

## Lab exploration 5: Self-organizing systems I: Computation

Math 309 Fall 2019

Deadline: class 2 November

- Conduct experiments as indicated.
- **Journal entry.** Respond to each of the “journal queries.” Using *concise and clear sentences*, incorporate data, symbols, and illustrations into your text. Have an audience in mind. Focus on *developing* an explanation or argument that stems from your simulations.

Submit 300-400 words 2-3 pages double-spaced in **hard copy**.

- **Recommended.** Work in groups of 2 or 3. Submit one journal entry for the group.
- **Suggestion.** Before running the simulations, read the “What is it?” and “How it works” sections under the [Info](#) tab.

**Model: CA 1D Elementary.** (Location: [Models Library/Sample Models/Computer Science/Cellular Automata](#).) In this model of a one-dimensional cellular automaton (CA), you can prescribe any of the 256 CA rules by setting the eight switches (indicated by the 3-digit binary strings). A diagrammatic representation of a rule can be displayed by selecting [show rules](#).

### 5.1 Journal query.

If you turn all switches on, what happens when you select [setup single](#) and then [go](#)? Now, run each of the eight CAs that you get when exactly one switch is off. Briefly describe the configurations that result and, for two of them, explain how the respective rules produce the result.

**Model: Life Turtle-Based.** (Location: [Models Library/Sample Models/Computer Science/Cellular Automata](#).) Conway’s game of life is a two-dimensional cellular automaton. A “live” cell remains alive after a time-step if two or three of its eight neighbors are alive and “dies” otherwise. A “dead” cell comes to life after a time-step if three of its neighboring cells are alive and, otherwise, remains dead.

You can arrange for a specific starting configuration by selecting [setup-blank](#) and [draw-cells](#) and then turning cells live with a mouse click. By selecting [go-once](#), Life will develop the initial state one step at a time. Notice that a live cell that will remain alive after a time-step is white and one that will die is gray. A dead cell that will live after a time-step is indicated by small green dots.

### 5.2 Journal query.

What’s the minimum number of live cells required for there to be live cells after a time step? Explain how you determined your answer.

### 5.3 Journal query.

Describe all possible 3-cell configurations that produce living cells for one time step. (Applying a systematic rule for generating such configurations should help.) What happens to each configuration under multiple time steps? Does it lead to extinction or some persistent behavior? In particular, take note of structures that don’t change.

#### 5.4 Journal query.

Explore 4-cell configurations and identify at least three such configurations that don't go extinct for all time. Do any stable configurations—either fixed or periodic—emerge out of the interactions?

#### 5.5 Journal query.

An interesting phenomenon is the “glider.” Take the following 5-cell configuration (x indicates a live cell):

		x		
			x	
	x	x	x	

First, let Life run repeatedly to see why this arrangement is called a glider. Next, run Life one step at a time until a new glider structure forms. How many time-steps does it take for this to occur? In what direction does it move? What are all the possible gliders and in what directions do they move?

#### 5.6 Journal query.

Create two gliders that collide; what does the debris look like? You could try collisions of different types—such as head-on and broadside.

#### 5.7 Journal query.

Now, let's investigate the role of the density of live cells. If the density is very low or very high, what happens when Life runs? By adjusting **initial-density**, look for a **lower threshold** and an **upper threshold** where cells remain alive reliably (for different initial configurations) for 100 time steps.

#### 5.8 Journal query.

Run Life for several different initial densities (not close in value and between the thresholds you found previously). After, say 100 time steps, does the **current density** value reach a state of making small oscillations? Give an approximate value  $D$  that the density hovers around. Now, set **initial-density**= $D$  and run Life. Compare the behavior that results with that which emerged when you ran Life on other initial density configurations.