Research Motivation. I am captivated by the open challenges in machine learning that biology evolved to solve. Backpropagation can be inefficient due to global error signals while static architectures seem to lack the plasticity to prevent catastrophic forgetting. This rigidity in vision models appears to cause poor generalizability and vulnerability to adversarial attacks. Such fragilities in complex tasks can create intractable exploration spaces and unscalable communication. **I am motivated to research how integrating the principles of computation from biological substrates may reduce these limitations**.

Selected Research Experiences. My research with Drs. Hanna, Sala, and Berland has led to **eight first-author full-length papers with five peer-reviewed publications in NeurIPS** workshops (four archival).

World Models for MARL. My research began with exploring bio-inspired multi-agent reinforcement learning (MARL), contributing to my team's **first-place finish at RoboCup**, the international MARL robotics competition. Leading a group investigating inter-agent communication, we found that an emergent strategy, nspired by signaling in simple organisms, collapsed to 12.2% success at task allocation with partial observability despite stabilization. Pivoting to experiment with a **world-model based approach** improved to 96.5% success, revealing the value of an agent internally simulating the environment.

Active Inference & Structural Plasticity. Inspired by theories of intelligence like the free energy principle and Dr. Michael Levin's work on basal cognition, I addressed the intractability of **active inference** by developing a novel approximation using **principles from RL**. After grounding this work in discussions with Dr. Josiah Hanna (RL) and Dr. Levin (biology), **Dr. Levin invited me to extend this research under his mentorship**. Without a reward, the model maintained 82% success in Cart Pole, forming a step towards computable active inference.

Visual-Cortex Architecture. Curious about macro-level perspectives, I led a team experimenting with **primate visual cortex architectures** for light field identification. We implemented biological features including **dual-stream processing and predictive coding**. Despite engineering challenges of integration, the model achieved 74.4% accuracy, outperforming the next-best by 2.3 percentage points while being 2.5 times smaller, and demonstrated the value of inductive bias through geometric neuroscience.

Industry Embodied AI. Concurrently, I **lead state estimation research** at an industry AI R&D lab. State-of-the-art (SOTA) algorithms proved unsuited for our constrained hardware and low-accuracy sensors. This drove me to develop an algorithm reducing dimensionality by disentangling data manifolds. The algorithm achieved over 100x improvement in accuracy over SOTA. It is now **deployed on all company robots** and received extensive positive customer feedback. I learned to navigate the research-to-deployment pipeline under real-world constraints.

Research Leadership and Mentoring. To create an interdisciplinary structure for this research at UW-Madison, **I founded and direct the Wisconsin Neuromorphic Computing and NeuroAI Lab**, securing formal funding, dedicated space, support from Dr. Akhilesh Jaiswal as advisor, and partnership with neuroAI startup FinalSpark. Through **nine graduate-level AI and neuroscience courses**, I gained technical foundations to lead this initiative. My role involves **mentoring 15 undergraduate researchers**, providing advice to over 100 researchers, developing research proposals, organizing biweekly workshops, and lecturing on topics like spike-timing-dependent plasticity drawing audiences of over 100 undergraduates, graduates, and professionals.

SAMPLE RESEARCH EXTENSION. One fascinating direction building on my prior research investigates autonomous **emergence of state space** through predictive compression of high-dimensional sensory streams **during navigation**. While successor representations (SR) via spike timing-dependent plasticity are established, current models rely on pre-defined place cells or passive perception.

A **visual-cortex-based encoder** fuses with internal motion cues, and lateral inhibition encourages self-organization of sparse place cells. Distinctly, the model navigates to **minimize expected surprise** of its SR map. This research explores if such a bio-mimetic objective **stabilizes the online emergence of predictive maps**.

HOW A PHD FITS MY CAREER GOALS. Researching in industry, my development was of empirical iteration. I realized a deeper understanding of mathematical theory may yield more efficient solutions. While I have strong practical skills, **I am driven to gain the theoretical depth to more rigorously devise novel algorithms**.

My long-term objective is **researching in a group like DeepMind's neuroscience lab**. Conversations with leads, Drs. Kim Stachenfeld and Matthew Botvinick, solidified a PhD as essential to gain the theoretical depth and research freedom required. Receiving an **invitation from Dr. Karl Friston** to present my prospective doctoral research at his theoretical neurobiology group reinforced the value of a PhD for engaging with these ideas.

WHY NEW YORK UNIVERSITY. NYU's faculty concentration in neuro-inspired AI is the ideal environment for my research goals. Captivated by **Dr. Yann LeCun's** work on actionable representations, I aim to leverage my computer vision background to extend LeJEPA into the temporal domain for learning intuitive physics. I propose a hierarchical LeJEPA where SIGReg enforces non-collapse in future state prediction, replacing video SSL heuristics. Leveraging LeJEPA's downstream prediction risk minimization and unsupervised segmentation, I could investigate constructing scalable, collapse-free hierarchical planners capturing long-horizon causal structures.

Fascinated by **Dr. Sherry Yang's** research on general-purpose agents, especially UPDP and UniPi, I aim to address the video diffusion latency that limits UniPi to open-loop execution. Applying my background in model-based control, I propose investigating progressive distillation or consistency models to accelerate sampling. This would enable high-frequency, closed-loop model predictive control, allowing policies to dynamically correct for stochastic disturbances by re-generating short-horizon video plans conditioned on updated observations.

Building on **Dr. Kyunghyn Cho's** research on generalization mechanics and my experience in neural geometry, I propose extending "The Geometry of Prompting" framework to Chain-of-Thought. I aim to investigate if LLM reasoning is geometrically equivalent to a progressive untangling of class manifolds and if generation trajectories expand representation dimensionality to transform tangled inputs into linearly separable regions. I am eager to contribute my background in collaborative research and interdisciplinary curiosity to NYU's research community.

My research on neuroscience-inspired intelligent systems began with the scholarly challenge of academic isolation. Professors in AI told me that researching the application of neuroscience for AI is uncommon. Noting I was the only engineer in his class, a neuroscience professor expressed a wish for research on building AI's neurons into hardware, independently envisioning neuromorphic computing, unheard of in his department. I had a passion for a field that, on my campus, did not seem to exist.

Driven by relentless curiosity, I searched for insights from textbooks and numerous papers outside of my coursework. I began to understand the active areas of research in this discipline and gain the skills required to work in them. I learned that the relevant subdisciplines were separated into distinct departments at UW-Madison, forming a systemic barrier to discovery.

In my early studies, I sought a way to connect to others with similar interests, a mentor to teach me about neuroscience-inspired AI, or collaborators to help me start conducting relevant research. Yet I found none. To spare others that same isolation, I created the community I once sought.

I founded the Wisconsin Neuromorphic Computing and NeuroAI Lab (WNCNL) to create both an interdisciplinary research hub and a learning community. To establish this university-sanctioned entity, I secured formal funding, dedicated space, and administrative support. I pitched the initiative to Dr. Akhilesh Jaiswal who offered his support as an advisor and I negotiated an official partnership with the NeuroAI startup FinalSpark. I was delighted to see the collaborative nature of the environment: students from neuroscience explaining the biomechanics of a neuron to engineers and computer scientists explaining artificial neural networks to biologists.

To share my passion for learning and for this field, I give lectures on relevant topics and organize weekly meetings including biweekly workshops. When members run into challenges like low model performance, I give advice on how to resolve them. I also explain concepts, provide research proposals, point to relevant literature, and propose avenues for future research. For instance, explaining spiking neural networks' aptitude for sparse event-driven processing motivated one group to begin new research on meteor detection.

My work with the WNCNL demonstrates my commitment to building scholarly community, a value I am eager to bring to New York University. Seeing students explain concepts from their own disciplines solidified for me that this cross-pollination is essential. I am keen to scale this model at NYU, such as by organizing a workshop series that operationally connects findings from the Center for Computational Neuroscience with engineering challenges at the Courant Institute. This goal would align with the Minds, Brains, and Machines Initiative by fostering a deeper dialogue between these fields. My lived experience of academic isolation is what drives me to mentor. I plan to serve as a mentor in the Summer Undergraduate Research Incubator program, guiding undergraduates through the challenges of interdisciplinary research. At New York University, I aim to be both a researcher and a community builder who ensures no student's passion exists in isolation.