Exercise 2: Conway's Game of Life

Conway's Game of Life is an example of a type of computational model called a ***cellular automaton***. We will be discussing cellular automata in more detail next week, but put simply, they are simulated systems that consist of a grid of cells, each of which can be in one of a set of finite states. The state of a cell depends on the state of neighboring cells and a simple set of rules explains how the state of each impacts the others. The Game of Life was developed by the mathematician John Horton Conway (best known for the construction of "Surreal Numbers") and became a national phenomenon after being publicized in Martin Gardner's "Mathematical Games" column in *Scientific American* (1970).

In Conway's Game of Life, the cell grid represents an infinite universe. Each cell can exist in one of two states ***live*** (colored) or ***dead*** (uncolored). Every cell interacts with its eight adjacent neighbors, according to the followings ***rules of interaction***:

1. Any live cell dies if it has fewer than two live neighbors (isolation).
2. Any live cell dies if it has more than three live neighbors (overcrowding).
3. Any live cell survives if it has two or three live neighbors.
4. Any dead cell with exactly three live neighbors comes to life (birth).

We will talk more next week about the details of implementing this sort of model.

As you explore Conway's Game of Life for this week's programming exercise, I would like you to think about how this simulated system relates to our discussion topic for the week: i.e., *how did life originate, or how did the transition from non-living to living occur?*

First, some background material:

1. Read the original Martin Gardner essay that triggered the Game of Life phenomenon (a reconstructed PDF is on the Course website).
2. Read a short excerpt from the first chapter (pgs. 10 – 15) of Sigmund, K. 1993. Games of Life: explorations in Ecology, Evolution, and Behavior, Penguin Books: England. A photocopy of the whole chapter is provided for those who are interested in reading further.
3. For more detail I also recommend the Wikipedia entry on "Conway's Game of Life."

Second, explore:

4. Download and install a great stand-alone version of the Game of Life from http://www.bitstorm.org/gameoflife/standalone/. There are versions for any platform.

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5. Play with the model. Try the basic configurations from the Martin Gardner essay, or Sigmund excerpt, use the built-in configurations, and come up with some of your own. In your opinion, what initial configurations produced the most surprising behavior? Why were they surprising? Are such behaviors emergent? Why or why not? Were there any behaviors that you felt were fully predictable given the initial conditions? Does this system have any deterministic qualities? Explain (you can supplement with screen snapshots, if you so choose).

Third, some thought questions:

6. Consider and write a short answer for each of the following:
    a. What is life? What conditions must be met for an entity (or thing) to be considered "living"?
    b. Why do you think this model is called a "Game of Life"?
    c. What sort of insight do you think this system gives into the problem of the origin of life from non-living elements?
    d. Thinking about your answers to number 4, do you think it is possible for a system to have both deterministic and emergent behavior? If so, what conditions do you think need to be met for emergence to arise out of determinism?