E3: Diffusion and tracking

Week 7. Due Wed 24 Feb 23:59, reviewed Thu 25 Feb

About 2 hours. This exercise feeds directly into milestone M2 of P1.

1. Nelson

Nelson: Your Turn 4b, 4c, 4d and 4e.

2. Diffusion times in the cell

Estimate the time $t \sim L^2/(2D)$ it takes to diffuse a distance L for:

a. a protein ($D \approx 10$ µm^2/s) across a bacterium (1 µm) and across a eukaryotic cell (20 µm);
b. a neurotransmitter ($D \approx 300$ µm^2/s) across a synaptic cleft (20 nm);
c. the same protein along a 1 m long nerve axon.

What do the numbers tell you about where cells can rely on diffusion and where they need active transport?

3. Test a tracking pipeline on synthetic data

Run `synthetic_brownian.py`. It makes a movie of beads with known D, tracks them with trackpy and prints the true and fitted D.

a. Run it with `--D 0.5`. How close is the fitted value?
b. In `track_and_fit`, set `search_range=5` and run again. What happens to D, and why? Estimate the per-axis step in pixels per frame and compare it with the search range.
c. Set `minmass=None`. What happens now, and why?
d. In one sentence: why must you test your own pipeline on synthetic data before you trust it on the lab data?