Sam Ocko Part 3 Reflections

Exam Date-May 14, 2012

Committee: Jeff Gore(Chair), Jeremy England, Alexander Van Oudenaarden
Total time-About an hour 20 minutes

Preparation:

About two and a half weeks, mostly spent reading Biological Physics by Philip Nelson, Physical Biology of the Cell By Phillips, Kondey, and Theriot, some of Brian Ross' guide http://web.mit.edu/physics/refs/generals/Biophysics_BrianRoss.pdf, and Kardar's Lecture notes for Statistical Physics in biology, occasionally going through a derivation for something I didn't understand. I found it very helpful to have several practice exams where a friend grills you on random areas of biophysics as well as your warm-up problem. This is much better preparation for the exam than working through back of the envelope calculations on your own, because it forces you to think on your feet and not get choked up, and exposes holes in your knowledge.

Other than my warm-up question, most of the questions were much less mathematical than I had anticipated-Instead of a complicated calculation, a qualitative explanation, a scaling argument, and a rough estimate of the quantities needed was all that was required. One resource I found helpful was the appendix in the back of Philip Nelson's book which had a lot of useful numbers to remember all in the same place.

My warm up problem involved DNA in the large force limit, to calculate the average length of a piece of DNA with length L, stiffness k, under a force F at a temperature T. The second part was to estimate the length and energy loss due to binding to a protein which introduced a kink which prevented it from being perfectly straight (8.591 PSet7 Problem 3). Answering the warm up problem took surprisingly long(Maybe 40 minutes) because my committee asked a lot of questions in the middle. There weren't clearly defined separations after my warm-up problem or between the random problems I was asked, everything flowed pretty organically from one thing to the next.

Some problems included:

Jeff: How much force do you need for the high force limit of stretched DNA to be relevant(about 1/10 of a piconewton)

Jeremy:

Write down the Fokker Planck equation(It arose in the context of proteins diffusing along DNA).

How does diffusion depend on drag coefficient. Write down the differential equation to solve for the steady state when you add a flow J from the left side to the right side. How does the free energy of the steady state distribution compare to the free energy of the equilibrium when you turn the flow off? Prove that the boltzmann distribution minimizes free energy.

If in the high force limit of DNA each segment is given a small force trying to orient each segment in an arbitrary direction, how does that change the Euler-Lagrange equation for the angle of DNA. How would you calculate the response, and what does it look like?

If you leave DNA at room temperature for a trillion years, what happens(It falls apart). Does putting DNA in acid or base speed up or slow down the rate of falling apart. (Jeff and Jeremy): What does putting a moderate pulling force do to the average breaking time, and why? Calculate the scaling relation and say/estimate what the relative quantities are.

Alex: Consider the protein kink problem with DNA under stretching. If you have multiple proteins that bind nonspecifically along the major groove of DNA, will there be an interaction between them which gives correlations in binding probability? (Jeff): What sort of interaction and how should it scale with the distance between the two proteins?

Style: Often I got confused as to what they were actually asking, I recommend if you're not sure, you should ask them to clarify. I had thought that each professor was going to come in and have a list of questions they were going to ask me, but it was more informal, and flowed from topic to topic without any well defined breaks.