**BIOPHYS 3G03 / LIFESCI 3BP3 - Modelling Life**

**Group Project Ideas**

You can choose whatever subject you like to make your group project about. Here are a few suggestions to get you thinking. You are welcome to work on any of these, or think of your own. But I am requesting that you don't pick a topic about disease spread. We have been thinking about disease spread much too much already just lately.

**Animal Foraging**

How do animals find food? How do they decide if it is better to stop and eat the first food they find, or to sometimes move on to try to find a better source? Food patches might differ in their total food value, and in the quality of the food – i.e how fast can the energy be extracted from the food. When should you ignore the food of lower value or quality? Maybe this depends on the overall frequency of food?

Alternatively, suppose that there are food patches of varying quality and you already know where these are. You have a choice of which type of food to go after in each time step. What should your probabilities be for each of the choices? Probably you should choose the higher quality food more often? But should you always choose the highest quality food every time? If everyone goes after one type of food there will not be enough to go round. Suppose there is a fixed amount of each type of food. If the number of foragers who go after the food is more than the amount of food available, then some of them will get none. Maybe itis better to go for the lower quality food because there will be fewer others going for that?

**Foraging in Groups**

Should you be a lone forager, or should you look for food in a group? Benefits of the group might be that a predator can only kill one member of the group (hopefully someone else), or that when there is a group, someone will spot an approaching predator earlier, so you are more likely to escape. Disadvantages of groups might be that you get less food from each food patch that you find and have to spend more time travelling to other food patches. When would group foragers do better than individuals? Maybe you need to spend less time watching for predators when there is a group because you can assume someone else is watching. That means more time for eating. How would the probability of watching for a predator versus eating evolve for animals that lived in a group?

**Food Sharing in Groups**

One kind of cooperation for social animals would be sharing of food caught with other members of the pack. Consider three kinds of behaviour

(i) a Loner that hunts alone and eats all the food it catches

(ii) a Cooperator that lives in a pack and shares any food it catches with everyone in the pack equally.

(iii) a Defector that lives in the pack, takes its share of food caught by others, but eats all the food that it catches by itself without sharing.

How successful would these strategies be evolutionarily?

**Competition between bacterial species**

Consider various types of cell that produce various kinds of toxin that are a harmful to other kinds of cells that do not have resistance genes. There is a cost of production of the toxin, so the producers grow more slowly, but they kill off competitors from other species. A non-producer would be a cheater that is resistant to the toxin but does not pay the cost of production.

When would a cheater invade a population of producers?

When would a resistant variant of the competitor population invade the susceptible ones?

**Plasmids**

Plasmids in bacteria are small circles of DNA that are separate from the main chromosomes. Plasmids can be transmitted horizontally, so they can spread even if they are disadvantageous to the hosts. There will be a metabolic cost to the host dependent on how many copies of the plasmid there are in the cell. If plasmids segregate randomly when a cell divides, there is a probability that a new host cell will be free of the plasmids. What are the conditions in which plasmids will be maintained in a population? Should a plasmid find a mechanism to regulate its number of copies so it does not overwhelm the cell? Should it find a mechanism of non-random segregation so it is less likely to be lost during cell division? How would things change if a plasmid encodes a gene that is beneficial to the host (for example an antibiotic resistance gene)? But then what would happen if this gene was transferred to the host chromosome, so that the plasmid is no longer necessary for resistance?

**Aggression**

Can you find a more realistic model of aggression than the simple hawks and doves model? Should there be degrees of fighting? Should your probability of fighting (and of winning) depend on other factors like how big you are or how hungry you are, or whether you are an owner or an intruder?

Does the degree of aggression depend on the frequency of encounters? What happens if there are more than two individuals competing for a resource?

Does it matter whether the resource is food, or whether it is a mating opportunity? Supposing there is a dominant male that gets to mate with all the females while the rest get nothing. How does this affect the expected degree of aggression?

**Sexual Selection**

When can exaggerated characteristics evolve (like peacocks' tails or enormous antlers) that are damaging to survival but give a higher probability of being selected for a mate? How choosy should a female be? How does choosiness coevolve with the selected trait? Why does it tend to be females who are choosy and males who have the exaggerated trait?

**Pecking orders**

In a social group there may be an established order in which those higher up get the best choice of food. How does such an order evolve? Should individuals be conformists, that accept their place in the order, or should they be disruptive and fight for the best share?

**Prisoners Dilemma**

Investigate the spatial and iterated versions of the prisoners' dilemma. There are lots of versions to consider? Is this a realistic model of cooperative behaviour? If not, what other features can be added?

**Stotting gazelles**

Several gazelle species jump about in an odd way called stotting when they are escaping from predators. This presumably makes them more visible, or slower, and makes them easier to catch than if they simply ran away without stotting. It is proposed that this is an honest signal of how fit and healthy they are. It tells the predator that they have so much energy that they can escape even if they stot. So it is a signal that the predator should go and chase someone else. Can you build a model that demonstrates how stotting behaviour could evolve? You will have to think about evolution of the predator response as well as the gazelle behaviour – i.e. should the predator stop chasing a gazelle who stots, or should it just chase everyone?