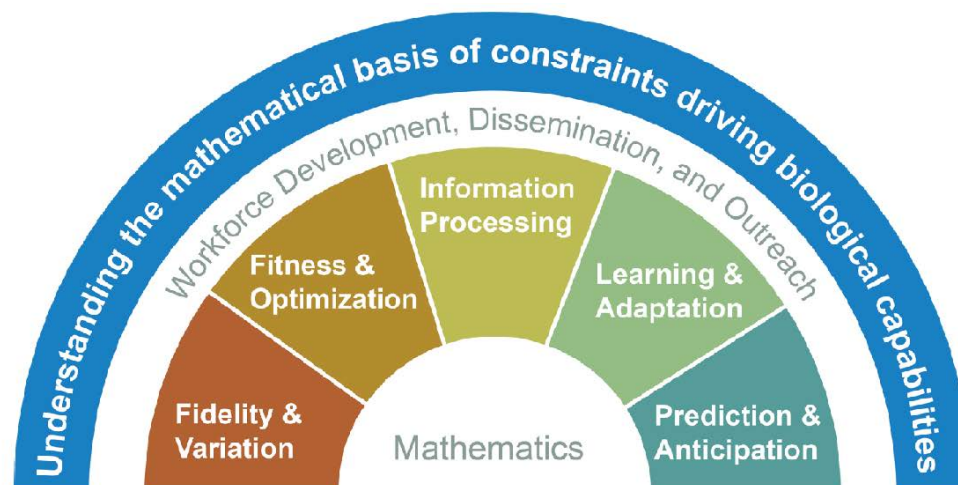




National Institute for Theory and Mathematics in Biology

Funded by the U.S. National Science Foundation and the Simons Foundation



Northwestern
University



THE UNIVERSITY OF
CHICAGO

SIM **NS**
FOUNDATION

Biology inspiring math, math inspiring biology

How do we do it? Our programs

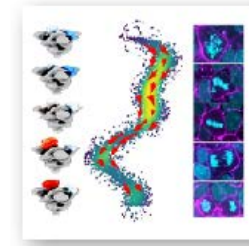


Workshops, Seminars, Conferences
NITMB Focused Research Groups

NITMB Research Trainee Program

Visitor Programs

NITMB Fellows Program
Summer Undergraduate Research Program



**Representing and Learning
Morphology and Shape
Dynamics from Biological Data**
October 19-23



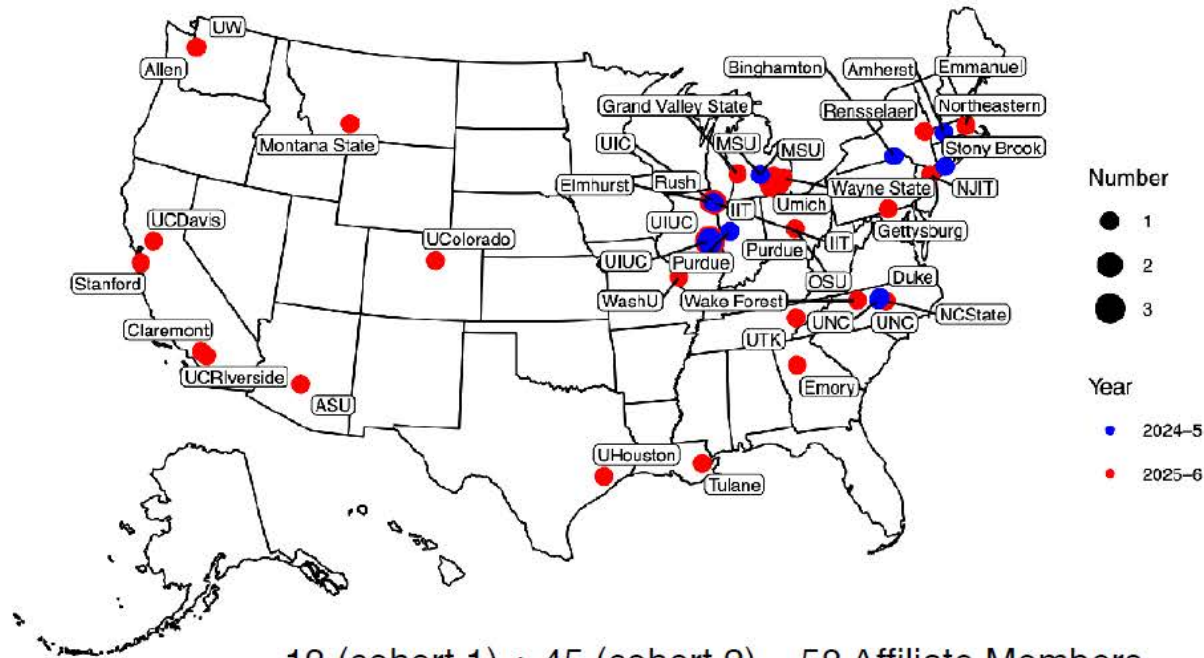
**Multi-Scale Biological
Adaptation to
Environmental
Variability**
November 9-13

**Image-Based Scientific Machine
Learning for Theories of Biological
Dynamics Across Scales**

February, March 2027



Expanded Affiliate Member Program



13 (cohort 1) + 45 (cohort 2) = 58 Affiliate Members
Representing 45 Institutions

Plans to increase our affiliate member numbers for cohort 3

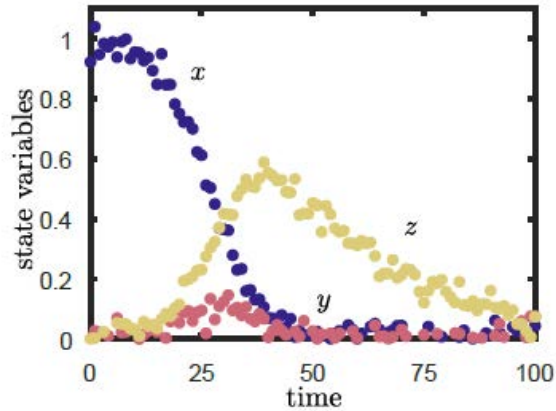
Affiliates receive travel funds and are expected to engage with NITMB activities.

18 Affiliates have visited since October 2025, with several making multiple visits.



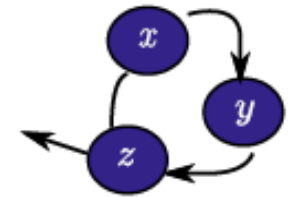
Data-driven model discovery for biological systems

Data

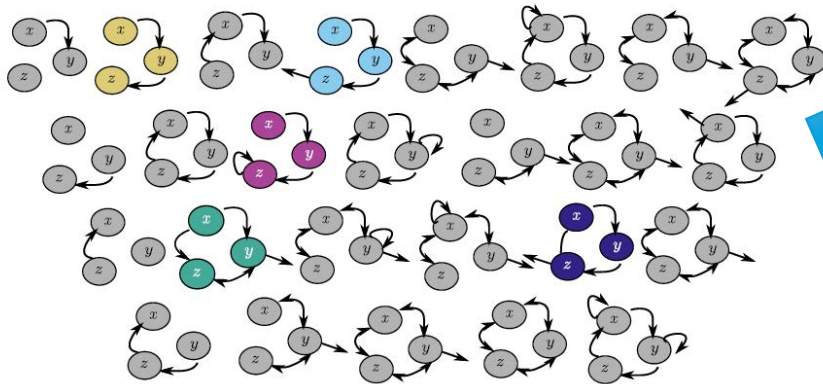


Optimization

$$\begin{aligned}\dot{x} &= -\beta_{x,y}xz \\ \dot{y} &= \beta_{x,y}xz - \beta_{y,z}y \\ \dot{z} &= \beta_{y,z}y - \beta_z z\end{aligned}$$



Existing
Biological
Knowledge



- **Niall M. Mangan**
- Associate Prof.
- Eng. Sci. & Applied Math
- Northwestern University



What could we learn?

How do animals
control their
temperature during
hibernation?



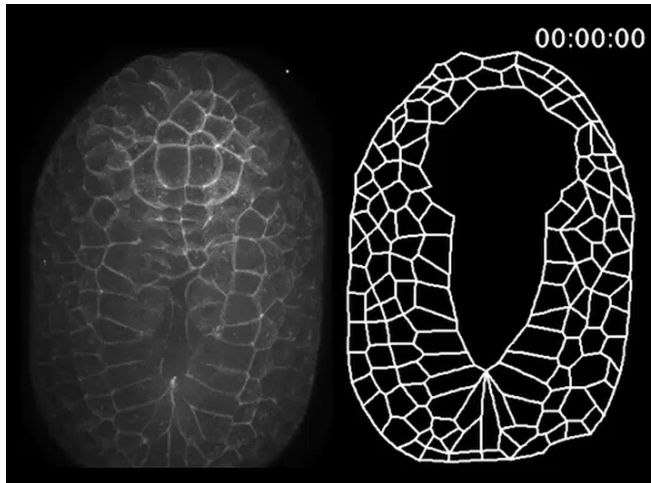
What could we learn?

How do animals control their temperature during hibernation?



National Parks Services

What “program” guides spinal cord development in embryos?



Munro Group U. Chicago



National Institute for Theory and Mathematics in Biology

Funded by the U.S. National Science Foundation and the Simons Foundation

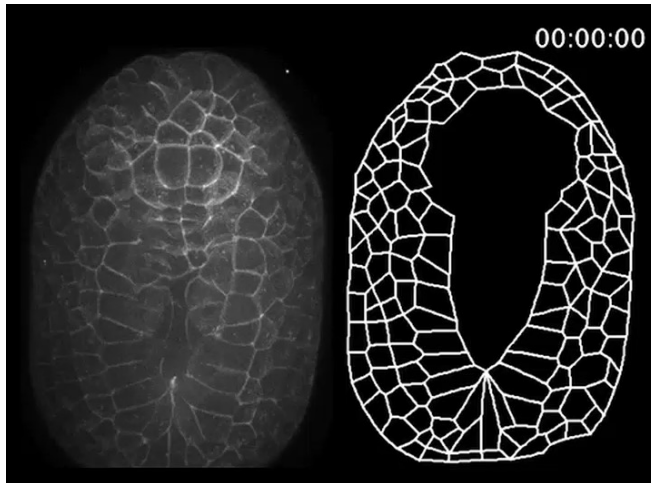
What could we learn?

How do animals control their temperature during hibernation?



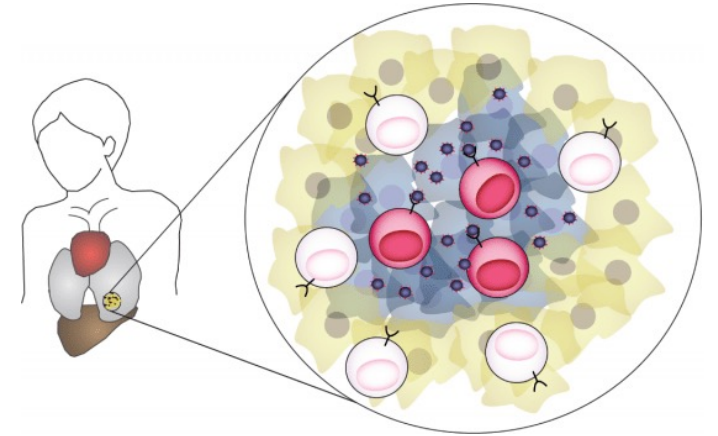
National Parks Services

What “program” guides spinal cord development in embryos?



Munro Group U. Chicago

Can we engineer our cells to fight disease?



Leonard Lab Northwestern



National Institute for Theory and Mathematics in Biology

Funded by the U.S. National Science Foundation and the Simons Foundation

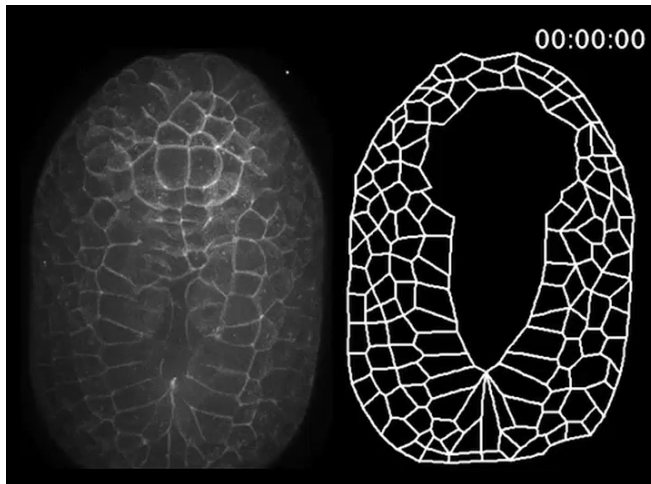
What could we learn?

How do animals control their temperature during hibernation?



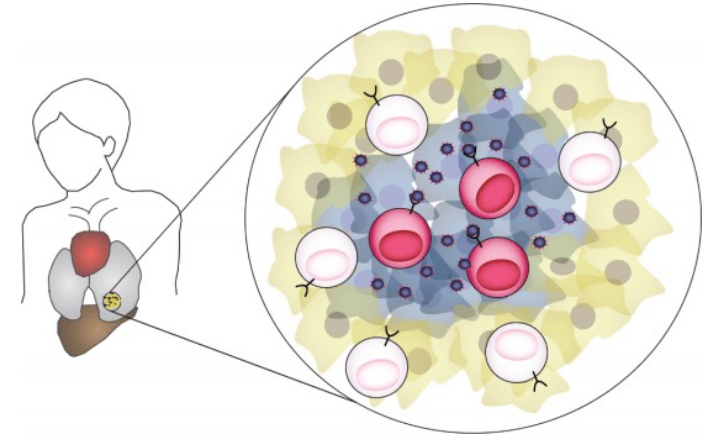
National Parks Services

What “program” guides spinal cord development in embryos?



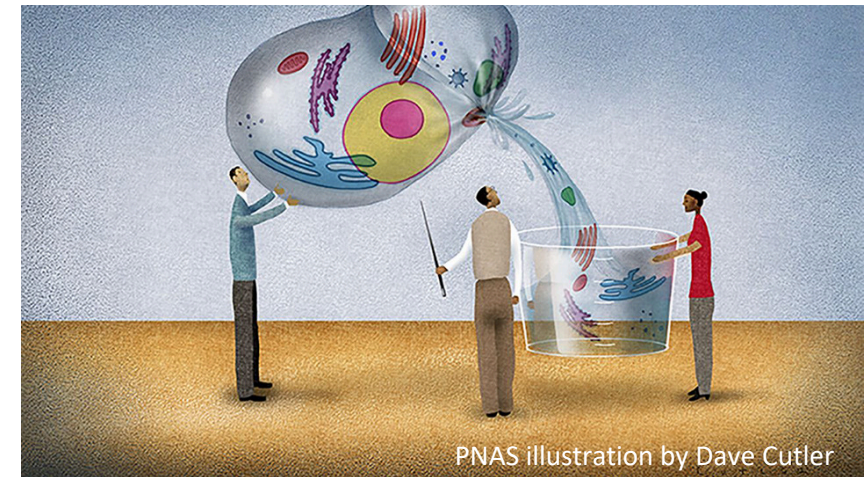
Munro Group U. Chicago

Can we engineer our cells to fight disease?



Leonard Lab Northwestern

How to optimize cellular machinery to reduce the cost of manufacturing?



PNAS illustration by Dave Cutler

Karim Lab Northwestern



National Institute for Theory and Mathematics in Biology

Funded by the U.S. National Science Foundation and the Simons Foundation

How do animals control body temperature during hibernation?



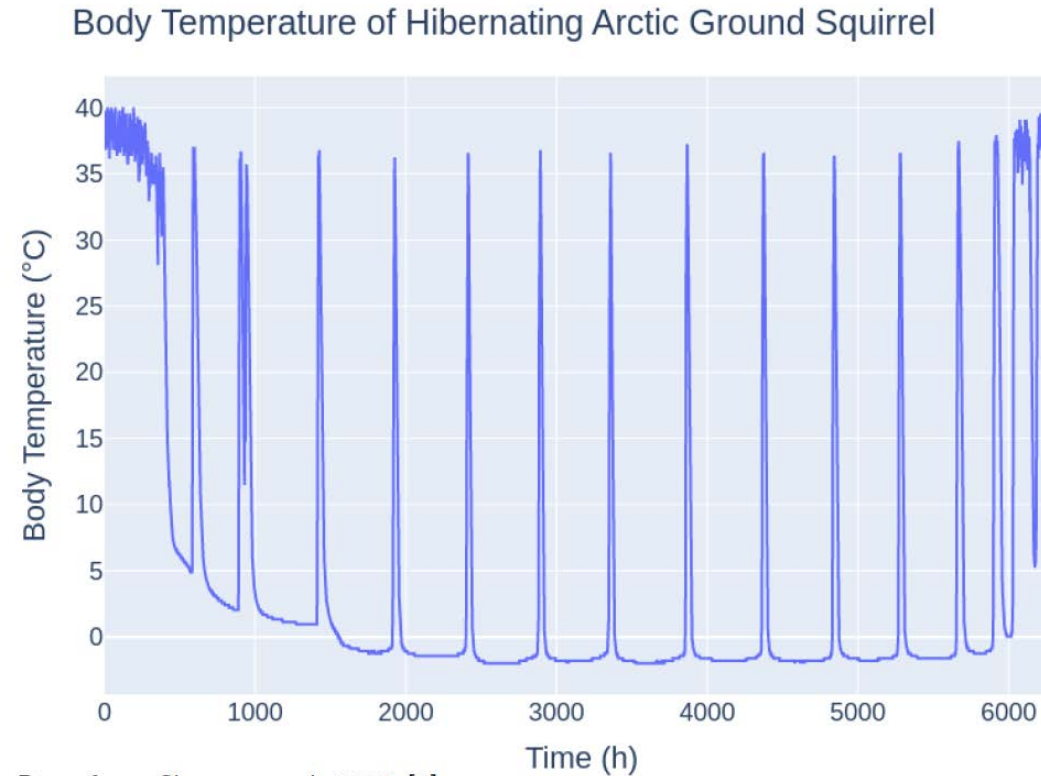
Dr. Cody
FitzGerald



Andrew
Engedal



Photo by Kirsty Knittel



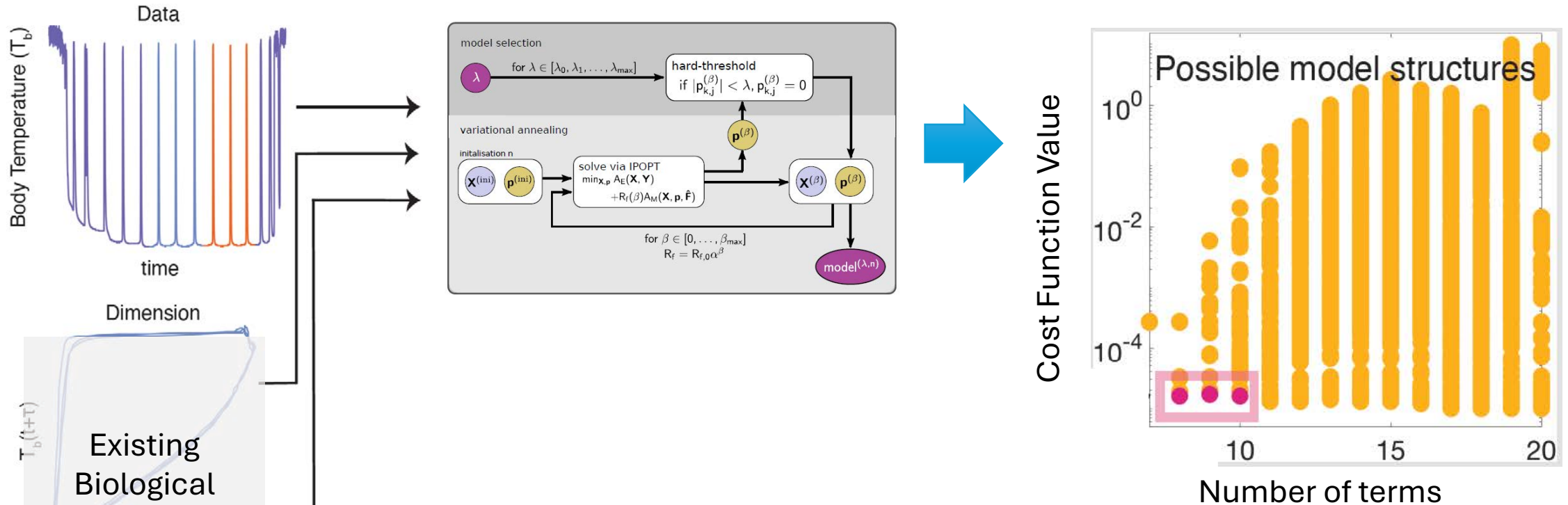
Data from Chmura et al. 2023 [1]

Sci. Rep. 2026



Apply our model selection algorithm.

(A) Inputs



Sci. Rep. 2026

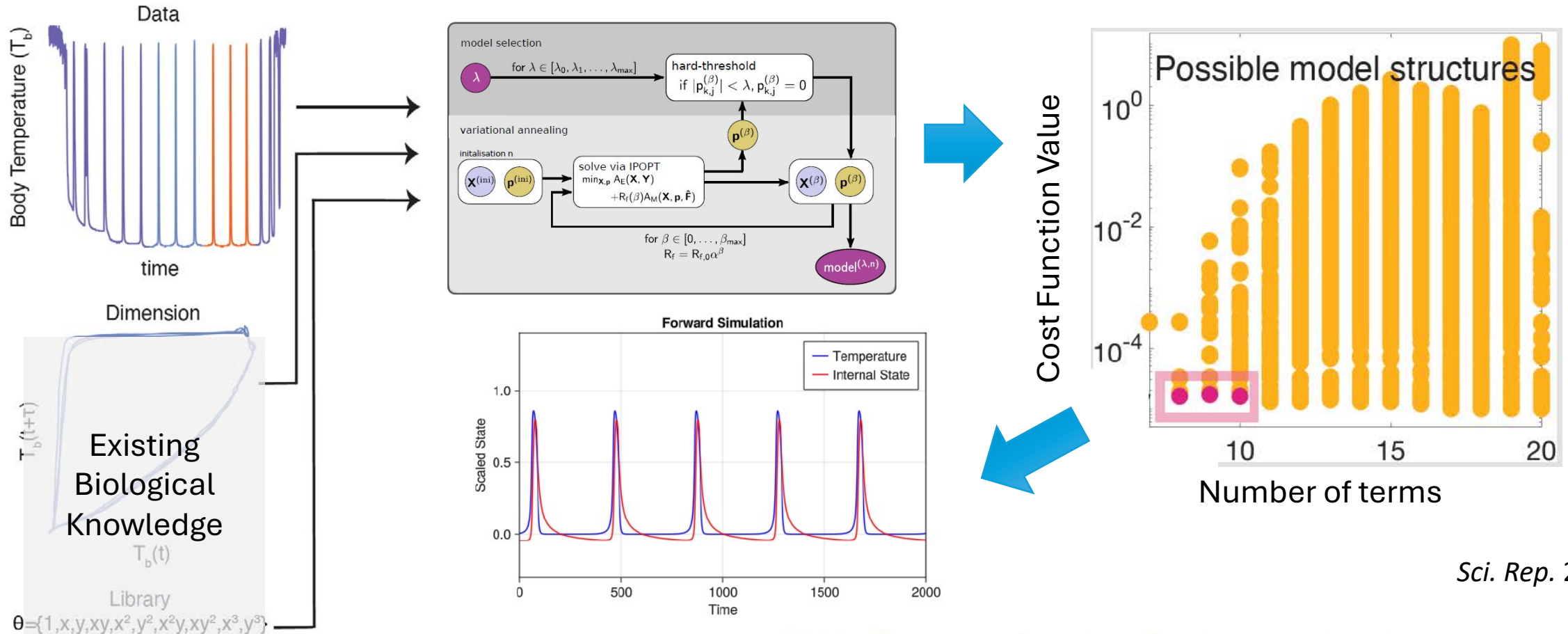


National Institute for Theory and Mathematics in Biology

Funded by the U.S. National Science Foundation and the Simons Foundation

Find a new “thermostat” controller!

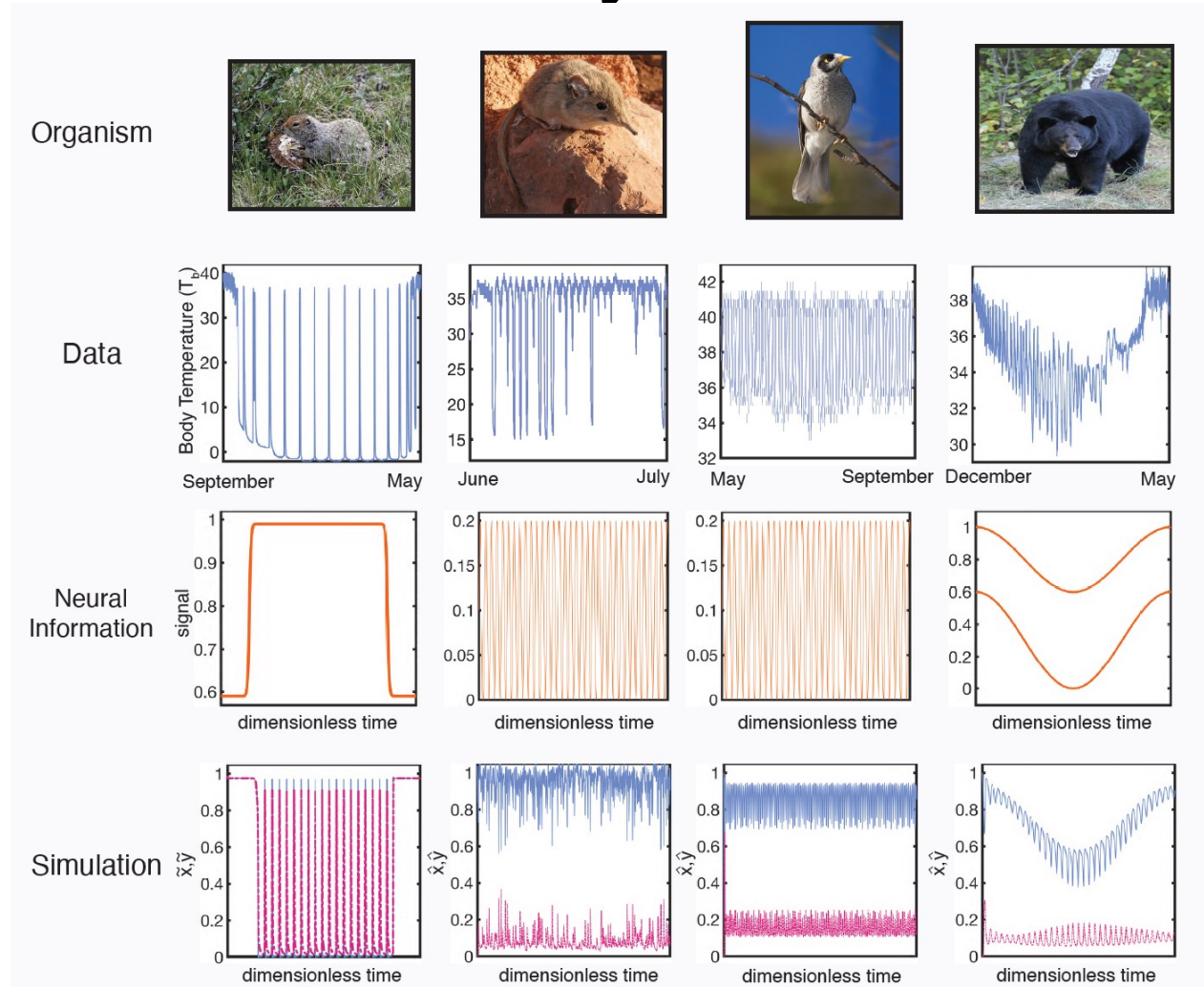
(A) Inputs



Sci. Rep. 2026



Predicts dynamics across organisms!



Dr. Cody
FitzGerald



Andrew
Engedal

Sci. Rep. 2026



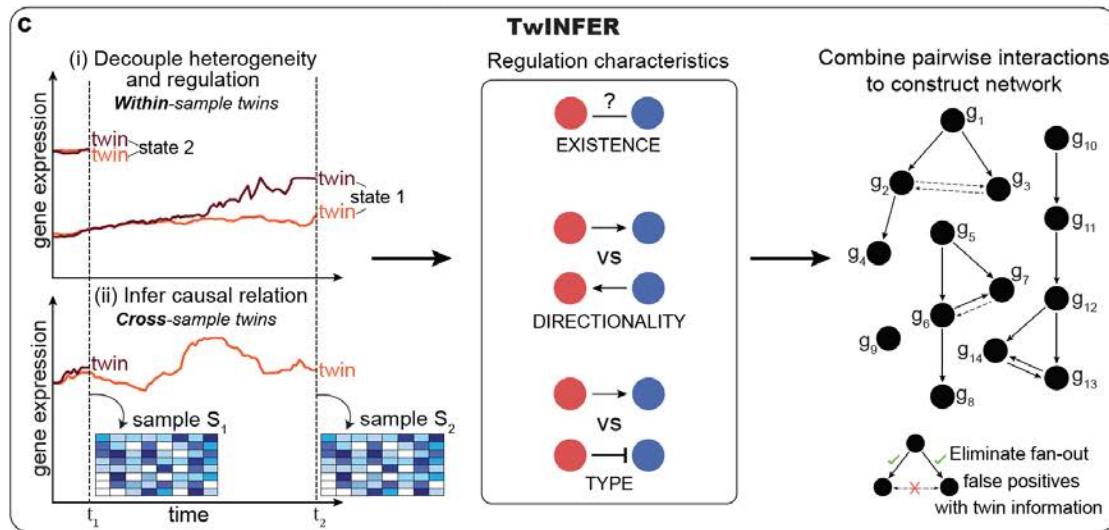
Across biological scales and fields

★	Lee K, Liu S, Crocker K, Wang J, Huggins DR, Tikhonov M, Mani M, Kuehn S	<i>Functional regimes define soil microbiome response to environmental change</i>	nature	Fitness & Optimization
	Lander SM, Fisher G, Everett B, Tran P, Prindle A	<i>Secreted nucleases reclaim extracellular DNA during biofilm development</i>	nature	Information Processing
	Montanari AN, Barioni AED, Duan C, Motter AE	<i>Optimal flock formation induced by agent heterogeneity</i>	nature communications	Prediction & Anticipation
	Dunworth JB, Xu Y, Graupner M, Ermentrout B, Reyes A, Doiron B	<i>Interleaving asynchronous and synchronous activity in balanced cortical networks with short term synaptic depression</i>	nature communications	Learning & Adaptation
	Lechon-Alonso P, Kundu S, Lemos-Costa P, Capitan JA, Allesina S	<i>Robust coexistence in competitive ecological communities</i>	nature communications	Fidelity & Variation
★	Natrajan M, Fitzgerald J	<i>Stability through plasticity: Finding robust memories through representational drift</i>	PNAS	Learning & Adaptation
★	Carlson M , Andrews B, Simons Y	<i>Distinguishing direct interactions from global epistasis using rank statistics</i>	PNAS	Fidelity & Variation
	Kuznets-Speck B, Ogonor BK, TP Wytock TP, Motter AE	<i>Generative prediction of causal gene sets responsible for complex traits</i>	PNAS	Fidelity & Variation



Leveraging Twin Information for Inference of Gene Regulatory Networks

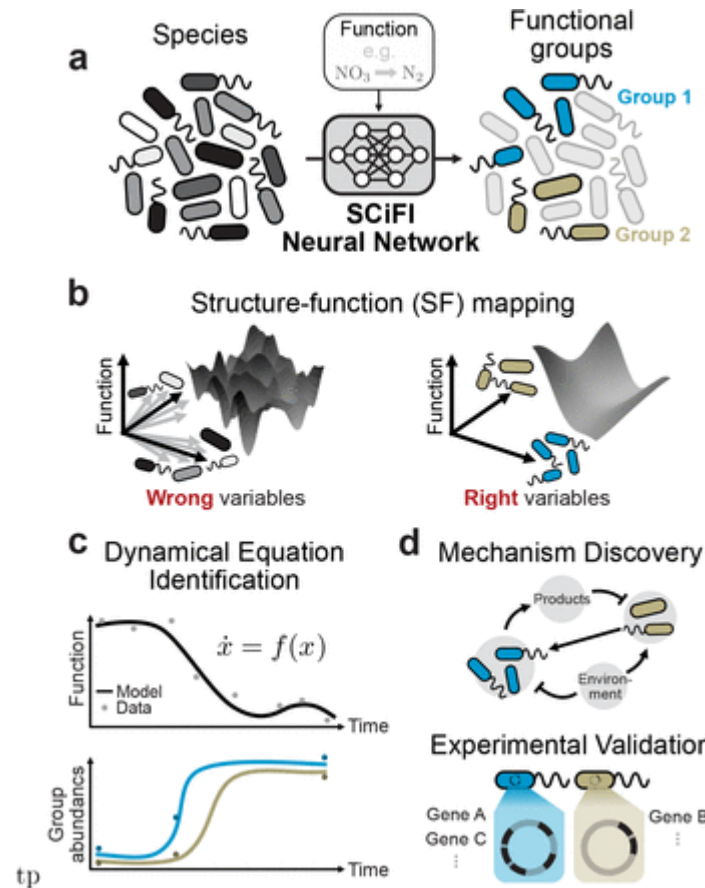
Keerthana M. Arun^{1,2,3,4,7}, Yuval Scher^{1,2,3,4,7,*}, Yuhua D. Zhang^{1,2,3,4}, Ida Büschel^{1,5},
Benjamin Kuznets-Speck^{1,2,3,4}, Carsten Marr⁵, and Yogesh Goyal^{1,2,3,4,6,*}



- Find regulatory activation, repression and loops
- Dynamics using single cell transcriptomics
- Math inspire new experiment

Learning functional groups in complex microbiomes

Matthew S. Schmitt^{1,2*}, Kiseok K. Lee^{3,4,5*}, Freddy Bunbury^{3,4,5}, Joseph A. Landsittel⁶, Vincenzo Vitelli^{1,2,5,7,8**}, Seppe Kuehn^{3,4,5,8**}



- Learn functional groups from species abundance
- Learn dynamics of those groups
- Targeted experiments and mechanism discovery



Of Mice and Machines: A Comparison of Learning Between Real World Mice and RL Agents

Shuo Han¹ German Espinosa² Junda Huang¹ Daniel A. Dombeck³ Malcolm A. MacIver² Bradly C. Stadie¹

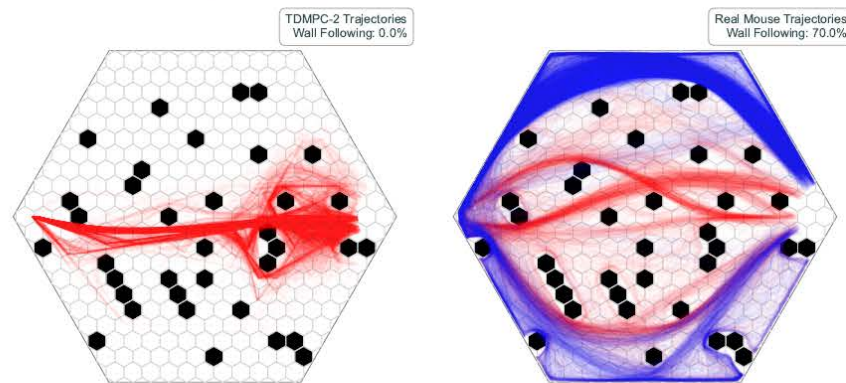


Figure 3. Trajectory plots: RL (left) vs Mouse (right). Blue indicates wall-following trajectories (thigmotaxis), while red indicates non-wall-following trajectories.

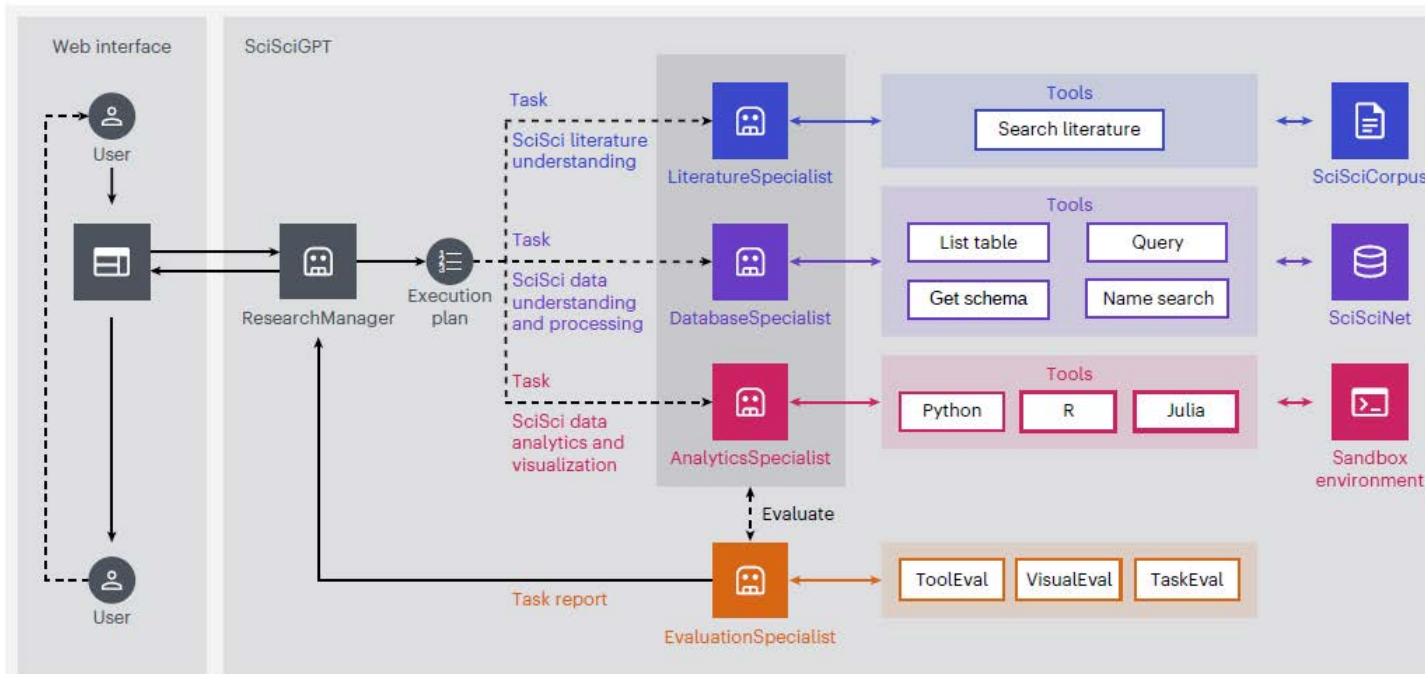
- RL agents consistently risk “death” for marginal efficiency gains
- Motivates new algorithms with risk-avoidance

SciSciGPT: advancing human–AI collaboration in the science of science

Received: 6 April 2025

Accepted: 14 October 2025

Erzhuo Shao^{1,2,3,4}, Yifang Wang^{1,2,3,5,6}, Yifan Qian^{1,2,3,5,6}, Zhenyu Pan⁴,
Han Liu⁴ & Dashun Wang^{1,2,3,4,5}✉



- AI agents have specialized skills
- Antagonistic Specialists and evaluators

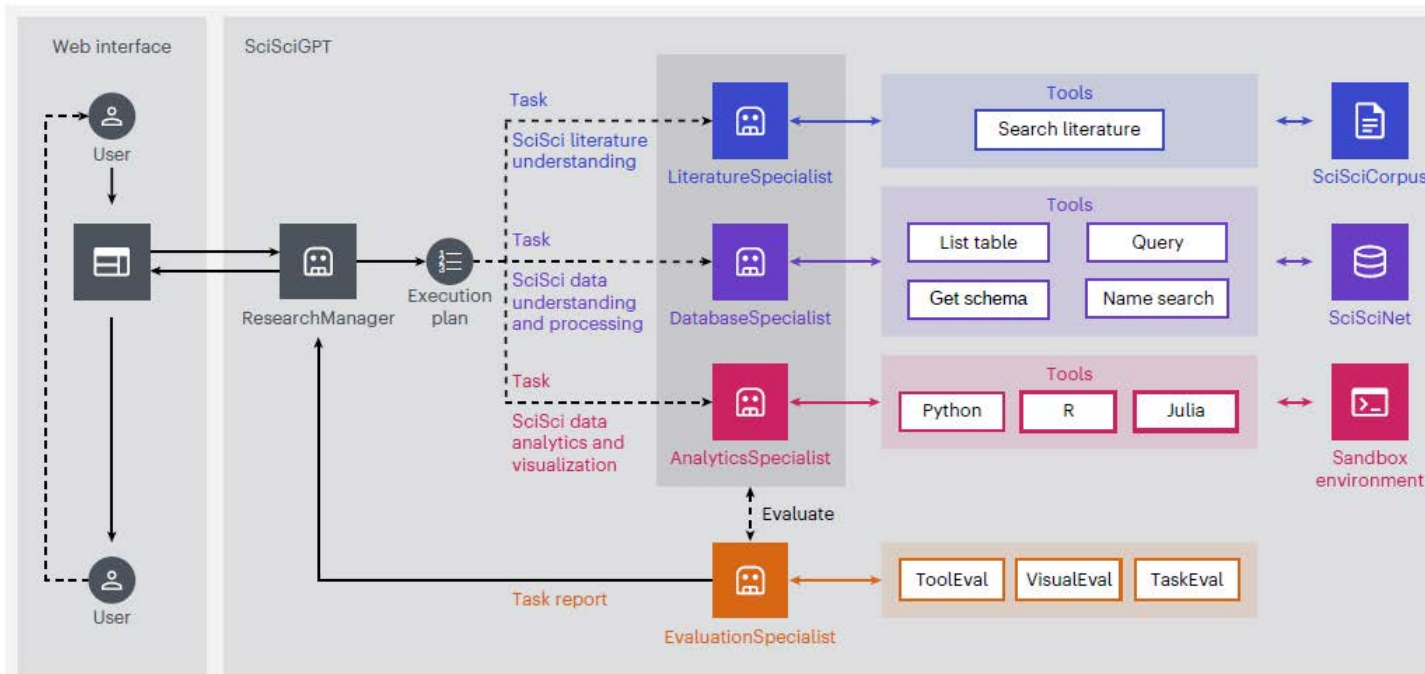


SciSciGPT: advancing human–AI collaboration in the science of science

Received: 6 April 2025

Accepted: 14 October 2025

Erzhuo Shao^{1,2,3,4}, Yifang Wang^{1,2,3,5,6}, Yifan Qian^{1,2,3,5,6}, Zhenyu Pan⁴,
Han Liu⁴ & Dashun Wang^{1,2,3,4,5}✉



Automated experimentation
for protein engineering
(Lucks, Tullman-Ercek, Jewett)



Biology inspiring math, math inspiring biology

How do we do it? Our programs

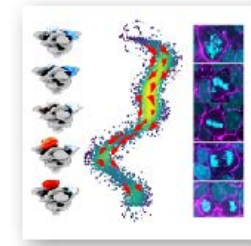


Workshops, Seminars, Conferences
NITMB Focused Research Groups

NITMB Research Trainee Program

Visitor Programs

NITMB Fellows Program
Summer Undergraduate Research Program



**Representing and Learning
Morphology and Shape
Dynamics from Biological Data**
October 19-23



**Multi-Scale Biological
Adaptation to
Environmental
Variability**
November 9-13

**Image-Based Scientific Machine
Learning for Theories of Biological
Dynamics Across Scales**

February, March 2027

