1. **Extensions of the spruce budworm model.** In class, we discussed the insect outbreak model for spruce budworm. The model as we discussed it is valid only on a short time scale, namely during the outbreak. A more complete model that incorporates tree dynamics is discussed in Ludwig et al, J. Anim. Ecol. 47, pp. 315-332, 1978. Furthermore, spatial effects such as budworm dispersal play an important role. A model incorporating diffusion is discussed in Ludwig et al, J. Math. Biol. 8, pp. 217-258, 1979 (also see Murray, Chapter 14.7).

2. **Models in whaling and fisheries management.** In Chapters 2.5 and 2.6 of Mathematical Biology, Murray briefly describes the use of discrete delay equations in models used by the International Whaling Commission to study the effect of whaling on baleen whales. More details are given in the references cited in these chapters (in particular, the article and book by Clark, and the review by May).

3. **The Hodgkin-Huxley equations and Fitzhugh-Nagumo equations.** These are fundamental models describing the electrical activity in the membrane of many types of cells, most notable nerve, muscle, and endocrine cells. See Keener & Sneyd, Chapters 3 and 4, and references therein.

4. **Bursting electrical activity.** A nice topic if you're already familiar with the Hodgkin-Huxley equations and like bifurcation analysis. Bursting refers to a particular pattern of membrane electrical activity, and has been studied extensively in the context of insulin release from pancreatic beta cells. See Keener & Sneyd, Chapter 6, and references therein.

5. **The dynamics of HIV.** Mathematical models have been used to help understand the dynamics of HIV infection and influenced the way AIDS patients are treated. The models describe the interaction between the HIV virus and the cells that are infected. Dynamical processes occur on different time scales. For entry into the literature, consult the following review articles: Perelson and Nelson, Mathematical analysis of HIV-1 Dynamics in Vivo, SIAM Review 41, pp. 3-44, 1999, and Kirschner, Using Mathematics to Understand HIV Immune Dynamics, Notices Amer. Math. Soc. 43, pp. 191-202, 1997.

6. **Spatial spread and control of a rabies epidemic among foxes.** This was a problem that received some attention in Britain a few years back. At the time, rabies was non-existent in Britain, and the rabies epidemic in continental Europe had reached the coast of France. It seemed plausible that rabies would be introduced to Britain through illegally imported pets. Models were used to determine the propagation speed of the potential rabies epidemic and investigate the effect of various control strategies. See Murray, Chapter 20, and references therein.
7. **Behavioural Ecology.** Using evolutionary principles, models can be developed to describe the behaviour of organisms. The models can then be used to analyse adaptations in behaviour in response to changes in the environment for example. Mangel and Clark have written an excellent book on this topic, Dynamic Modeling in Behavioral Ecology, 1988. Several interesting case studies (hunting behaviour of lions, migrations of aquatic organisms, etc) are included in the book, any of which would make a nice project topic. The book is not in the library, but I have a copy.

8. **Animal Aggregations.** This topic deals with swarms of insects, schools of fish, flocks of birds, etc. Many aggregations are the result of social interactions. What are the mechanisms keeping organisms together? How do aggregations influence avoidance of predators, detection of prey, transmission of disease? For an introduction into the literature, see the review article by Grunbaum and Okubo in Frontiers in Mathematical Biology.

9. **Spiral and scroll waves in the BZ reaction.** In class, we will discuss the BZ reaction in the context of oscillations. The BZ reaction can also generate waves, including complex spiral waves, and scroll waves. See the review article by Tyson in Frontiers in Mathematical Biology for references. I have a number of other review articles on this topic from Scientific American, Nature, and Science.

10. **Immersed boundary method for biological fluid dynamics.** This method is used to study the beating of the heart, the swimming of organisms (from bacteria to eels), platelet aggregation during blood clotting, etc. The method combined the Navier-Stokes equations for fluid flow with Hooke's law for springs. See me for references.

11. **Mechanical models for pattern formation and morphogenesis.** In class, we will discuss spatial pattern formation via reaction-diffusion mechanisms. Chapter 17 in Murray provides a nice introduction to an alternative mechanism for pattern formation based on a consideration of mechanical forces. This mechanism is of relevance to wound healing as well, which is an interesting topic on its own.

12. **Cell motility.** Cells can respond to their environment, and move towards regions that are more favourable. Mathematics has been used to study how a cell moves. See Alt and Hoffmann (eds), Biological Motion, Lecture Notes in Biomathematics Volume 89, 1990.

13. **Chemical signalling in cellular slime molds.** Cellular slime molds are found in soil. They have an interesting life cycle, governed by the chemical cyclic-AMP, which is produced by the organism itself. Mathematical models exhibit oscillations, interesting bifurcations, excitability, etc. See Chapter 6 of Segel, Modeling dynamic phenomena in molecular and cellular biology.

14. **The dynamics of actin filaments in the cytoskeleton.** Actin filaments are involved in determining structural and mechanical properties of cells. Actin filaments may form bundles or networks. Mathematical models help to understand the dynamics of actin