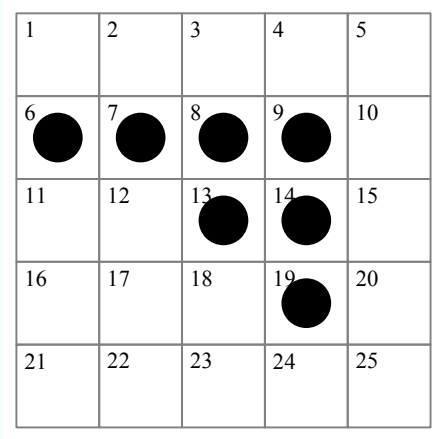
Extra!

The grids at the top of each chapter in this book together form an example of John Conway's **Game of Life**. The Game of Life is played on a grid of squares. Each square **cell** is either alive or dead. We'll place a black circle in each live cell, and leave each dead cell blank. Each cell has 8 neighboring cells; these are the cells vertically, horizontally, or diagonally adjacent to it.

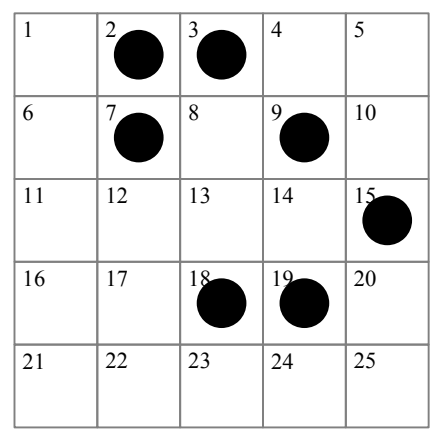
On each turn, the following occurs:

1. If a cell is alive but has fewer than 2 live neighbors, it dies of loneliness.
2. If a cell is alive but has more than 3 live neighbors, it dies of overcrowding.
3. If a cell is alive and has exactly 2 or 3 live neighbors, it stays alive.
4. If a cell is dead but has exactly 3 live neighbors, it springs to life.

For a simple example of one turn in the game of life, consider the two grids below.



Grid A



Grid B

Grid B shows what happens after we take one step when starting with Grid A. Let's take a closer look to see how Grid B is formed. First, we'll look at what happens to each of the live cells in Grid A. Cell 6 has only one neighbor, so it dies of loneliness. Therefore, Cell 6 of Grid B is empty. Cells 8, 13, and 14 in Grid A are all overcrowded, so they die too, leaving these cells empty in Grid B. Cells 7 and 9 each have three live neighbors in Grid A and Cell 19 has two live neighbors, so these cells stay alive in Grid B.

Next, let's look for dead cells in Grid A that spring to life in Grid B. Dead Cells 2, 3, 15, and 18 in Grid A each have three live neighbors, so they spring to life in Grid B.

Combining all these observations gives us our completed Grid B, and we're ready to take the next step. Although our board is only 5×5, typically the Game of Life is played on an infinite board. Despite such simple rules, there are patterns that grow forever.

Conway's Game of Life has been thoroughly studied by mathematicians and computer scientists because the very simple rules of the game lead to very complex and interesting results... just like mathematics in general! For more about the Game of Life, including applets that will allow you to experiment with patterns of your own, visit `http://www.bitstorm.org/gameoflife/` and `http://www.ibiblio.org/lifepatterns/`. Better yet, if you know how, program a computer yourself to play Conway's Game of Life.