Arrays of Primitive Values

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Arrays

- Arrays are objects that hold multiple values of the **same type**.
- Each data value stored in an array is called an ***element***.
- Each element is accessed using an integer ***index*** or ***subscript***.
  - As with strings, the first subscript is 0.
- Organizing data in an array allows programs to access huge amount of data multiple times and in any order!

Array Objects

- Arrays are like objects and need to be created with the `new` operator:

$$\underbrace{\texttt{int[]}}_{\text{type}}\ \texttt{counts = }\underbrace{\texttt{new int[}\overset{\text{number of elements}}{\texttt{6}}\texttt{];}}_{\text{creates the array}}$$

- You can use any type: E.g.,

```
double[] lowTemp = new double[365];
boolean[] isOn = new boolean[20];
```

must match

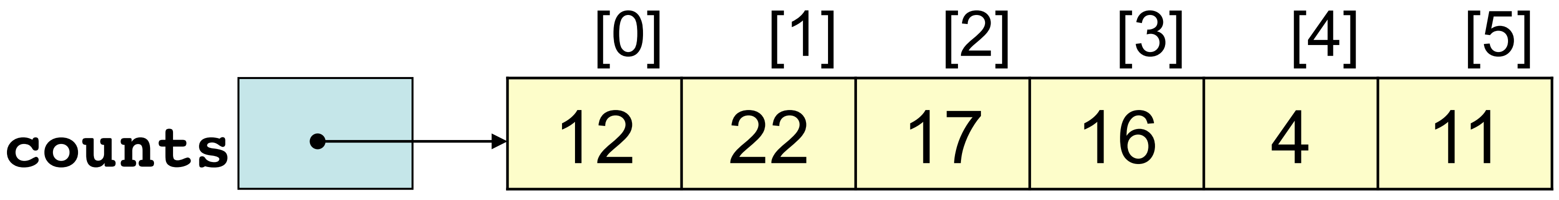
Creating an Array

no length

```
int[] counts = new int[2*3];
counts[0] = 12;
counts[1] = 22;
counts[2] = 17;
counts[3] = 16;
counts[4] = 4;
counts[5] = 11;
```

length can be an `int` expression

bacteria colony count on 6 Petri dishes



reference to the array

Array Traversal

Constant: number of elements in the array

```
int sum = 0;
for (int i = 0; i < counts.length; i++) {
    sum = sum + counts[i];
}

if (counts.length > 0){
     System.out.print(“The average number of “ +
                          “bacteria colonies is “);

    System.out.println(___________________________);
}
```

Not a method: There is no () !!

Array Basics

- Anywhere you can use a variable you can use an array element of the same type.

  E.g., Suppose **`y`** is of type **`int`** and **`x`** is of type **`int []`**:

```
y = x[0] + x[1];
x[2] = x[0] / x[1];
x[1] += 2;
```

- Java treats **`x[1]`** as type **`int`** and it can be manipulated the same way as **`y`**.

Array Index

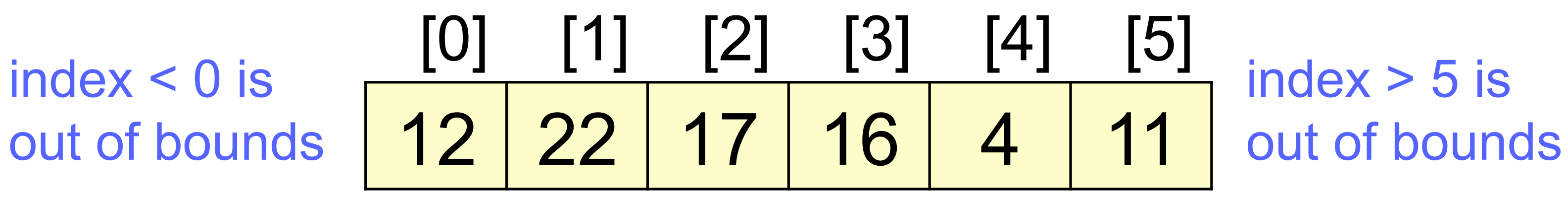
- The index of an array must be a literal, variable, or expression of type **`int`**.

E.g.,

`x[0] = 3;`	assign the first element 3;
`x[num] = num;`	use an `int` variable as index
`x[j-3] = x[j];`	use an `int` expression as index
`x[x[0]] = max;`	use an `int` array element as index

Bounds Checking

- *Out-of-bounds* errors occur when you attempt to access an array element that does not exist.



- If you write `x[index]` the compiler cannot determine if `index` is out of bounds.
- When your run the program, however, Java checks whether the index is out of bounds.

Bounds Checking

```
int sum = 0
for (int i = 0; i <= counts.length; i++) {
    sum += counts[i];
}
```

When `i` equals `counts.length` and the program attempt to access `counts [i]`, Java raises an **`ArrayIndexOutOfBoundsException`**

- You need either to make sure the index stays within the bounds or to check that it is so before using it.

Initializer List

- You can declare, create, and initialize an array with a **list of literals.**

```
int[] counts = {12, 22, 17, 16, 4, 11};
```

- You can use an initializer list only when the array is first declared.
- Each value must match the type of the array.
- The values go into the array in the order given and determine the length of the array.

Example

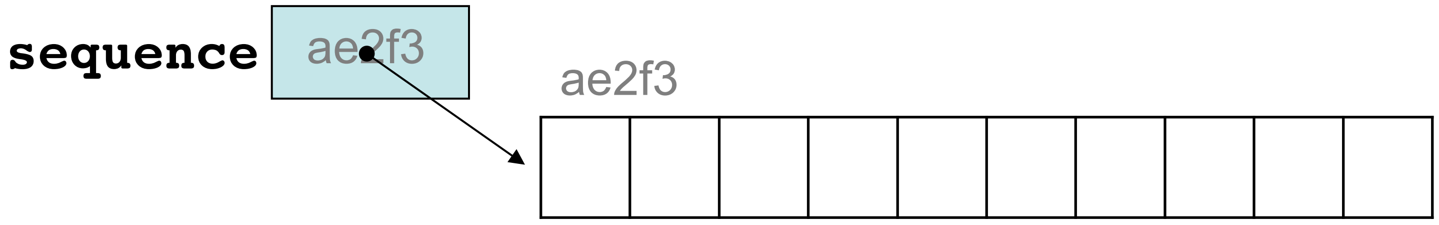
Find the minimum value stored in an array:

```
int min = counts[0]  ;
for (int i =  1  i < counts.length; i++) {
   if  (counts[i] < min)  {
      min = counts[i];
   }
}
```

- What happens if there are two or more values in the array that are the minimum?
- How do we modify the code to return the index of the minimum bacteria count?

Arrays as Parameters

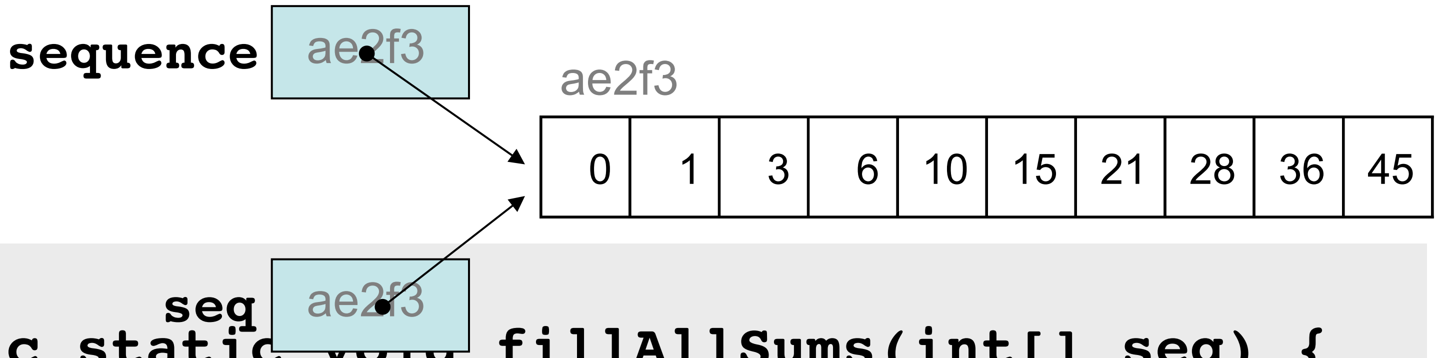
```
   int[] sequence = new int[10];
   fillAllSums(sequence);
   …
}
```



```
public static void fillAllSums(int[] seq) {
   seq[0] = 0;
   for (int i = 1; i < seq.length; i++) {
       seq[i] = seq[i-1] + i;
   }
}
```

Arrays as Parameters

```
   int[] sequence = new int[10];
   fillAllSums(sequence);
   …
}
```



```
public static void fillAllSums(int[] seq) {
   seq[0] = 0;
   for (int i = 1; i < seq.length; i++) {
         seq[i] = seq[i-1] + i;
   }
}
```

Arrays as Parameters

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fillAllSums(sequence);
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}
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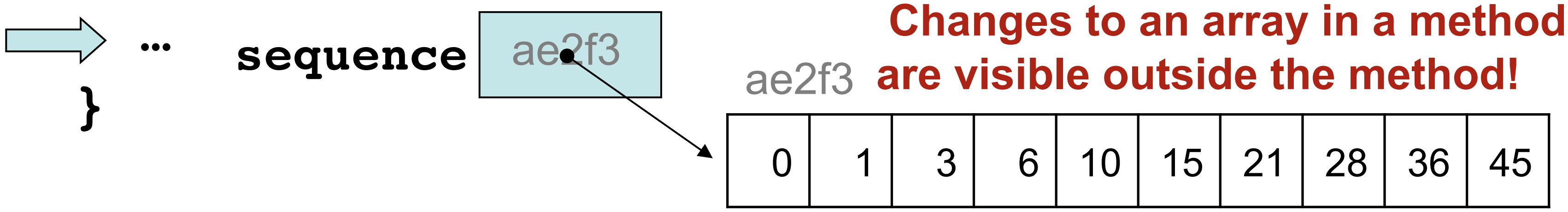

Changes to an array in a method are visible outside the method!

```
public static void fillAllSums(int[] seq) {
  seq[0] = 0;
  for (int i = 1; i < seq.length; i++) {
       seq[i] = seq[i-1] + i;
  }
}
```

Returning an Array

```
  int[] sequence = getAllSums( 8 );
  …
}
public static int[] getAllSums(int n) {
  int[] seq = new int[n];
  seq[0] = 0;
  for (int i = 1; i < n; i++) {
       seq[i] = seq[i-1] + i;
  }
  return seq;
}
```

The `null` reference

- An array variable holds the special value **`null`** if no array is created (distinct from an array with 0 elements.)

```
int array[] counts;      counts | null |
```

```
public static int[] copy(int[] data){
    if (data == null) return null;
    int[] data2 = new int[data.length];
    for (int i = 0; i < data.length; i++){
        data2[i] = data[i];
    }
    return data2;
}
```

Causes nullPointerException if data is `null`