Matter and Motion Winter 2016 Reading Questions

Seminar 1 (Chaos pages 1- 154)

Come prepared to seminar ready to discuss with 2 copies of typed up responses to a few of the following questions.

1. The meaning of a theory: The physics and chemistry you have been learning so far is "deterministic" – i.e., if you know the starting conditions (say, position and velocity) of a system, you can predict everything that will happen thereafter. Quantum mechanics, which you will see in the spring, changes this: the predictions of QM are "probabilistic", which is to say that if you know the initial state of a system, there are things about its behavior which you can only answer on average – e.g., "the particle will be between x1 and x2 10% of the time, if we repeat the experiment lots of times." The theory still allows for prediction, but only on average for some quantities. Statistical Mechanics is similar in certain respects. Chaos suggests that due to the very sensitive dependence on initial conditions, even for a classical deterministic theory it can be impossible to predict what will happen very far into the future; the tiniest error in the initial knowledge of the position or velocity can result in huge differences in the predicted outcome (the opposite of the usual case – if your coffee is at 99˚ and cools to room temperature in about 30 minutes, then if it starts instead at 98˚C you expect it to cool in something very close to 30 minutes… not 1 minute or 3000 minutes). What does it mean for a theory to be complete, or even for it to be predictive?

2. Phase space: This is an important concept in physics, and covered in the chapter on strange attractors. Try drawing a phase diagram for a mass oscillating on a spring. What goes on the horizontal axis? What goes on the vertical axis? What does the plot look like? Try drawing a phase diagram for child on a swing. What happens if they start out not moving, then pump their legs until they start swinging higher and higher, until they max out at some maximum angle θ, when they can't get the swing to go any higher? What does the diagram look like if they then stop pumping their legs and slowly the swing slows down?

3. Gendered language: Does Gleick ever use non-male pronouns? Does it even seem possible to Gleick that people of other genders could be included in the scientific process?

4. Hagiography: What does Hagiography mean? Do you think Gleick is likely to be being objective in his descriptions, or was it to his benefit (in trying to write a popular bestseller) to "make heroines"? If my use of the word "heroines" caused you to pause; ask yourself why, and think about it in the context of Gleick's book.

5. Over-reaching. Gleick may leave you with the sense that all the deterministic physics you have learned (and are learning) is incomplete garbage. If chaos is so important, why do any of these theories work at all? Why can you even predict what a simple mass on a spring will do? How come we didn't have to throw out all the old physics books and write completely new ones? What part (if any) do you think Gleick is leaving out of minimizing?

6. What other parts of this story (the science or personal) are particularly interesting or important to you?

7. What parts of this story bother you or don't speak to you and your personal experience in science?