Liu, Y., Gore, J., Fiete, I.R., Miikkulainen, R., & Qiu, X. "The Blessing of Dimensionality in LLM Fine-tuning: A Variance-Curvature Perspective." *In Preparation* (2026).
- [2] **Song, J.**, Wang, S., Shun, J., & Zhu, Y. "Efficient and Transferable Agentic Knowledge Graph RAG via Reinforcement Learning." *In Preparation* (2025).
- [3] **Song, J.**, Gore, J. & Kleiman, M. 'Estimating Empowerment of Langague Model Agent" *arXiv preprint* (2025). [\[PDF\]](#)
- [4] Akke, M., Yang, S., Ruža, J., **Song, J.**, Pan, E., & Gómez-Bombarelli, R. *When Do LLMs Improve Bayesian Optimization? A Systematic Comparison Across Molecular and Protein Design*. NeurIPS 2025, AI4Science Workshops. [\[PDF\]](#)
- [5] Son, G., Hong, J., Fan, H., Nam, H., Ko, H., Lim, S., **Song, J.**, Choi, J., Paulo, G., Yu, Y., & Biderman, S. "When AI Co-Scientists Fail: SPOT - Benchmark for Automated Verification of Scientific Research." *arXiv preprint* (2025) [\[PDF\]](#),
- [6] **Song, J.\***, Han, S.\*., Argawal, P., & Gore, J. "Emergence and Effectiveness of Task Vectors in In-Context Learning : An Encoder Decoder Perspective" ICML 2025, **Spotlight** [\[Link\]](#),
- [7] Yang, S., Nam, J., Perez, T., **Song, J.**, Du, X., & Gomez-Bombarelli, R. "Probing the Embedding Space of Protein Foundation Models through Intrinsic Dimension Analysis" Neurips 2025, AIDrugX Workshop[\[Link\]](#),
- [8] Ying, A.\*., **Song, J.\***, Cui, H.\* ... et al. "MethylGPT - Foundational GPT-like model for human methylation data" 2024. submitted for *Nature Methods* [\[Link\]](#)
- [9] Pearce, T., & **Song, J** "Reconciling Kaplan and Chinchilla Scaling Laws" *TMLR*, 2024. [\[Link\]](#)
- [10] **Song, J.\***, Liu, Z.\*., Tegmark, M., & Gore, J. "Resource model for neural scaling law," 2024 ICRL, BGPT Workshop, 2024. [\[Link\]](#)

## Biophysics related

- [1] **Song, J.**, Hu, J. & Gore, J. "Interspecies Interaction Shapes Community-level Selection in Microbial Coalescence," *In Preparation*, 2025.
- [2] **Song, J.\***, Jeong, B.S.\*..., & Oh, B.H. "Noncovalent antibody catenation on a target surface greatly increases the antigen-binding avidity," *Elife*, 9: e81646, 2023. [\[Link\]](#)
- [3] Lee, M.\*., Lee, Y. H.\*., **Song, J.\***, ..., & Park, Y. "Deep-learning-based three-dimensional label-free tracking and analysis of immunological synapses of CAR-T cells," *Elife*, 9, 2020. [\[Link\]](#)
- [4] Kim, G., Ahn, D., Kang, M., Jo, Y., Ryu, D., Kim, H., **Song, J.**, ..., & Kim, K. "Rapid species identification of pathogenic bacteria from a minute quantity exploiting three-dimensional quantitative phase imaging and artificial neural network," *Light, Science & Applications*. [\[Link\]](#)

## Awards and Honors

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2025	<b>Scholarship:</b> "Machine Learning and Theory Scholarship(MATS)"
2023	<b>Scholarship:</b> "Mokam Research Scholarship"
2016	<b>Fellowship:</b> "KAIST Presidential Fellowship (KPF)"
2023	<b>Award:</b> "2020 KPS Best Oral Presentation Award"
2020	<b>Honorary Title:</b> "Excellent Graduate of KAIST"
2014 - 2020	<b>Scholarship:</b> "Korea Presidential Science Scholarship"

## Teaching & Extracurricular Experiences

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2024 - 2025	<b>Organizer:</b> AI Weekly Journal Club in Physics of Living Systems	MIT
2023	<b>Teaching Assistant:</b> "Complex Systems Biology"	MIT
2015 - 2018	<b>Freshmen Tutoring Program</b>	KAIST

## Skills

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<b>Programming</b>	Python, Matlab, R, Github, Torch, and Cuda
<b>Languages</b>	English(Fluent), Korean(Native), Chinese(Elementary)

## References

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- Prof. Max Kleiman @ UW
- Prof. Jeff Gore @ MIT
- Prof. Oh, Byung-Ha @ KAIST