Quantitative principles in biological systems
Final project
Progress update in class on 2026/05/22
Presentation in class on 2026/06/12
Report due before presentation

The goal of the final project is to further explore one of the themes discussed in class. Students auditing the class are welcome to participate. We will get as much out of this project as we put in. You can choose any model system you like, eg systems you are working on in your own research. The scope of the project should be like a large problem set. You can imagine your final product to be a problem set for this course. Some possibilities include analyzing an existing data set using methods and perspectives related to those covered in this course or distilling a quantitative principle into a clear demonstration grounded in data.

A major learning goal is to practice communicating across disciplines. To this end, part of the final project is a mini-presentation several weeks before the final presentation. Look at this update as a chance to get feedback. The last week of class will be your final presentations. Each presentation will be 20 minutes plus 10 minutes for discussions, aimed at an interdisciplinary audience interested in quantitative understanding of biological systems. Accompanying your presentation is a ~5-page written report emphasizing the quantitative principle that your team focused on.

Below is a collection of references and some comments to get you started. Feel free to select your own reference to focus on, but make sure it is related to the themes we discussed. At a minimum, you should plan to present a paper and related questions during the progress update. Do not hesitate to contact me or the TAs with questions.

- "E. coli do not count single molecules"
  https://www.biorxiv.org/content/10.1101/2024.07.09.602750v1.full
  The title of this paper contradicts our expectations from unit 1. 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

- "Observation of universal ageing dynamics in antibiotic persistence"
  https://www.nature.com/articles/s41586-021-04114-w
  This paper proposes a spin glass model for persistence. What data can be used to test this model? (eg single-cell transcriptomes for large cell numbers like those below?)

- "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 in Taniguchi et al?

- "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

- … your ideas here!