Introduction to quantitative biology
Final project
Progress update in class on 2026/12/04
Presentation in class on 2026/12/22 + 25
Report due before presentation

The goal of the final project is to further explore the quantitative principles discussed in class. The scope of the project is like a large problem set; imagine your product to be a problem set for this course. Work in groups of 2-3 (so that we have in total ~9 groups). You can choose any model system you like, including but not limited to systems you are working on in your own research. Some possibilities include analyzing existing data using methods and perspectives related to those covered in class, or distilling a quantitative principle into a clear demo grounded in experiments.

The progress update is a mini-presentation, 10 + 5 minutes, several weeks before the final presentation. It is a chance to get feedback. Then the last week of class will be your final presentations, 15 + 10 minutes. Accompanying your presentation is a ~5-page written report.

Below is a collection of references to get you started. Feel free to select your own references to focus on, but they should be related to the course content. At a minimum, plan to present a paper and related questions during the progress update.

- "E. coli do not count single molecules"
  https://www.biorxiv.org/content/10.1101/2024.07.09.602750v1.full (now published)
  The title of this paper contradicts our expectations from class. What is their argument?

- "Excessive cell growth causes cytoplasm dilution and contributes to senescence"
  https://www.cell.com/cell/fulltext/S0092-8674(19)30051-0

- "Ligand interaction landscape of transcription factors and essential enzymes in E. coli"
  https://www.cell.com/cell/fulltext/S0092-8674(25)00032-7

- "Probe-based bacterial single-cell RNA sequencing predicts toxin regulation"
  https://www.nature.com/articles/s41564-023-01348-4
  How do single-cell transcriptome data compare to noise measurements?

- "D-SPIN constructs gene regulatory network models from multiplexed scRNA-seq data revealing organizing principles of cellular perturbation response"
  https://www.biorxiv.org/content/10.1101/2023.04.19.537364v4

- "Rewiring the specificity of two-component signal transduction systems"
  https://www.cell.com/cell/fulltext/S0092-8674(08)00614-4

- "Maximum entropy models for antibody diversity"
  https://www.pnas.org/doi/abs/10.1073/pnas.1001705107

- "Eigenvalue spectra of random matrices for neural networks"
  https://journals.aps.org/prl/pdf/10.1103/PhysRevLett.97.188104

- "Large-scale discovery, analysis, and design of protein energy landscapes"
  https://www.nature.com/articles/s41586-026-10465-z (and related paper in 2023)

- "Bonsai reconstructs tree representations for distortion-free visualization and exploration of high-dimensional data"
  https://www.nature.com/articles/s41587-026-03220-2

- … your ideas here!