

9.4. Physiology

tween fast, incoherent clapping and slower, synchronized clapping may occur. Apparently, an audience has a desire for both synchronization and high noise intensity. However, synchronization can only occur with a low clapping frequency, corresponding to a low noise intensity. When members of the audience increase their clapping frequency to increase the noise intensity, synchronization is lost.

Develop a model that reproduces the phenomenon of self-organization by clapping audiences.

Experimental findings on the clapping phenomenon can be found in Neda et al. [124]. For some modeling ideas, the work by Strogatz on the synchronization of male fireflies may be helpful (see [152] for an introduction).

Project 23: Tumor Growth and Radiotherapy

The development of cancer is a multistage process involving multiple genetic events. Damage to DNA can cause mutations. Some mutations alter the function of tumor suppressor genes, such as P53, which controls cell growth. Such mutated cells grow faster than normal cells.

Develop a model that describes cancer growth in an environment with limited resources (such as oxygen). Start with one cell which has undergone a mutation for faster growth (initiated cell). The initiated cell grows and proliferates. In successive generations, more and more mutations occur and some cells become more and more aggressive. The aggressive cells grow faster, but they need more resources. Assume that all cells, cancerous and healthy, compete for the same resources.

Model the different mutation stages. Does your model show that the tumor grows unlimited, or will the growth come to a halt due to limited resources?

If time allows, add *radiotherapy* to your model (see Figure 9.8). Assume that an ionizing beam is used periodically, which (i) kills cells and (ii) enhances mutations. Unfortunately, radiation also affects normal cells. What happens? Can you design a good treatment plan? According to your model, how often would you radiate and in which time periods to optimize treatment and to minimize side effects on normal tissue? For further reading on cancer in general, we recommend the "World Cancer Report" by Stewart and Kleihues [150].

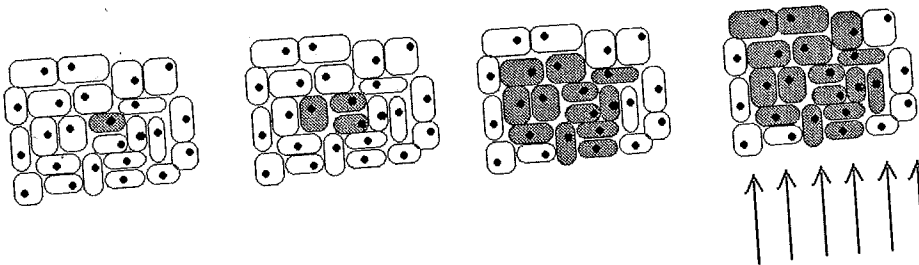


Figure 9.8. Schematic of tumor progression and radiation treatment.