Review

- Recursion
- Call Stack

Two-dimensional Arrays

- Visualized as a grid
- int[][] grays = {{0, 20, 40},
  {60, 80, 100},
  {120, 140, 160},
  {180, 200, 220}};
- int[][] grays= new int[4][3];

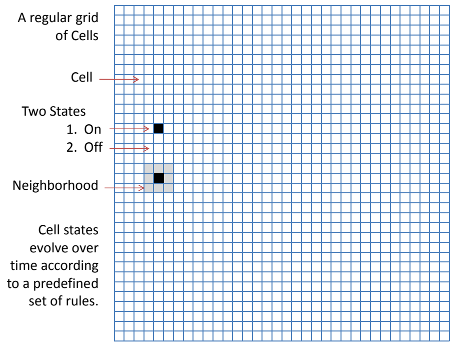
Processing 2D Arrays

- Need two indices, one for the rows and one for the columns.
- int[][] grays = {{0, 20, 40},
  {60, 80, 100},
  {120, 140, 160},
  {180, 200, 220}};
- grays[2][1] = 255;
- grays[2][3] = 0;

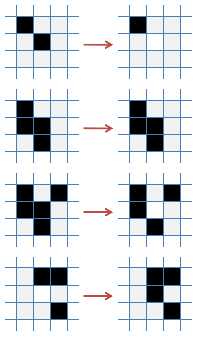
Lengths of 2D Arrays

- int[][] grays = new int[80][100];
- println(grays.length);
- println(grays[0].length);

Cellular Automata


A regular grid of Cells
Cell
Two States
1. On
2. Off
Neighborhood
Cell states evolve over time according to a predefined set of rules.

Sample Set of Rules – Conway's Game of Life

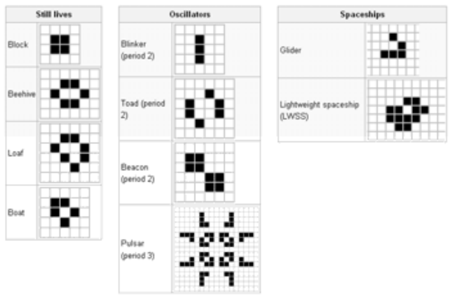


1. Any live cell with fewer than two live neighbors dies, as if caused by under-population.
2. Any live cell with two or three live neighbors lives on to the next generation.
3. Any live cell with more than three live neighbors dies, as if by overcrowding.
4. Any dead cell with exactly three live neighbors becomes a live cell, as if by reproduction.

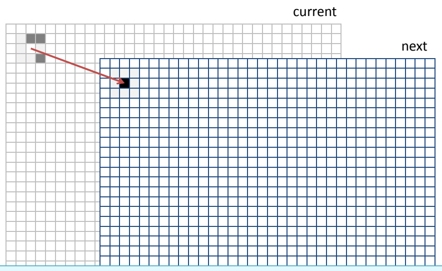
An example of "Emergence"

http://en.wikipedia.org/wiki/Conway%27s_game_of_life

Interesting Patterns – Conway's Game of Life



http://en.wikipedia.org/wiki/Conway%27s_game_of_life



Top-level procedure

1. Draw the current grid
2. Advance game by applying rules to all cells of current and filling next
3. Swap current and next grid

```
int N = 5;
boolean[] cell = new boolean[N];
```

	cell
0	false
1	false
2	false
3	false
4	false

← One-dimensional array

```
int N = 5;
boolean[][] cell = new boolean[N][N];
```

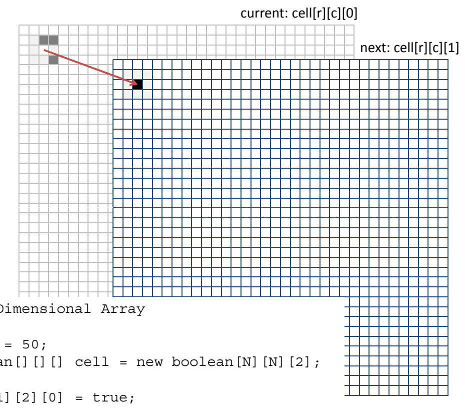
cell	0	1	2	3	4
0	false	false	false	false	false
1	false	false	false	false	false
2	false	false	false	false	false
3	false	false	false	false	false
4	false	false	false	false	false

← Two-dimensional array

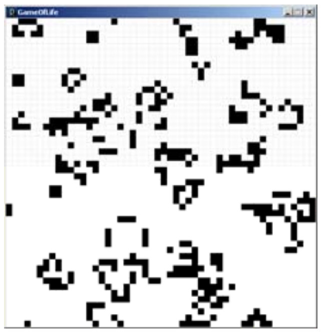
… an array of arrays

```
int N = 5;
boolean[][] cell = new boolean[N][N];

cell[1][2] = true;
```

cell	0	1	2	3	4
0	false	false	false	false	false
1	false	false	true	false	false
2	false	false	false	false	false
3	false	false	false	false	false
4	false	false	false	false	false



```
// 3-Dimensional Array

int N = 50;
boolean[][][] cell = new boolean[N][N][2];

cell[1][2][0] = true;
```



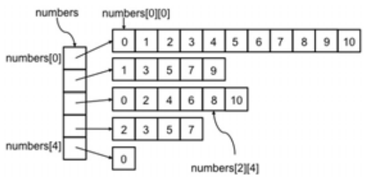
Add the necessary lines of code within `setup()` to fill the `vals` array with random numbers of your choosing. Your implementation must use `for` loops.

```
float[][] vals;

void setup() {
    vals = new float[20][300];

    // Add your code here






} // Closing brace for setup()
```

```
float[][] vals;

void setup() {

  vals = new float[20][300];

  for (int i=0; i<20; i++) {

    println( vals[i].length );   // What is going on here?

  }
}
```

Ragged Arrays

```
int[][] numbers = {
{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10},
{1, 3, 5, 7, 9},
{0, 2, 4, 6, 8, 10},
{2, 3, 5, 7},
{0},
};
```



```
float[][] grays = new float[100][100];
int cellSize = 5;

void setup() {
  size(500, 500);

  for (int i=0; i<grays.length; i++) {
    for (int j=0; j<grays[i].length; j++) {
      grays[i][j] = int(random(255));
    }
  }

  for (int i=0; i<grays.length; i++) {
    for (int j=0; j<grays[i].length; j++) {
      fill(grays[i][j]);
      pushMatrix();
      translate(j*cellSize, i*cellSize);
      rect(0, 0, cellSize, cellSize);
      popMatrix();
    }
  }
}
```

Fill a 2D array with data and draw it to the sketch as grayscale levels.

Challenge

- Modify the previous example to plot black squares whenever both the row and column of a cell are even.