In nature, species do not live in isolation. Rather, they coexist and interact with a myriad of other species in their biological communities. These interspecific interactions can affect the species involved positively, negatively, or not much at all. This exercise explores competitive interactions, where both species a negatively affected by each other, and predator-prey interactions, where one species benefits and the other is harmed. The classic experiments of G.F. Gause are simulated.

Background

Competition is an interspecific interaction that occurs when two or more species are utilizing the same resources. These resources can be space, water, or energy, none of which are unlimited. Because the resources are limited, those used by one species *necessarily* reduce those available to other species. Without competition with other species, a population will typically grow in numbers until competition for resources within the population (intraspecific competition) leads to a balancing of births and deaths. This balance point is referred to as the 'carrying capacity' of that population, and is seen in the typical logistic population growth curve (Fig. 1).

There are several possible results of interspecific competition. One result is that both species can persist, but each with their stable population sizes depressed by competition with the other. This is most likely to occur when the resources being competed for is only a portion of the resources each species can utilize. However, if two species are competing for exactly the same resources, it is generally thought that one species will have a competitive 'edge' and drive the other to local extinction (Fig. 2). A possible long-term result of interspecific competition is niche partitioning, or character displacement. In this case the species evolve (morphologically or behaviorally) to exploit different resources, effectively easing the competition between them.

In the case of predator-prey relationships, one species *is* the resource for the other. It is easy to imagine that the relative success of each species is affected by the other. In the classic lynx (predator) and hare (prey) relationship, when there are a lot of hares around, the lynx population gets a lot to eat and consequently grows in number. With the increased lynx population, more of the hares get eaten and the hare population declines, which in turn leads to starvation and decline in the lynx. The resulting pattern observed for these species was multi-year population size cycles in each species, with the lynx cycles lagging behind the hare.

Figure 1: Intraspecific competition

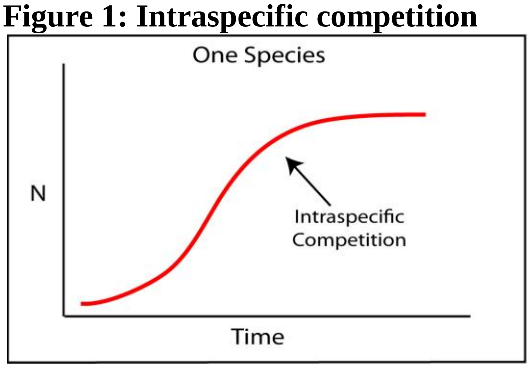
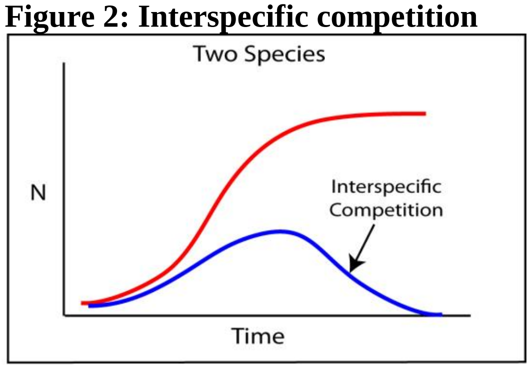


Figure 2: Interspecific competition



In 1934, G.F. Gause wrote a book called 'The Struggle for Existence' (translated from Russian), in which he empirically explored the interspecific interactions of competition and predator-prey. He conducted experiments on a small scale (called microcosms), with various unicellular organisms in dishes. Some of his most famous experiments involved the ciliated protists *Paramecium* and *Didinium*. This exercise will simulate experiments based on Gause's early work. In our virtual microcosm there will be bacteria which are food for two species of *Paramecia*. One *Paramecium* species is *P. Aurelia* (Fig. 3), which is smaller, and reproduces faster than the other species *P. Bursaria* (Fig. 4). *Paramecium bursaria* has an endosymbiotic relationship with green algae (called zoochlorellae) which photosynthesize and provide the host *Paramecium* with food. The predator in this microcosm is also a ciliated protest, *Didinium*. *Didinium* feed on *Paramecia* (which are usually larger than themselves), by 'harpooning' them with a toxicyst, and slowly ingesting them over time (Fig. 5).

Figure 3: *P. aurelia*

Photo: Barfooz

Figure 4: *P. bursaria*

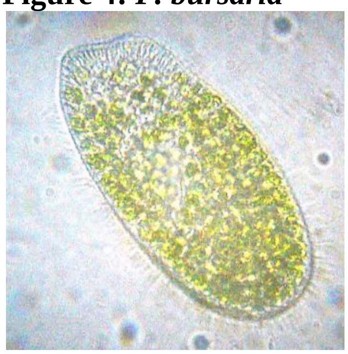
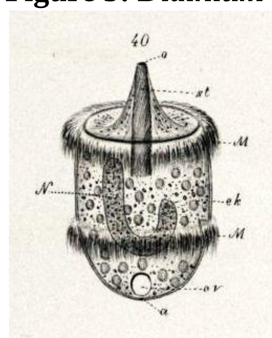


Photo: Bob Blaylock

Figure 5: *Didinium*



Using the Model

With a java-enabled web browser go to:

http://virtualbiologylab.org

Under the Community Ecology menu, click the 'Microcosm' model.

The model opens to a virtual petri dish, which is initially filled with sterile nutrient broth. When 'Go' is clicked on, you can add a specified amount of each microbe, and watch them move about the dish (Fig. 6). Bacteria in the model gain nutrient from the broth, and the population grows to a carrying capacity related to the volume of the dish. *Paramecia* gain energy by feeding on bacteria, and will reproduce by dividing when they have enough energy. *Didinium* gain energy to reproduce by eating *Paramecium*, with one meal being enough to divide. Both *Paramecium* and *Didinium* use energy as they move about the dish, and will die if their energy reserves hit zero. The volume and light level of the microcosm can be adjusted in the simulation (Table 1). Take some time to familiarize yourself with the model before beginning the exercise.

Figure 6: Screen shot of the 'Microcosm' simulation

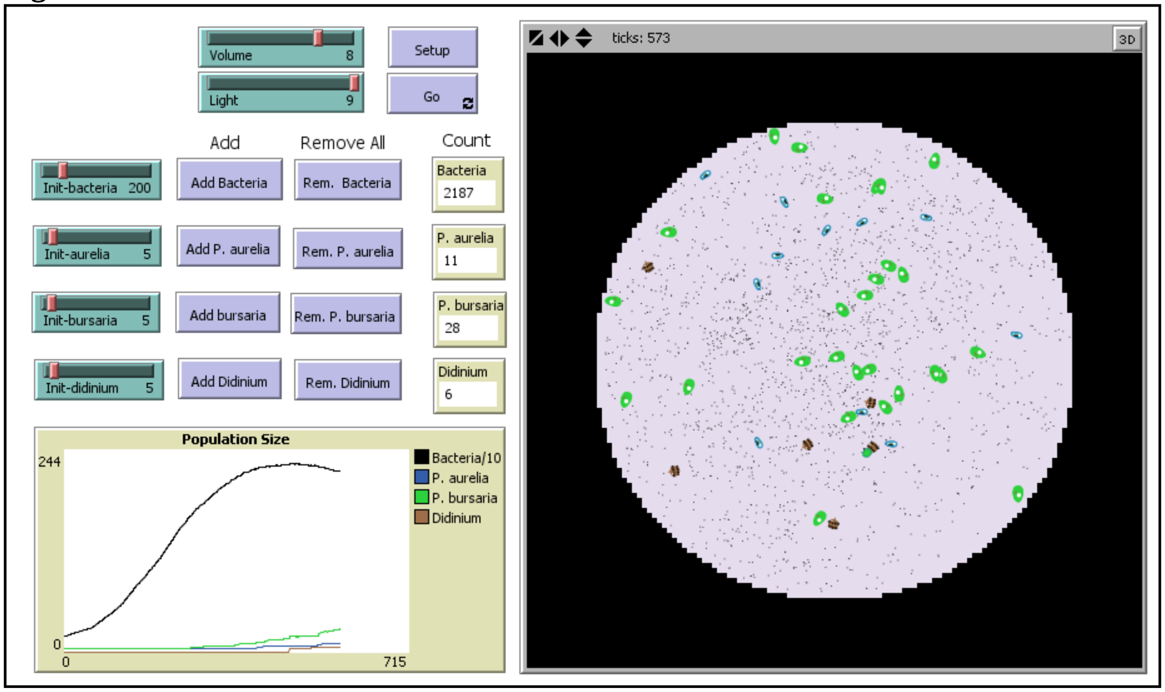


Table 1: Controls and reporters for the 'Microcosm' simulation

Control	**Effect**
Setup	Resets the model to the parameters shown
Go	Sets the model in motion, individuals breeding and dying
Volume	The diameter of the virtual petri dish (2-10)
Light	The light level of the microcosm (2-9)
Init-'x'	The number of the specified microbe to be added
Add 'x'	Adds the specified number of the specified microbe
Rem. 'x'	Removes all of the specified microbe
Reporter	**Description**
Count 'x'	The number of the specified microbe in the microcosm
Population Size (graph)	The population sizes of each microbe over time

References

Gause, G.F. 1934. *The Struggle For Existence.* The zoological Institute of the University of Moscow.