(a) Modeling multi-omics data

~ 1mm

~ 10 cm

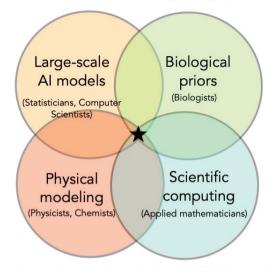**SPATIAL PROFILING**
Ex: seqFISH / MERFISH
○ Reaction-diffusion, active matter
● Fourier Neural Operators
⊙ Physics-Informed Neural Nets

EPIGENOMICS
$10\,\mu m$ ~
Ex: Hi-C, scATAC-seq, FISH
○ Rouse models
⊙ Effective Gaussian Polymer models/Maximum Entropy

PROTEOMICS, TRANSCRIPTOMICS, METABOLOMICS
Ex: scRNA-seq, Mass Spectrometry, Perturb-seq
○ Chemical Fokker-Planck Equation
● Dynamical optimal transport
⊙ Physics-informed Neural ODE

○ **Biophysical**
● **Purely data-driven**
⊙ **Physics-informed ML**

~ 2 nm

(b) Interdisciplinary approach

Large-scale AI models
(Statisticians, Computer Scientists)

Biological priors
(Biologists)

Physical modeling
(Physicists, Chemists)

Scientific computing
(Applied mathematicians)

★ AI-accelerated simulations of biological systems
★ AI-assisted biophysical models
★ Mechanistic insight guiding therapeutics

AI-assisted biophysics engine

Multi-modal foundation model

Transfer learning

$d\mathbf{x} = f(\mathbf{x}, \theta)dt + \sqrt{2Ddt}\xi$

Generate hypothesis

Lab-in-the-loop

Pretrain

Update data

Wet lab experiment

Multi-omics data

Pax6
Sp8
Fgf8
Emx2
Coup