### Two Dimensional Arrays

"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

Based on slides for Building Java Programs by Reges/Stepp, found at http://faculty.washington.edu/stepp/book/

#### 2D Arrays in Java

- Arrays with multiple dimensions may be declared and used
  
  ```java
  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

#### What is What?

```java
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
```

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<table>
<thead>
<tr>
<th>row</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>column</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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</tbody>
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This is our abstract picture of the 2D array and treating it this way is acceptable.

(actual implementation is different)

```java
mat[2][1] = 12;
```
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 ...

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

clicker question

- 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.

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

- www.ibiblio.org/lifepatterns/

* indicates occupied, . indicates empty

**Generation 0**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</table>

**Generation 1**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
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<th>4</th>
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</tbody>
</table>

* indicates occupied, . indicates empty
Or, Generation 1

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<table>
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</tbody>
</table>

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 Question

- 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 Question

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