"Computer Science is a science of abstraction-creating the right model for a problem and devising the appropriate mechanizable techniques to solve it."

-Alfred Aho and Jeffery Ullman

Arrays with multiple dimensions may be declared and used
int[][] mat = new int[3][4];

the number of pairs of square brackets indicates the dimension of the array.

by convention, in a 2D array the first number indicates the row and the second the column

Two Dimensional Arrays

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>column</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

This is our abstract picture of the 2D array and treating it this way is acceptable.

(actual implementation is different)
mat[2][1] = 12;

What is What?

int[][] mat = new int[10][12];

// mat is a reference to the whole 2d array
// mat[0] or mat[r] are references to a single row
// mat[0][1] or mat[r][c] are references to // single elements
// no way to refer to a single column
// mat.length is the number of rows
// mat[0].length is the number of columns
// in row 0.
2D Array Problems

- Write a method to find the max value in a 2d array of ints
- Write a method that finds the sum of values in each column of a 2d array of doubles
- Write a method to print out the elements of a 2d array of ints in row order.
  - row 0, then row 1, then row 2 ...
- Write a method to print out the elements of a 2d array of ints in column order
  - column 0, then column 1, then column 2 ...

Clicker 1

- What is output by the following code?

```java
String[][] strTable = new String[5][8];
System.out.print(strTable.length + " ");
System.out.print(strTable[0].length + " ");
System.out.print(strTable[2][3].length());
```

A. 40 0 0
B. 8 5 0
C. 5 8 0
D. 5 8 then a runtime error occurs
E. No output due to a syntax error.

Use of Two Dimensional Arrays

- 2D arrays are often used when I need a table of data or want to represent things that have 2 dimensions.
- For instance an area of a simulation

Example of using a 2D array

- Conway's Game of Life
  - a cellular automaton designed by John Conway, a mathematician
  - not really a game
  - a simulation
  - takes place on a 2d grid
  - each element of the grid is occupied or empty
Simulation

- Select pattern from menu
- Select region in large area with mouse by pressing the control key and left click at the same time
- Select the paste button

Generation 0

```
0 1 2 3 4 5
0 . * . * . *
1 * . * * * *
2 . . * * . *
3 . * * * . *
```

* indicates occupied, . indicates empty

Generation 1

```
0 1 2 3 4 5
0 . * . * . *
1 . . . . . *
2 . . . . . *
3 . * . * . *
```

* indicates occupied, . indicates empty
Or, Generation 1

0 1 2 3 4 5

0 1 2 3 4 5

1 1 1 1 1 1

2 2 2 2 2 2

3 3 3 3 3 3

Rules of the Game

- If a cell is occupied in this generation.
  - it survives if it has 2 or 3 neighbors in this generation
  - it dies if it has 0 or 1 neighbors in this generation
  - it dies if it has 4 or more neighbors in this generation
- If a cell is unoccupied in this generation.
  - there is a birth if it has exactly 3 neighboring cells that are occupied in this generation
- Neighboring cells are up, down, left, right, and diagonal. In general a cell has 8 neighboring cells

Clicker 2

- Implement a program to run the simulation
- What data type do you want to use for the elements of the 2d array?
  A. String
  B. char
  C. int
  D. boolean
  E. double

Clicker 3

- Do you want to use a buffer zone on the edges?
  A. No
  B. Yes