Recall Arrays

- Arrays: sequences of elements from the same base type
  
  ```java
  int[] a;  // array of ints
  Date[] d; // array of references to Dates
  ```

- Base type may be:
  - Primitive (i.e. `int`)
  - Reference (i.e. `Date`, other objects)

- Arrays are also objects.

- Notice the similarities:
  - Arrays created using `new`
  - Array elements stored on heap
  - Array variables store references to space on the heap
Allocation of Space

- Syntax for allocating space for the 1st level array:
  ```
  char[][] a;       // Array of char arrays
  a = new char[3][];   // Create array of 3 arrays
  ```

- Syntax for allocating space for the 2nd level of arrays:
  ```
  a[0] = new char[4];   // Create array of 4 char
  a[1] = new char[6];   // Create array of 6 char
  a[2] = new char[3];   // Create array of 3 char
  ```

Example

```java
char[][] a;
a = new char[3][];
a[0] = new char[4];
a[1] = new char[6];
a[2] = new char[3];
a[1][3] = 'a';
```

- This array has **two dimensions**: rows, columns
- This kind of array is called **ragged** because the rows are of unequal length
Questions

```
char[][] a;
a = new char[3][];
a[0] = new char[4];
a[1] = new char[6];
a[2] = new char[3];
```

- What does `a[1][2] = 'x';` do?
  
  Set element in row 2, column 3 to `'x'`

- What does `a.length` return?
  
  3

- What does `a[1].length` return?
  
  6

What type is `a`?

- a reference to an array of array references

What Type is `a[0]`?

- a reference to an array of characters

What type is `a[0][0]`?

- a character

Initializers

- In one dimension:

```
char[][] a;
a = new char[3][];
a[0] = {'a','b','c','d'};
a[1] = {'x','y','z'};
a[2] = {'m','n'};
```

- In two dimensions:

```
char[][] a = {{'a','b','c','d'},
             {'x','y','z'},
             {'m','n'}};
```
Rectangular Arrays

- Often we want 2-dimensional arrays in which rows have the same length
  - Tables
  - Matrices
- Java has a special short-hand syntax for creating rectangular arrays
  ```java
  int[][] a = new int[2][4];   // 2 rows, 4 cols
  ```
  Equivalent to:
  ```java
  int[][] a = new int[2][];
  a[0] = new int[4];
  a[1] = new int[4];
  ```
- The short-hand takes care of allocating each row, initializing each cell in each row

Example

```java
int[][] a = new int[2][4];
```

- Note each cell is initialized to default value (0)
- Each row is a 1-dim array
2-D Arrays of Objects

- The array name when indexed with two indexes is of that indicated type
- Of Strings:
  ```java
  String[][] s = new String[4][2];
  s[0][0] = "Fred";
  s[1][1] = "Jane";
  ```
- Of Cats:
  ```java
  Cat[][] c = new Cat[4][2];
  c[0][0] = new Cat("Fred");
  c[1][1] = new Cat("Jane");
  ```