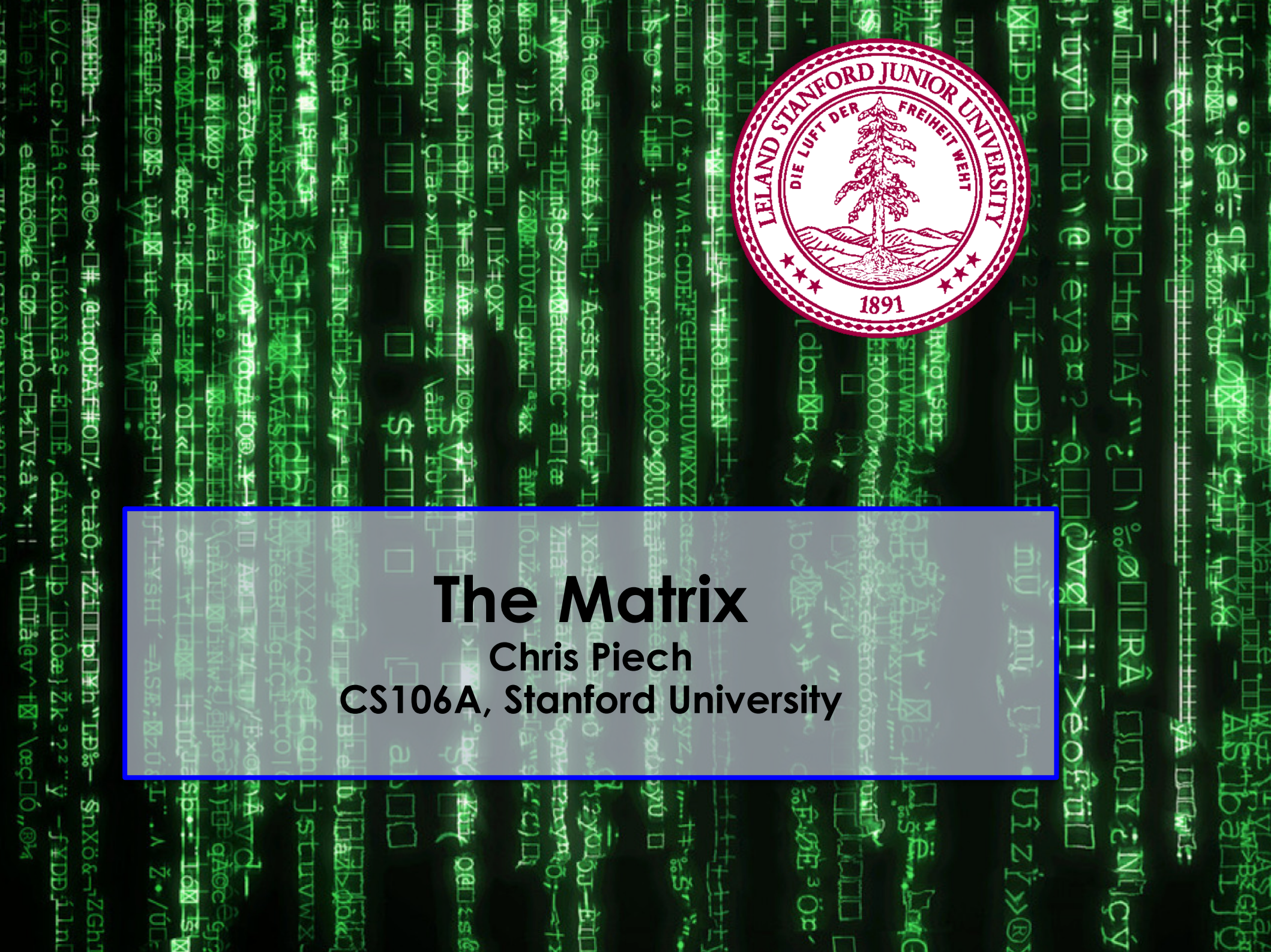
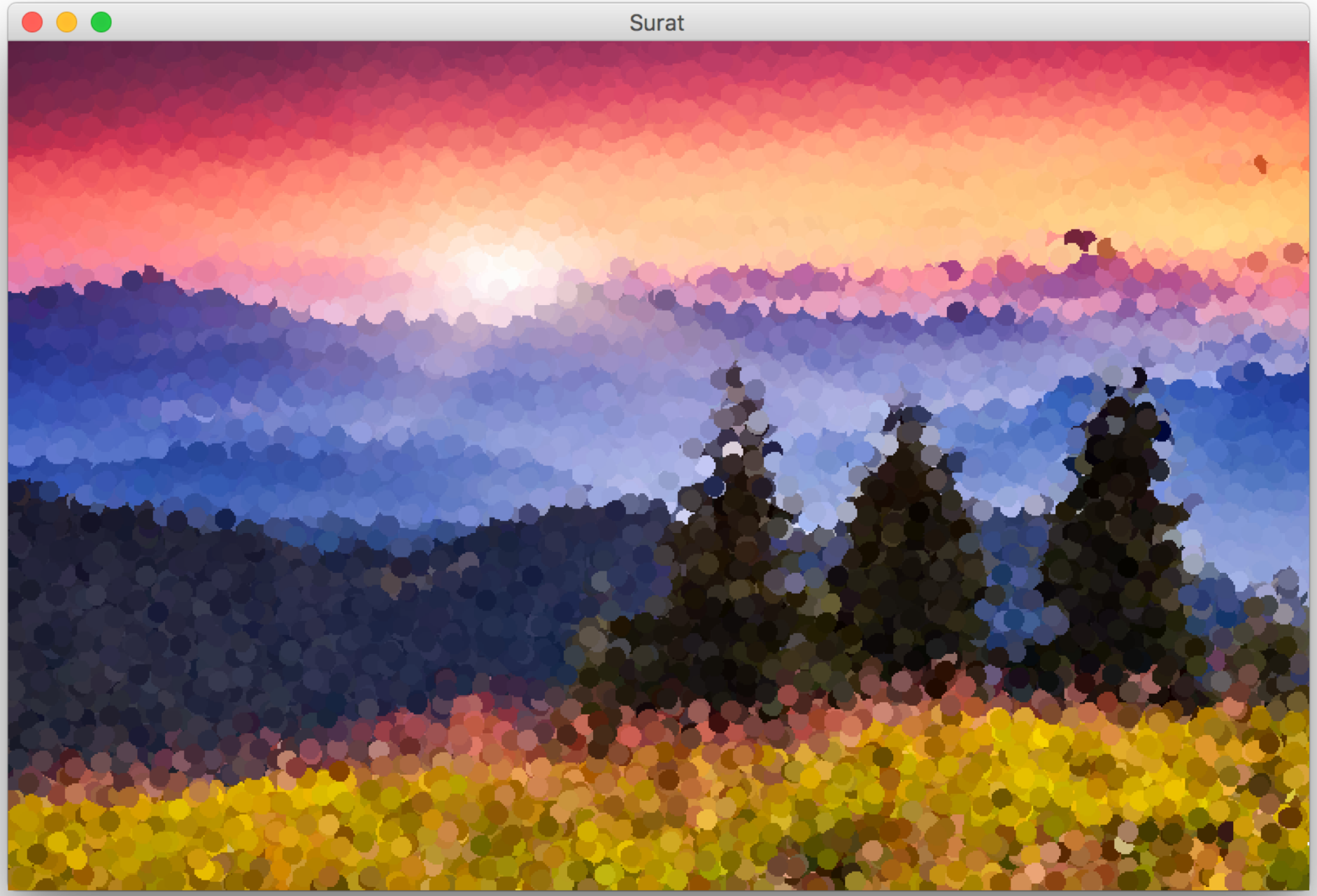


The Matrix

Chris Piech
CS106A, Stanford University


Surat

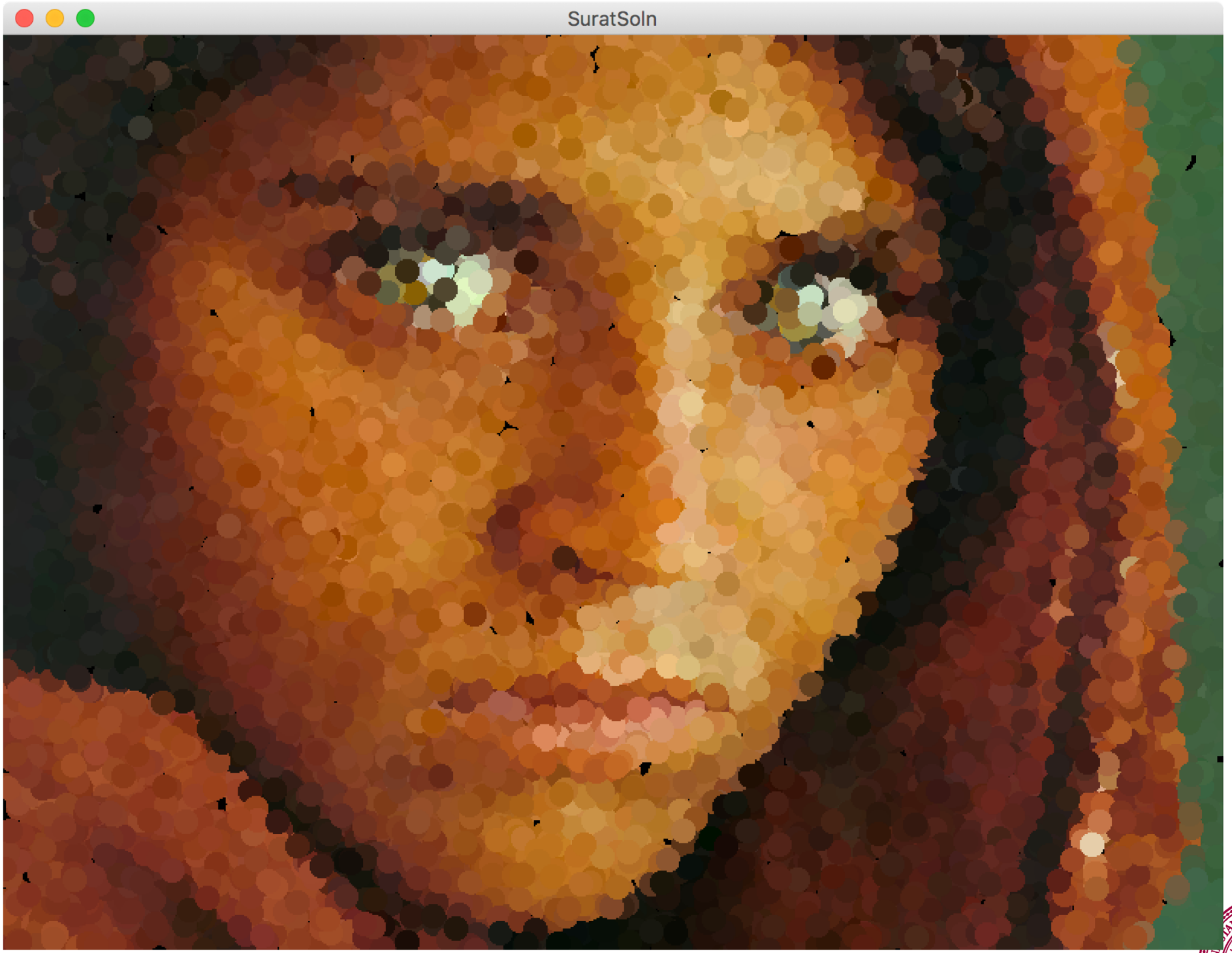
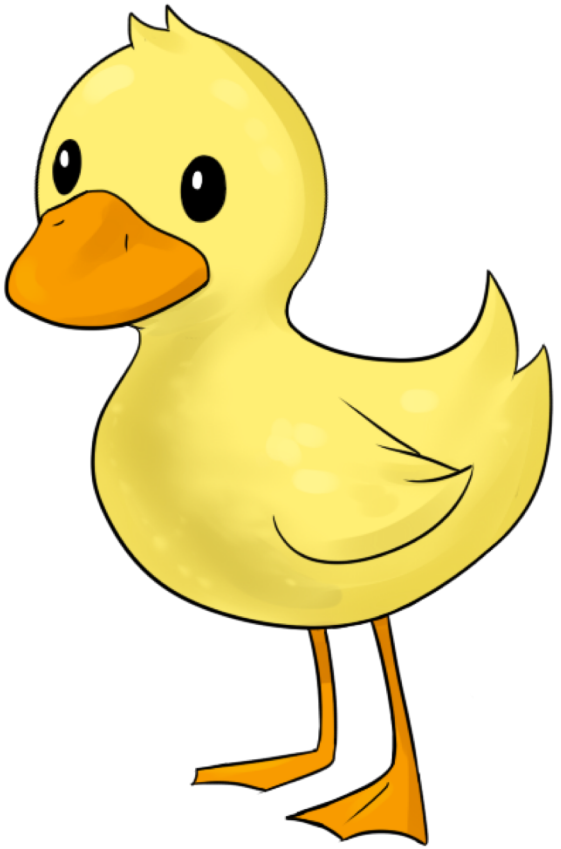


Photo of Sharbat Gula by Steve McCurry

Dim the lights

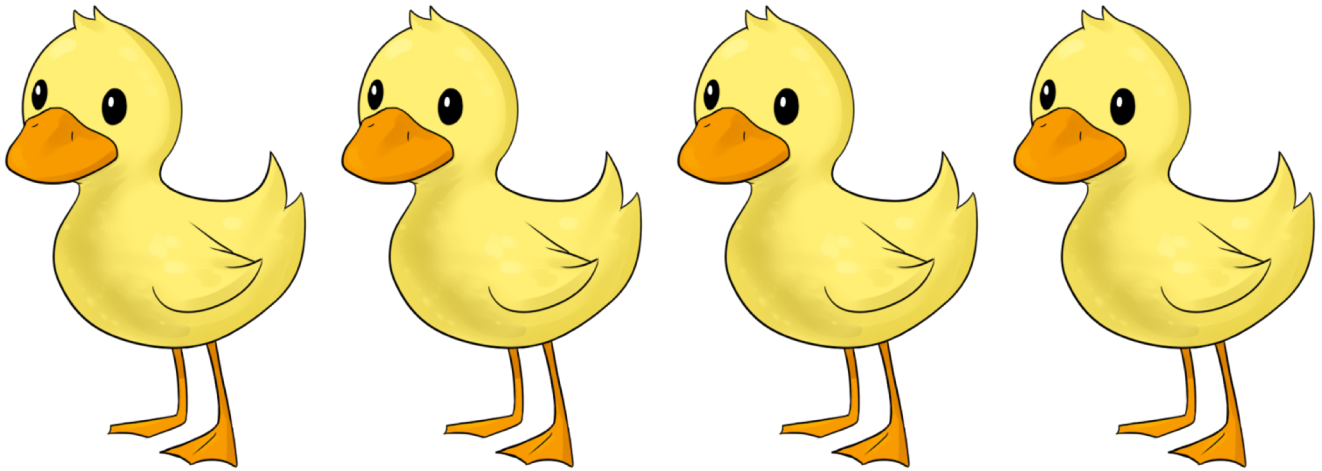
Type:
Duck



Value:
Yellow

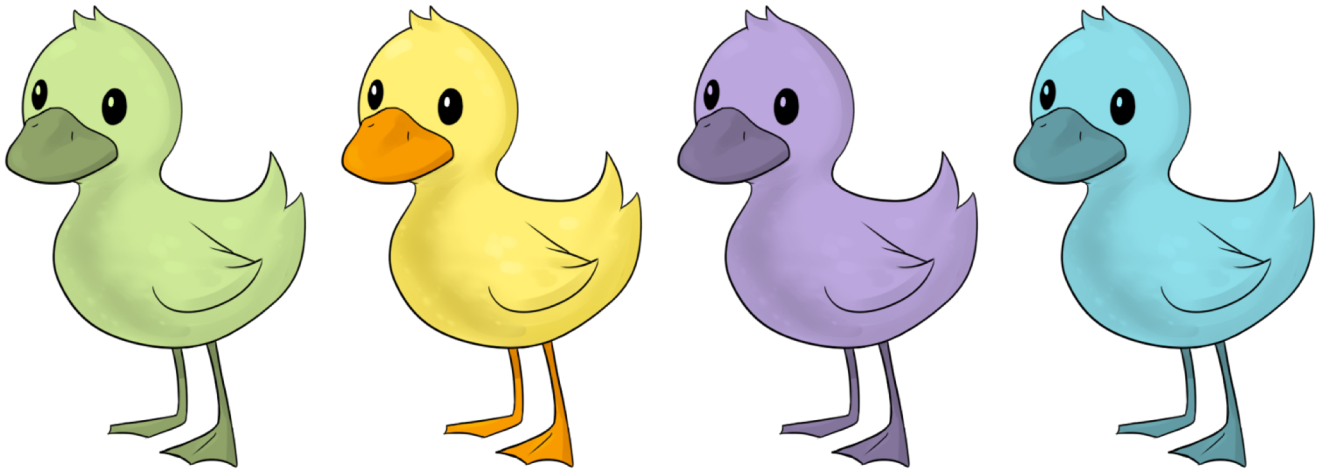
Metaphor for
a bucket in memory

```
Duck[] duckArray = new Duck[4];
```



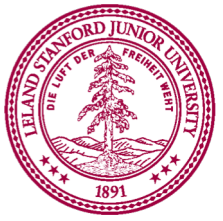
0 1 2 3

```
Duck[] duckArray = new Duck[4];
```

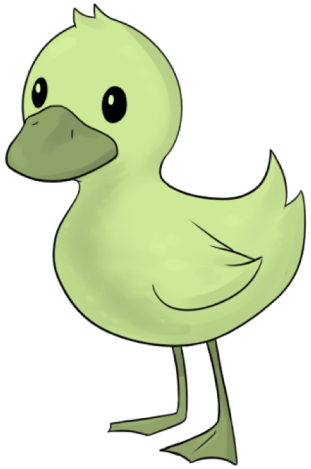


0 1 2 3

```
ArrayList<Duck> duckList = new ArrayList<Duck>();
```

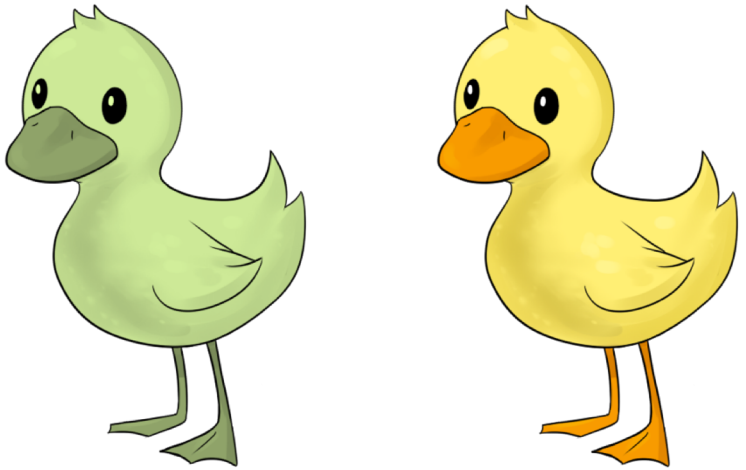
```
ArrayList<Duck> duckList = new ArrayList<Duck>();
duckList.add(  );
```



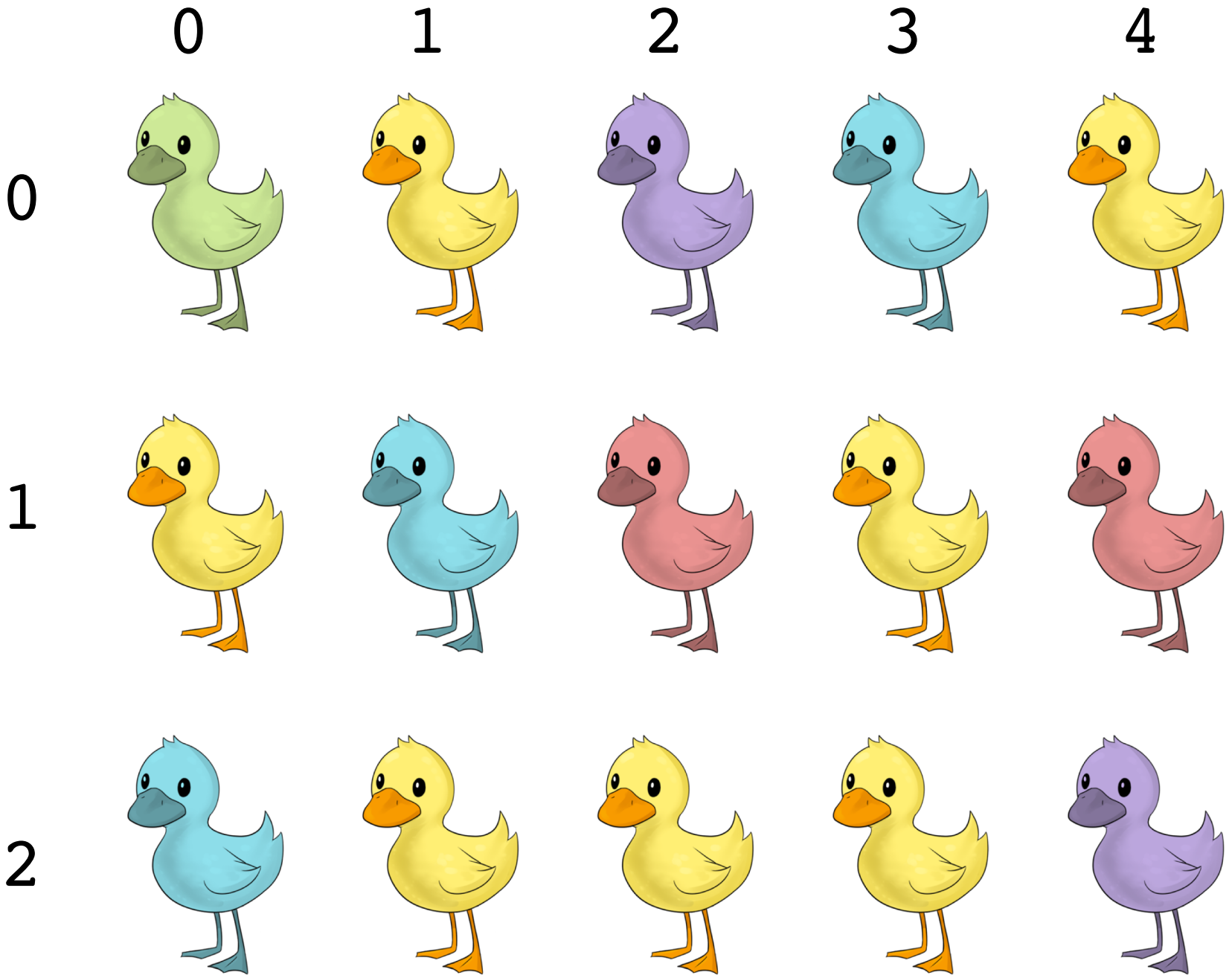
0

```
ArrayList<Duck> duckList = new ArrayList<Duck>();
duckList.add( );

duckList.add( );
```



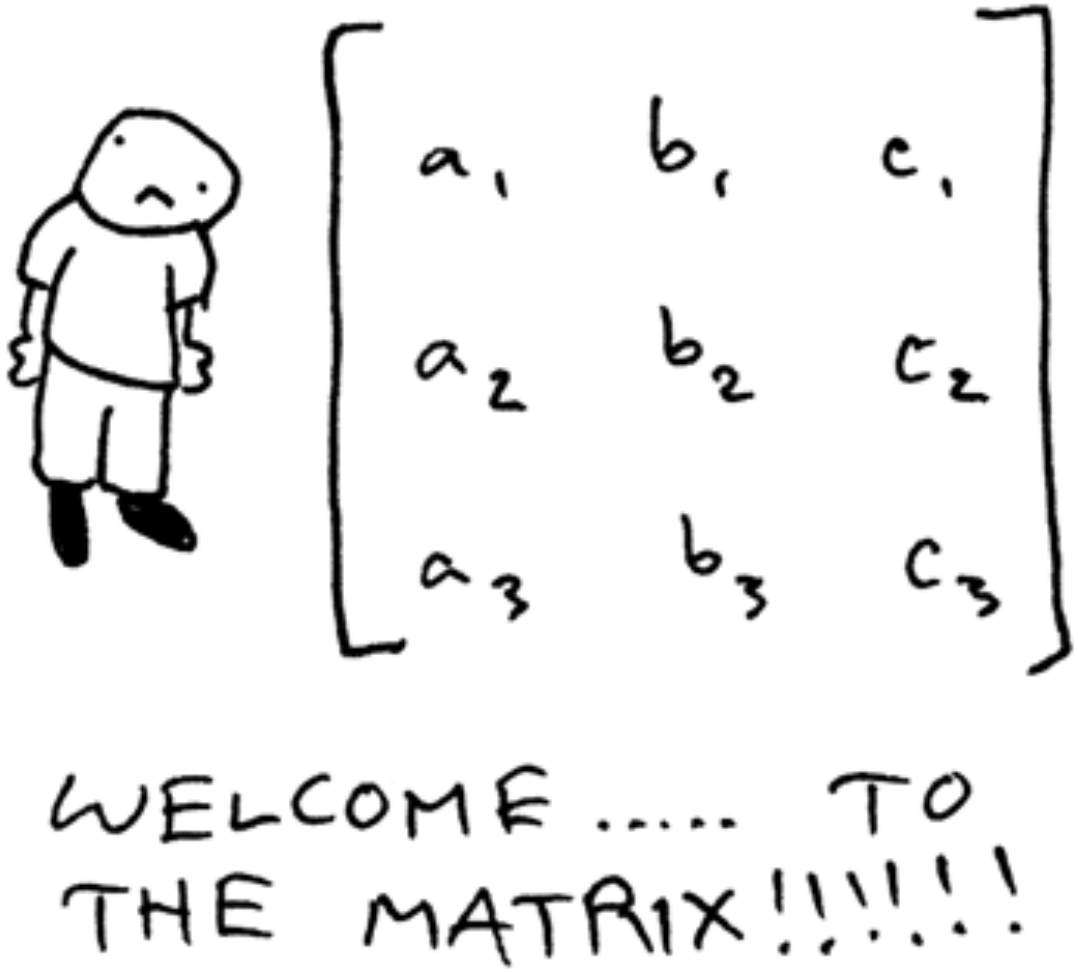
0 1



* Attack of the clone army of ducks! Hide your children!

The Matrix

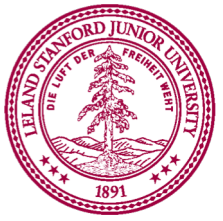
The Matrix



a.k.a. 2D arrays

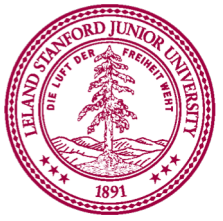
My First Matrix

```
int[][] morpheus = new int[2][4];
```

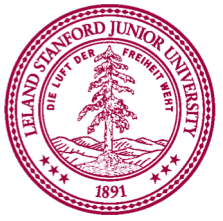
My First Matrix

```
int[][] morpheus = new int[2][4];
```

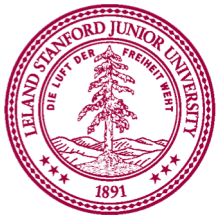
My First Matrix

```
int[][] morpheus = new int[2][4];
```

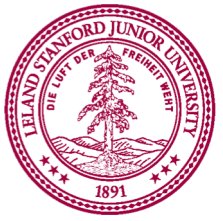
My First Matrix

```
int[][] morpheus = new int[2][4];
```

My First Matrix

```
int[][] morpheus = new int[2][4];
```

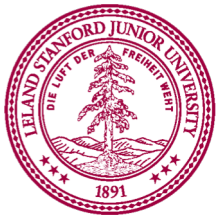



My First Matrix

```
int[][] morpheus = new int[2][4];
```

Number of cols

Number of rows

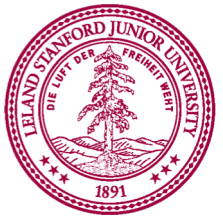


My First Matrix

```
int[][] morpheus = new int[2][4];
```

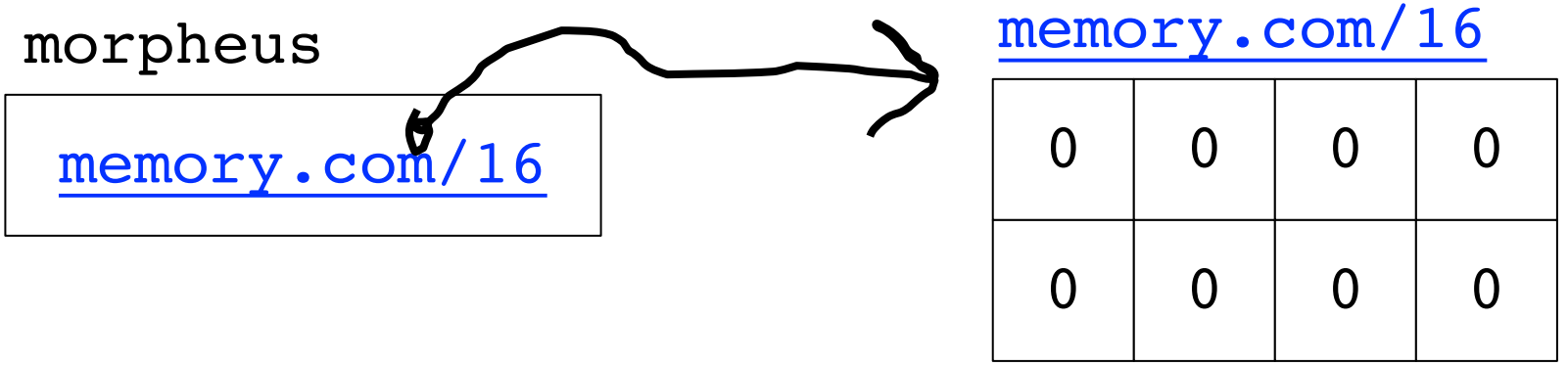
morpheus

0	0	0	0
0	0	0	0



My First Matrix

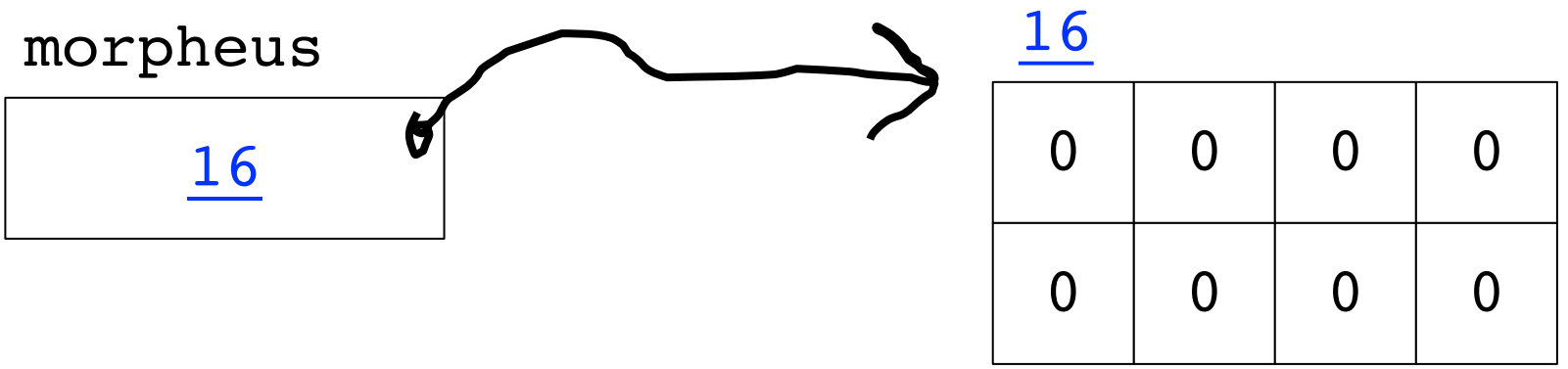
```
int[][] morpheus = new int[2][4];
```



Aside: It's actually more like this.

My First Matrix

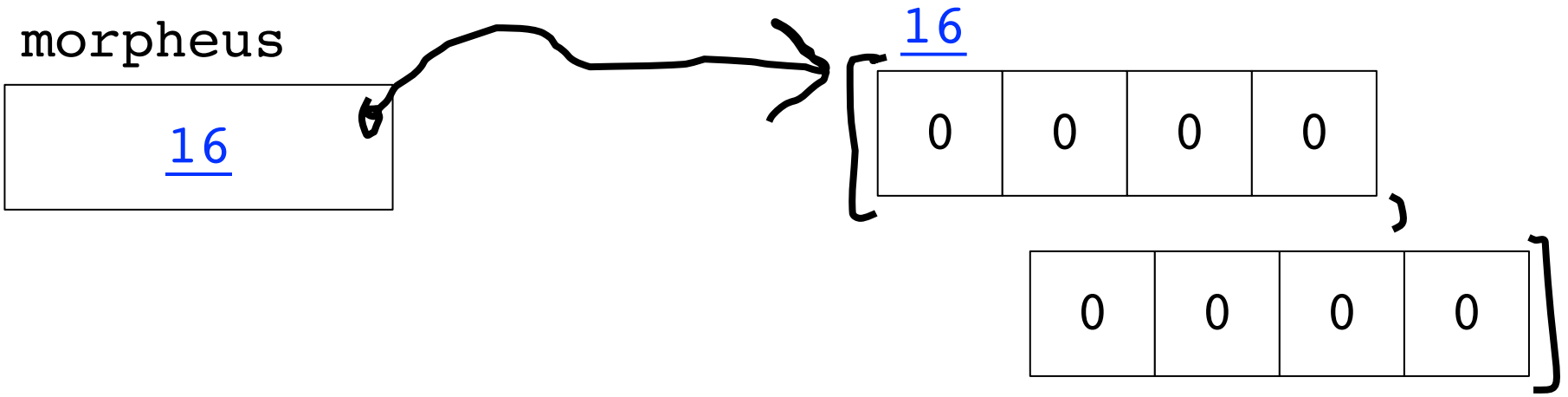
```
int[][] morpheus = new int[2][4];
```



Aside: It's actually more like this.

My First Matrix

```
int[][] morpheus = new int[2][4];
```



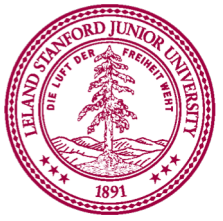
If we are going to be brutally honest

My First Matrix

```
int[][] morpheus = new int[2][4];
```

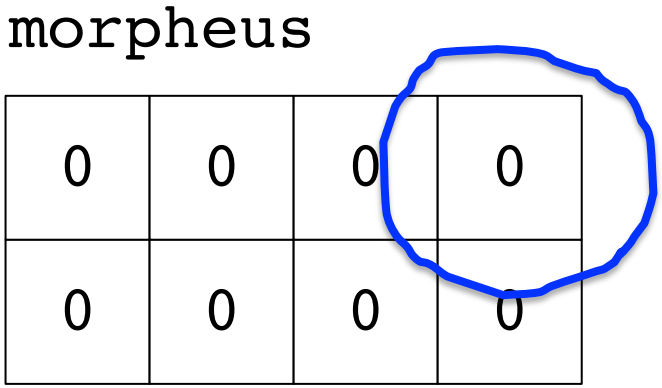
morpheus

0	0	0	0
0	0	0	0



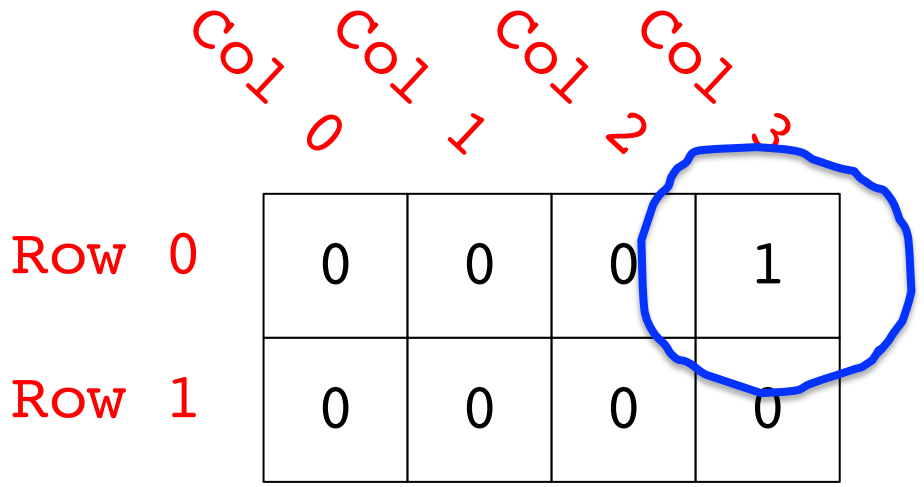
My First Matrix

```
int[][] morpheus = new int[2][4];
```



Task: Make this cell hold the value 1

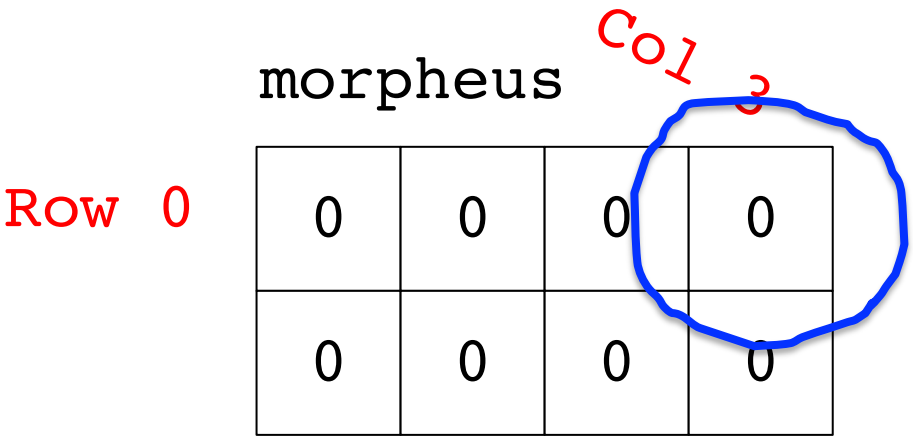
```
int[][] morpheus = new int[2][4];
```



Task: Make this cell hold the value 1

My First Matrix

```
morpheus[0][3] = 1;
```



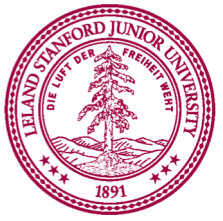
My First Matrix

```
morpheus[0][3] = 1;
```

`morpheus`

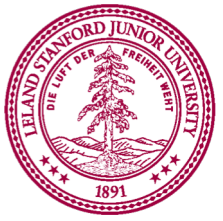
0	0	0	**1**
0	0	0	0

When “indexing” into a matrix, row comes first, then column.



```
myMatrix[     row        ][        col           ]
```

When “indexing” into a matrix, row comes first, then column.



R is for stanfoRd

C is for Cal

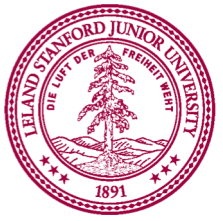
```
myMatrix[ ][ ]
```

When “indexing” into a matrix, row comes first, then column.

Matrix: The revolutions

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

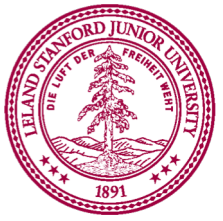
Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

Before the method call:

matrix

0	0	4	0
0	17	0	0
0	0	0	6



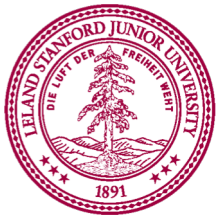
Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

After the method call:

matrix

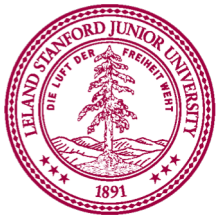
1	1	1	1
1	1	1	1
1	1	1	1



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```

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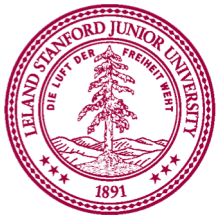

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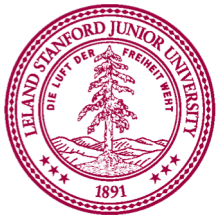
```

Set Values to One

```
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    setValuesToOne(morpheus);
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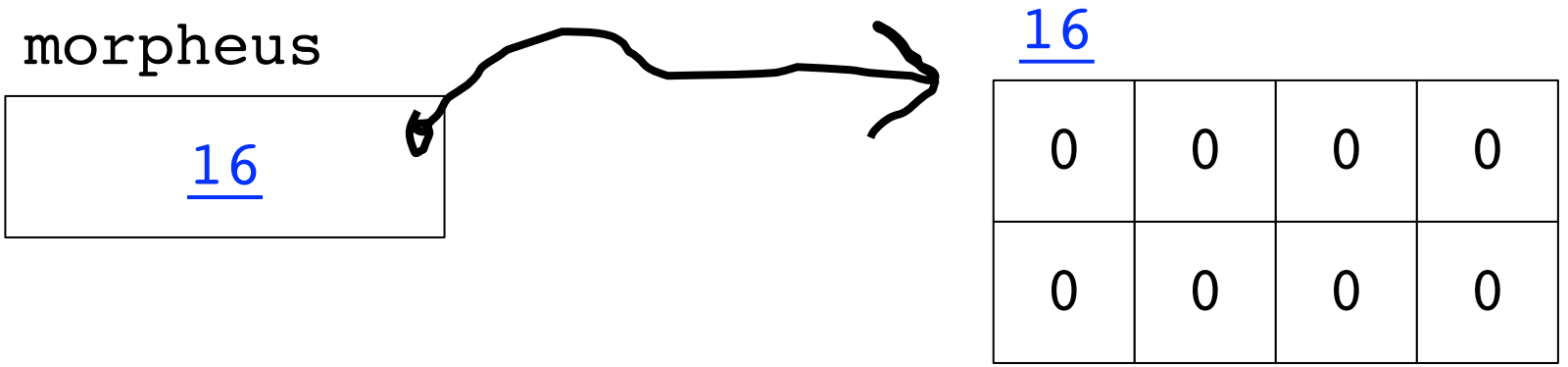
```



Set Values to One

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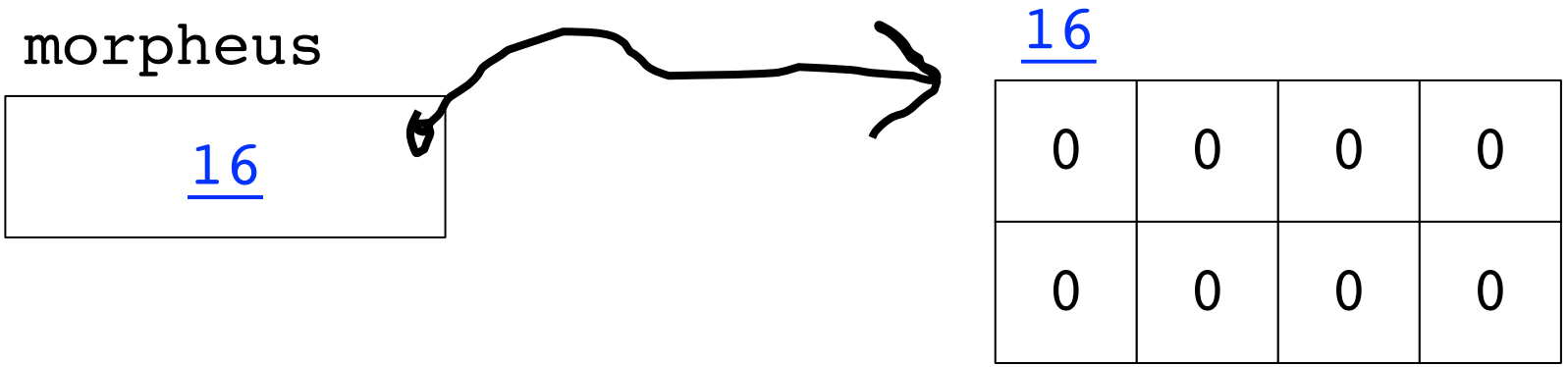

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    int[][] morpheus = int[4][2];
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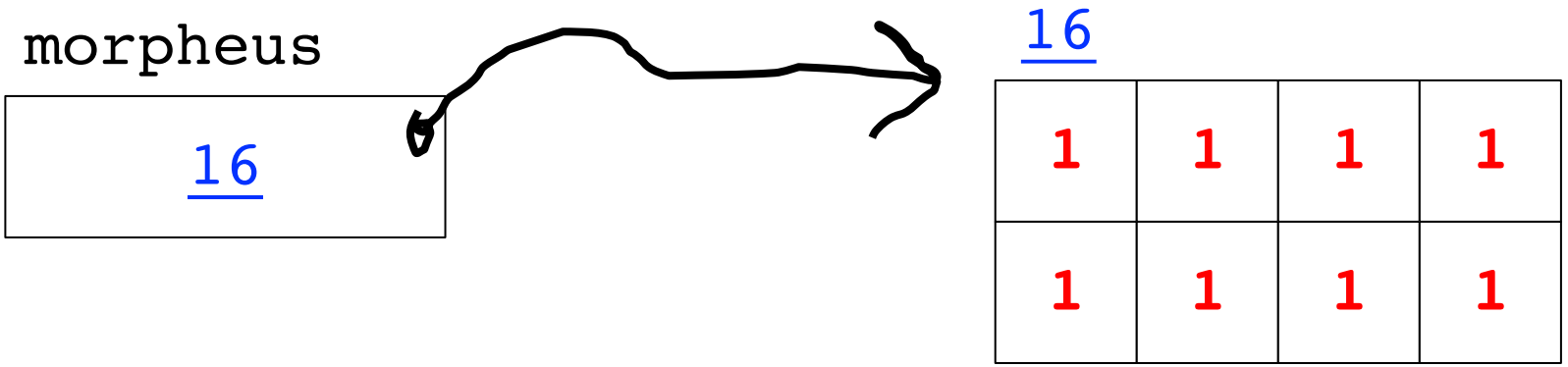

Set Values to One

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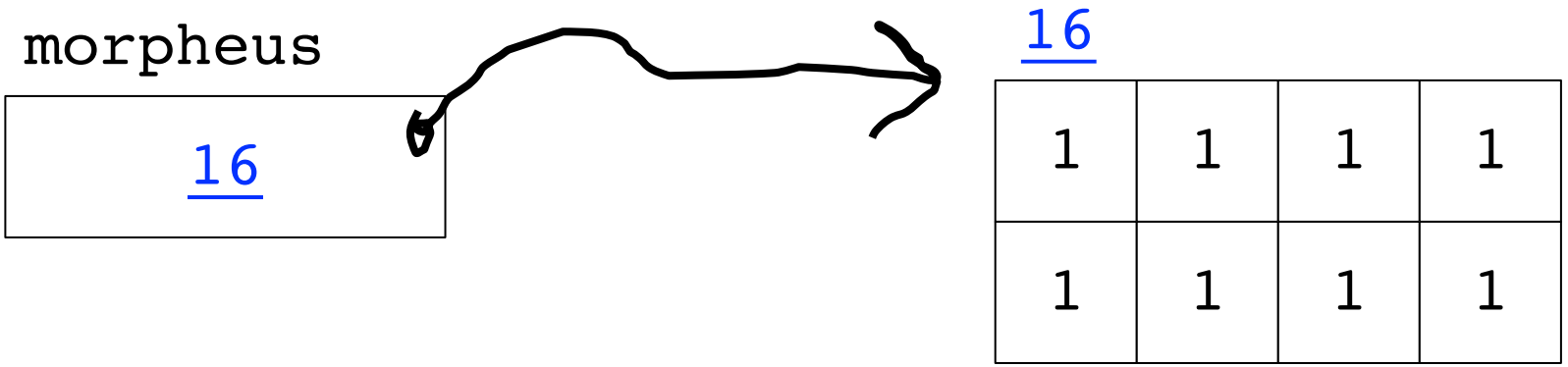

Set Values to One

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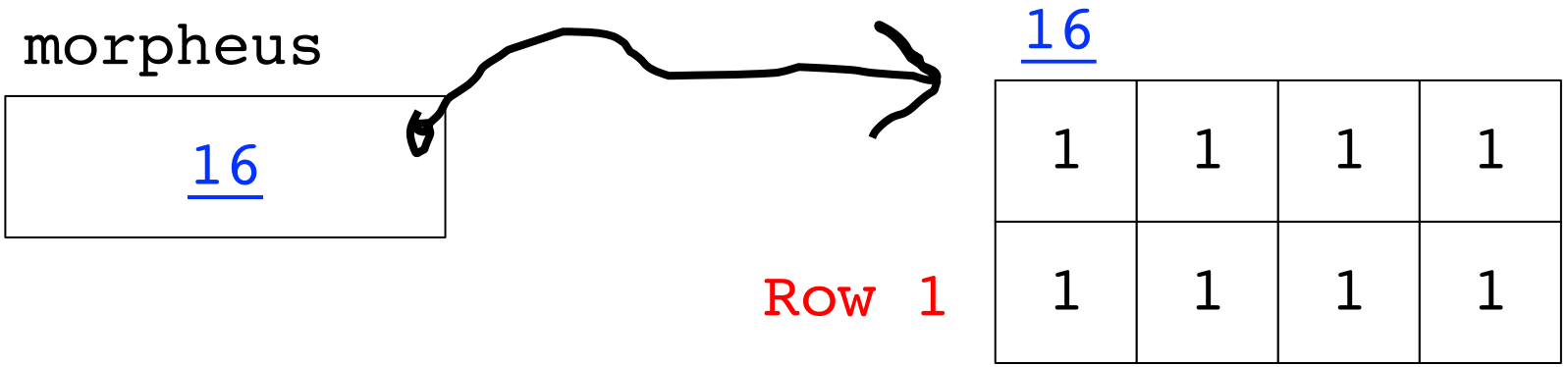

Set Values to One

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    // your code here…
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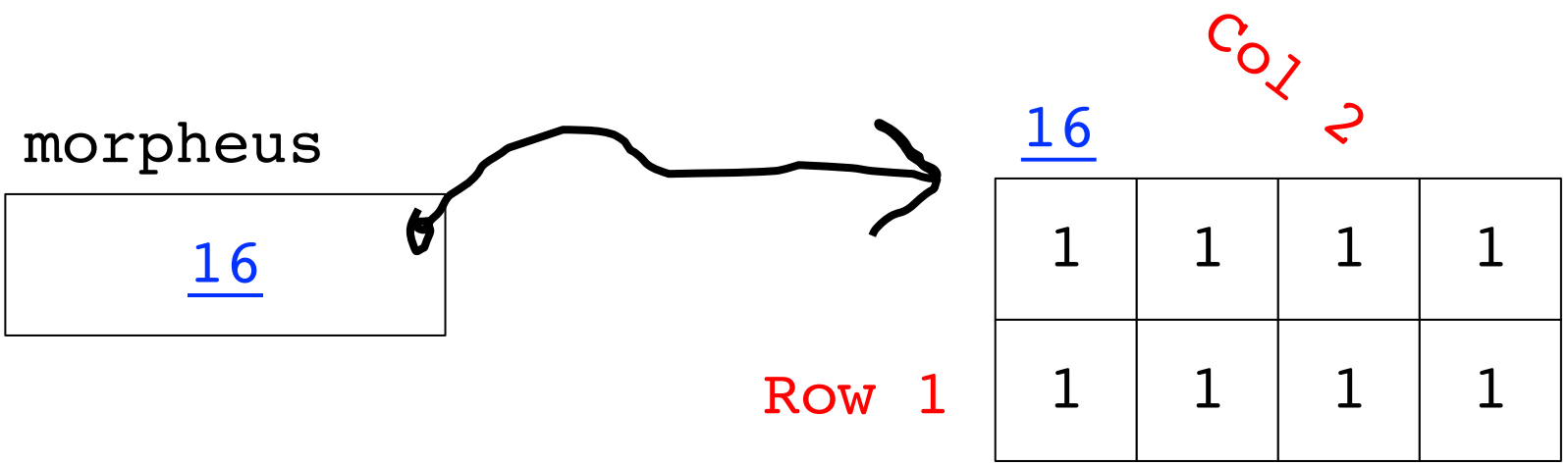
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```



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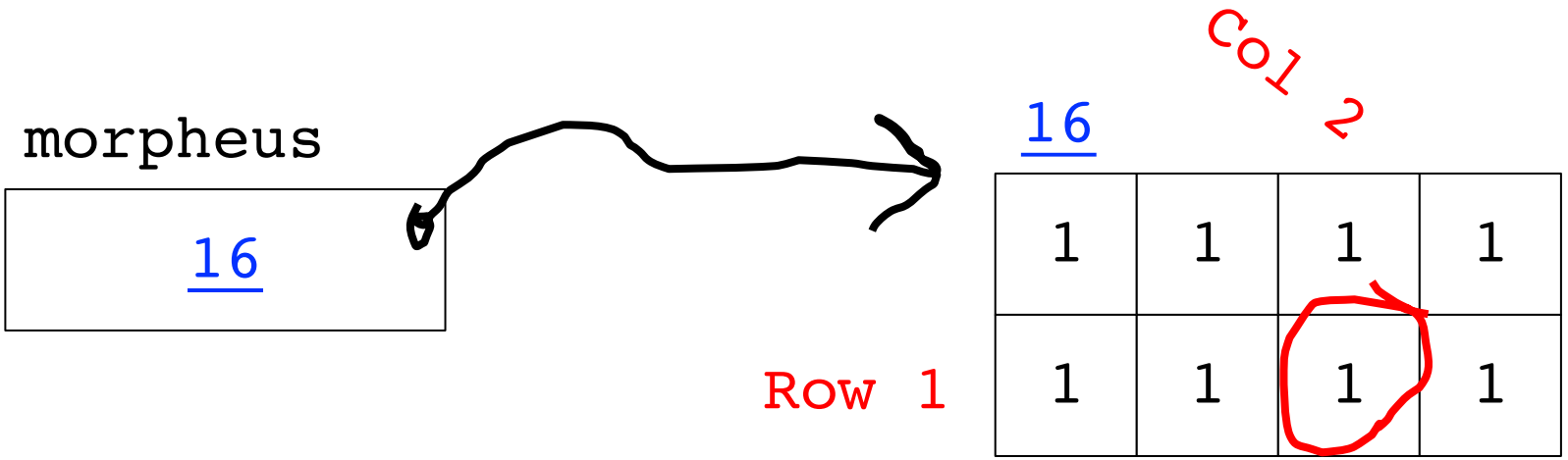
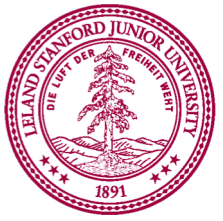


Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

Set Values to One

```
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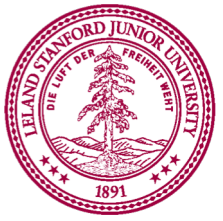
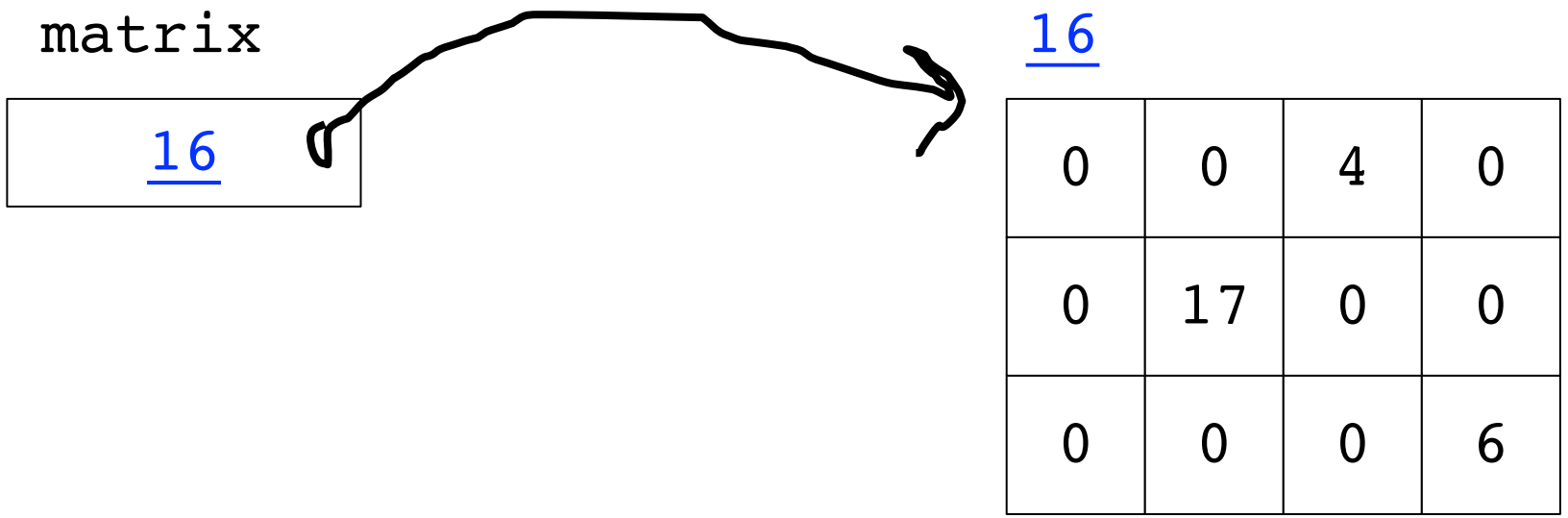
}
```

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

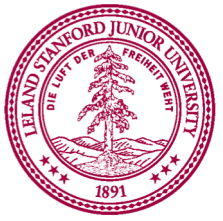


Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

matrix

0	0	4	0
0	17	0	0
0	0	0	6

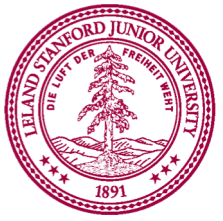


Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(each row r) {
        for(each col c) {
            matrix[r][c] = 1;
        }
    }
}
```

matrix

0	0	4	0
0	17	0	0
0	0	0	6

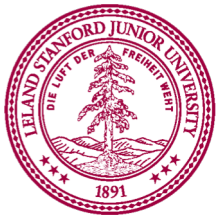


Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < 3; r++) {
        for(int c = 0; c < 4; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

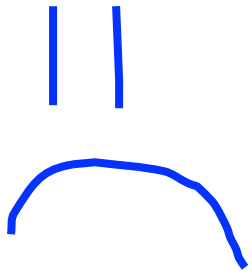
matrix

0	0	4	0
0	17	0	0
0	0	0	6



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < 3; r++) {
        for(int c = 0; c < 4; c++) {
            matrix[r][c] = 1;
        }
    }
}
```



matrix

0	0	4	0	4	0
0	17	0	0	0	0

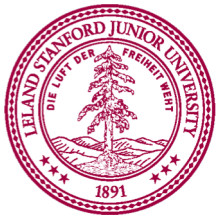
Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

Works for this matrix

matrix

0	0	4	0	4	0
0	17	0	0	0	0



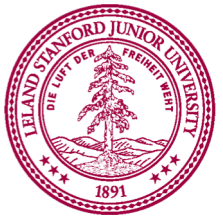
Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

Also works for this matrix

matrix

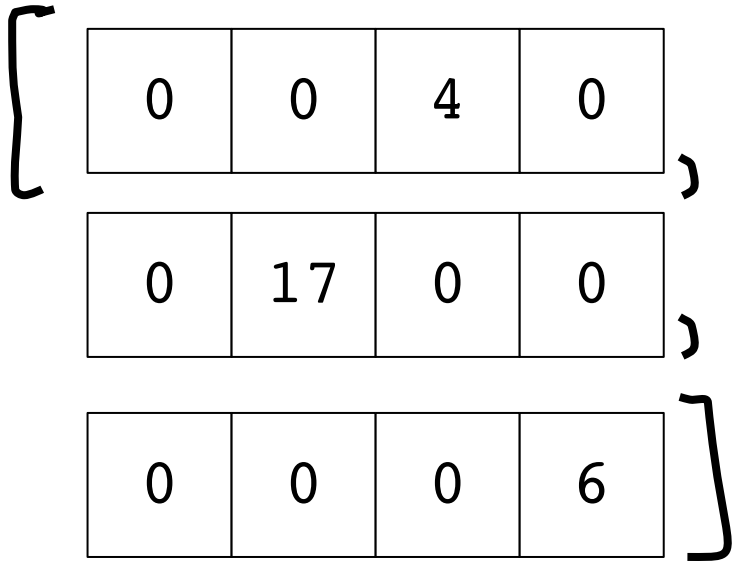
0	0	4	0
0	17	0	0
0	0	0	6



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

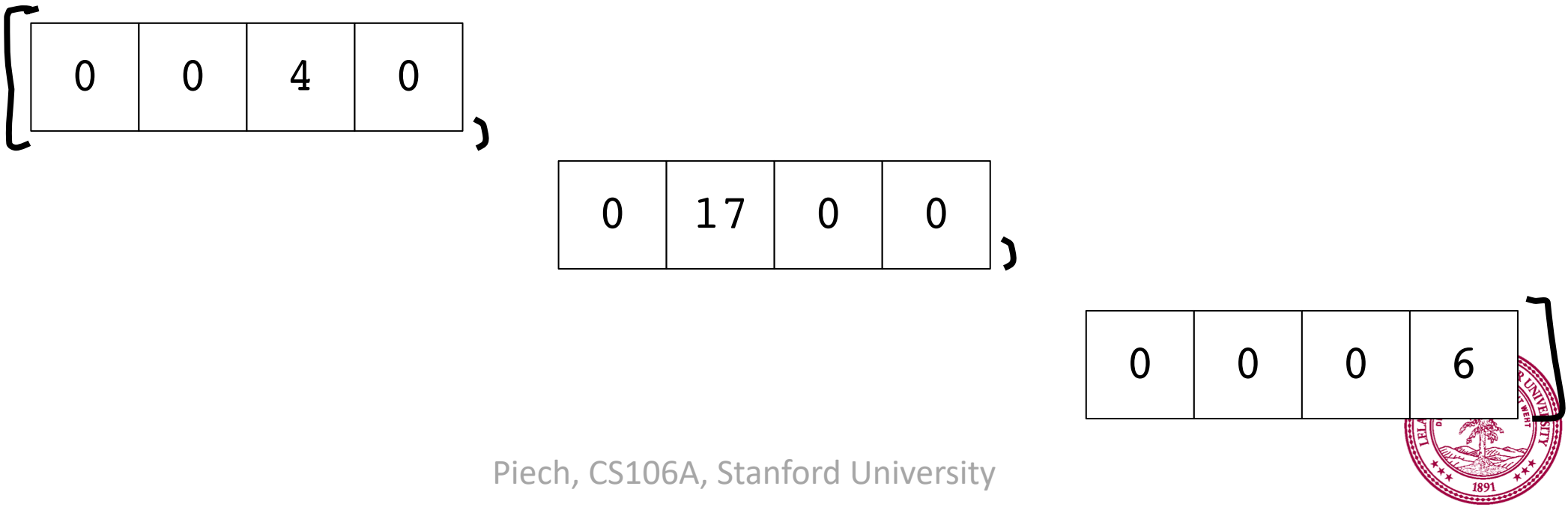
matrix



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

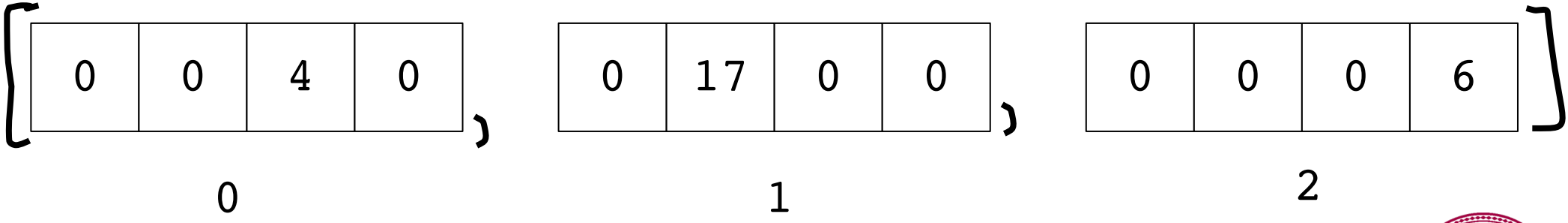
matrix



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

matrix

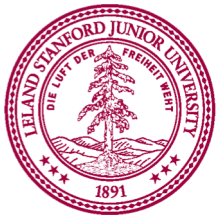


Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

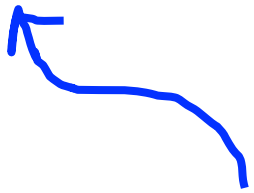
matrix

0	0	4	0
0	17	0	0
0	0	0	6



Set Values to One

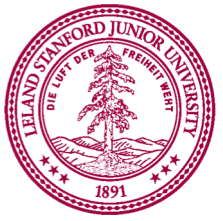
```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < numRows(matrix); r++) {
        for(int c = 0; c < numCols(matrix); c++) {
            matrix[r][c] = 1;
        }
    }
}
```



These aren't defined.
But I highly recommend them :-)

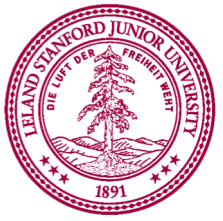
matrix

0	0	4	0
0	17	0	0
0	0	0	6



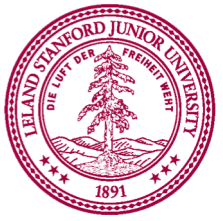
How to get number of rows

```
private int numRows(int[][] matrix) {
    return matrix.length;
}
```

How to get number of cols

```
private int numCols(int[][] matrix) {
    return matrix[0].length;
}
```

2D Arrays on one slide

1. Make a Matrix

```
double[][] mahMatrix = new double[nRows][nCols];
```

2. Set and get values from a matrix using bracket notation

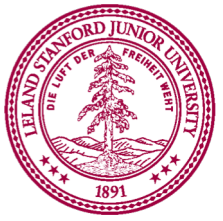
```
mahMatrix[4][2] = 99.0;
println(mahMatrix[0][0]);
```

3. Get the number of rows and columns of a matrix (pro-tip: define method)

```
int nRows = mahMatrix.length;
int nCols = mahMatrix[0].length
```

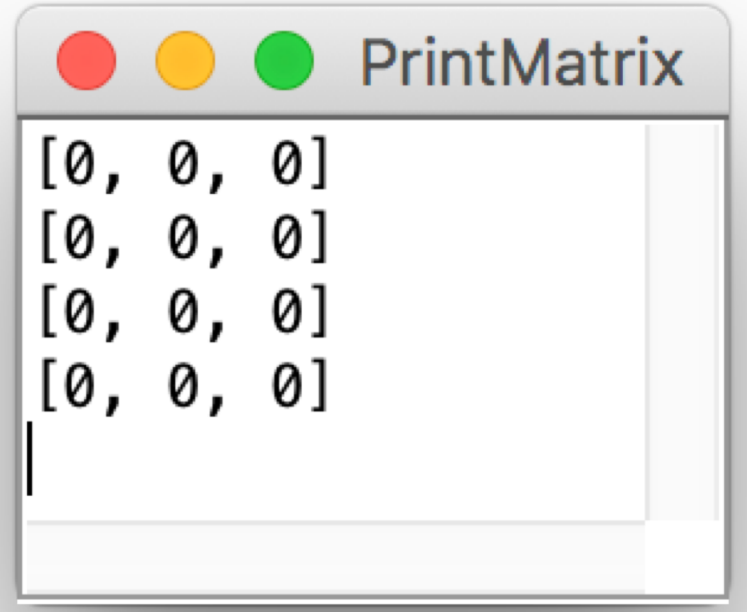
4. Use a double for loop to iterate over the whole matrix

```
for(int r = 0; r < mahMatrix.length; r++) {
   for(int c = 0; c < mahMatrix[0].length; c++) {
      //party pixel: mahMatrix[r][c]
   }
}
```



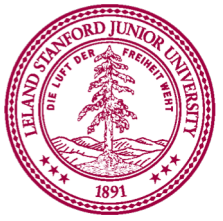
Your turn: print matrix

```
private void printMatrix(int[][]matrix){
    // TODO: fill this in
}
```

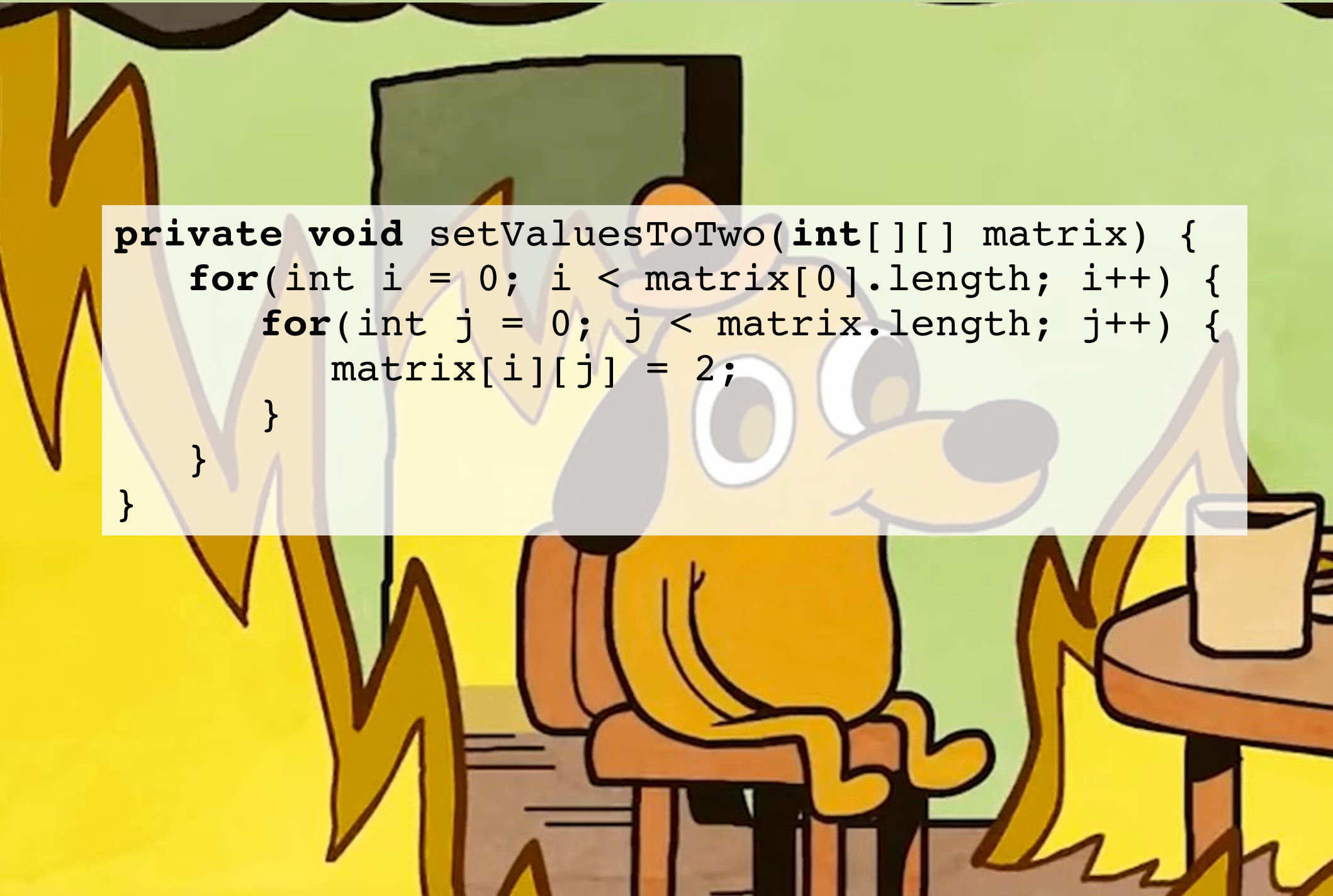


A deadly lack of style…

```
private void setValuesToTwo(int[][] matrix) {
    for(int i = 0; i < matrix[0].length; i++) {
        for(int j = 0; j < matrix.length; j++) {
            matrix[i][j] = 2;
        }
    }
}
```

A deadly lack of style...



```
private void setValuesToTwo(int[][] matrix) {
    for(int i = 0; i < matrix[0].length; i++) {
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            matrix[i][j] = 2;
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    }
}
```

A deadly lack of style…

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private void setValuesToTwo(int[][] matrix) {
    for(int i = 0; i < matrix[0].length; i++) {
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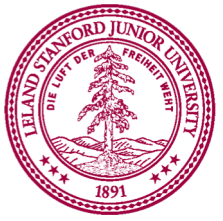
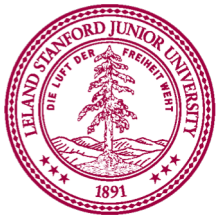
            matrix[i][j] = 2;
        }
    }
}
```

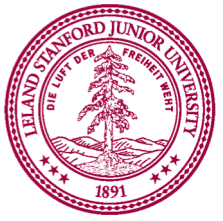
A deadly lack of style…

```
private void setValuesToTwo(int[][] matrix) {
    for(int i = 0; i < matrix[0].length; i++) {
        for(int j = 0; j < matrix.length; j++) {
            matrix[i][j] = 2;
        }
    }
}
```

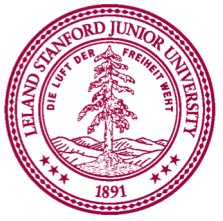
A deadly lack of style…

```
private void setValuesToTwo(int[][] matrix) {
    for(int r = 0; r < matrix[0].length; r++) {
        for(int j = 0; j < matrix.length; j++) {
            matrix[r][j] = 2;
        }
    }
}
```

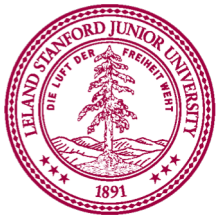
A deadly lack of style…

```
private void setValuesToTwo(int[][] matrix) {
    for(int r = 0; r < matrix[0].length; r++) {
        for(int c = 0; c < matrix.length; c++) {
            matrix[r][c] = 2;
        }
    }
}
```

A deadly lack of style…

```
private void setValuesToTwo(int[][] matrix) {
    for(int r = 0; r < numRows(matrix); r++) {
        for(int c = 0; c < numCols(matrix); c++) {
            matrix[r][c] = 2;
        }
    }
}
```

Images are Matrices!

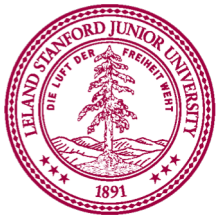
Images are Matrices!

```
GImage img = new GImage("snowman.jpg");
int[][] pixels = img.getPixelArray();
```

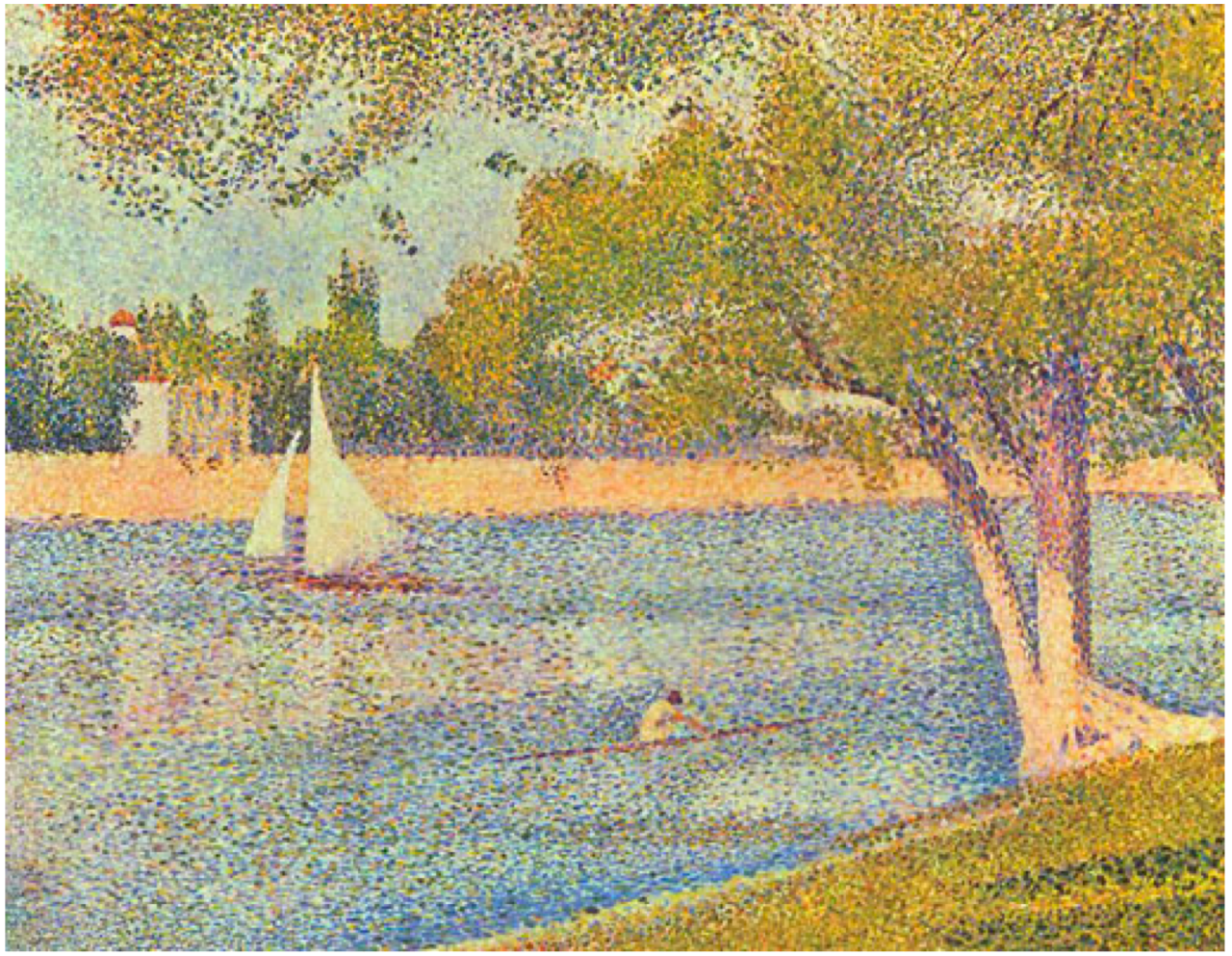
Gives you the image as a matrix of ints (which you can edit)

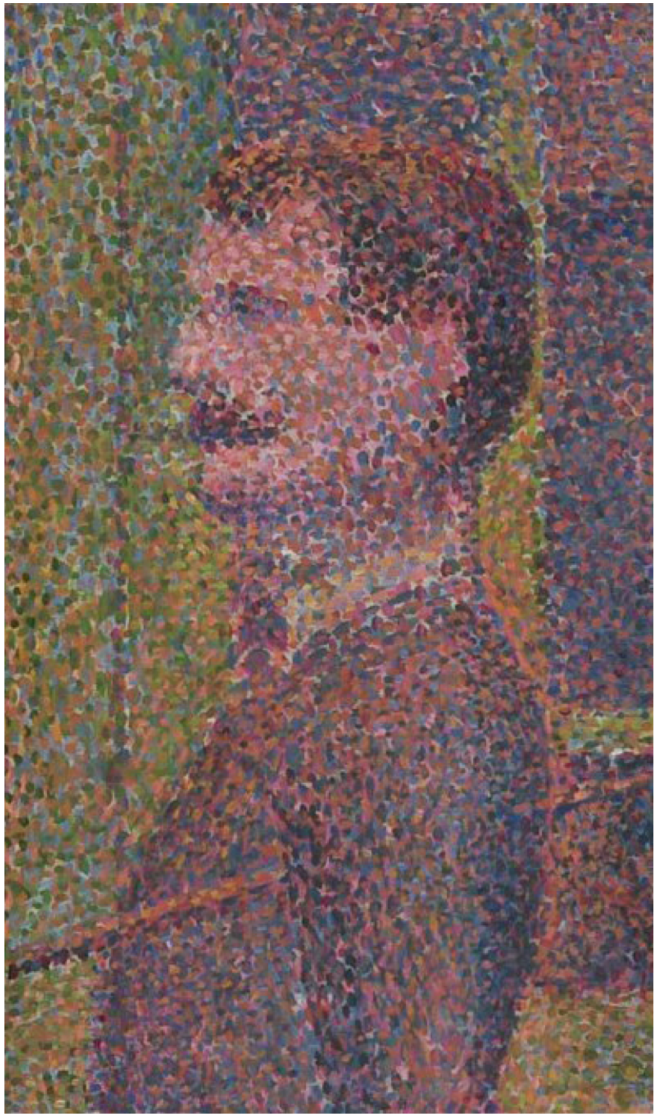
Creates an image from a matrix of pixels

```
GImage copy = new GImage(pixels);
```

Part two: Surat meets Instagram



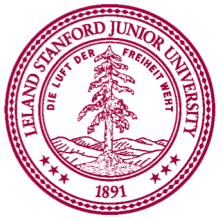


Seurat: French post impressionist painter

Pointillism Filter

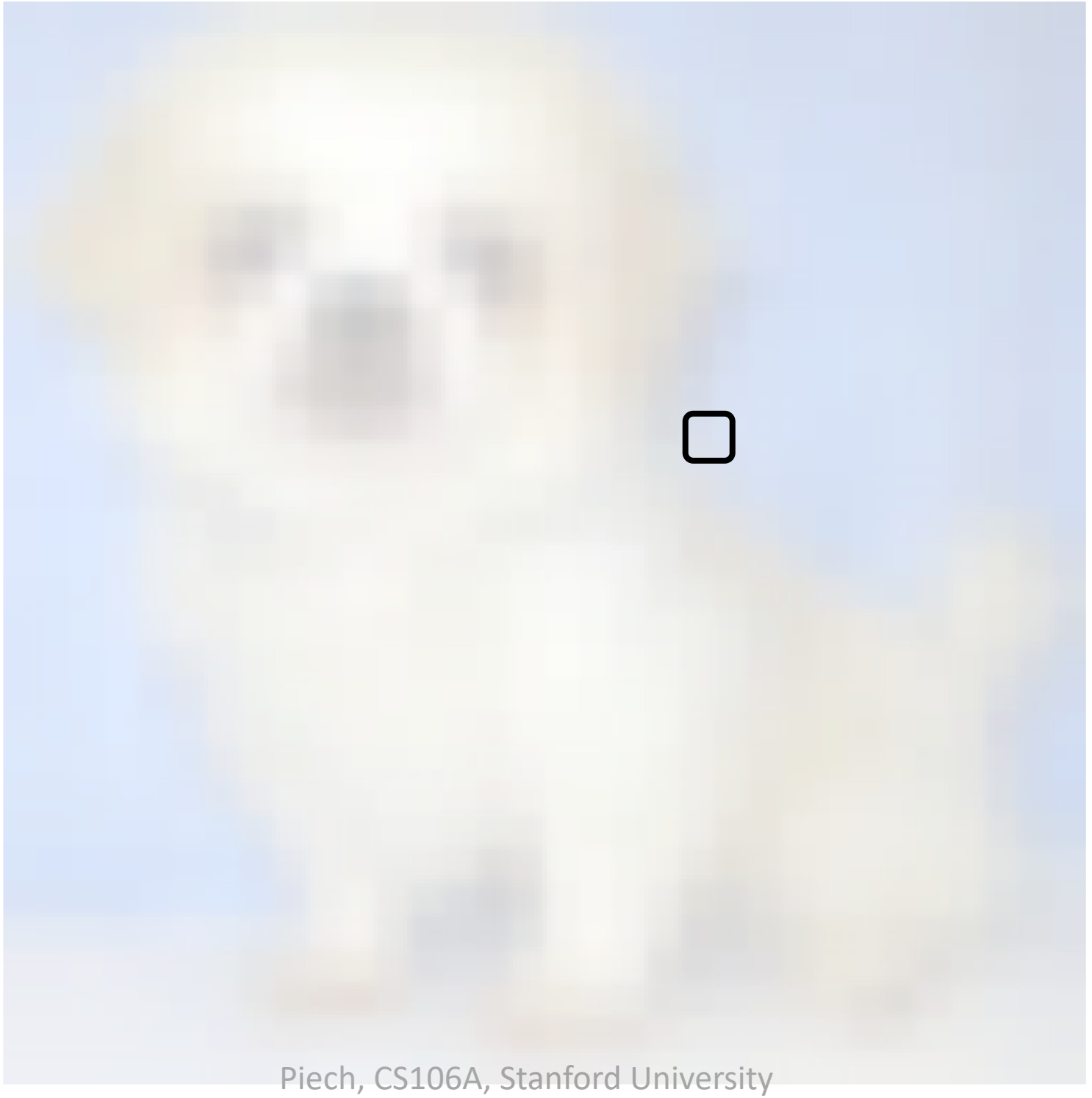
Repeat many times:

1. Pick a random pixel from an image.
2. Find the pixel's color
3. "Paint" a rather large brush stroke at a corresponding location, with the color



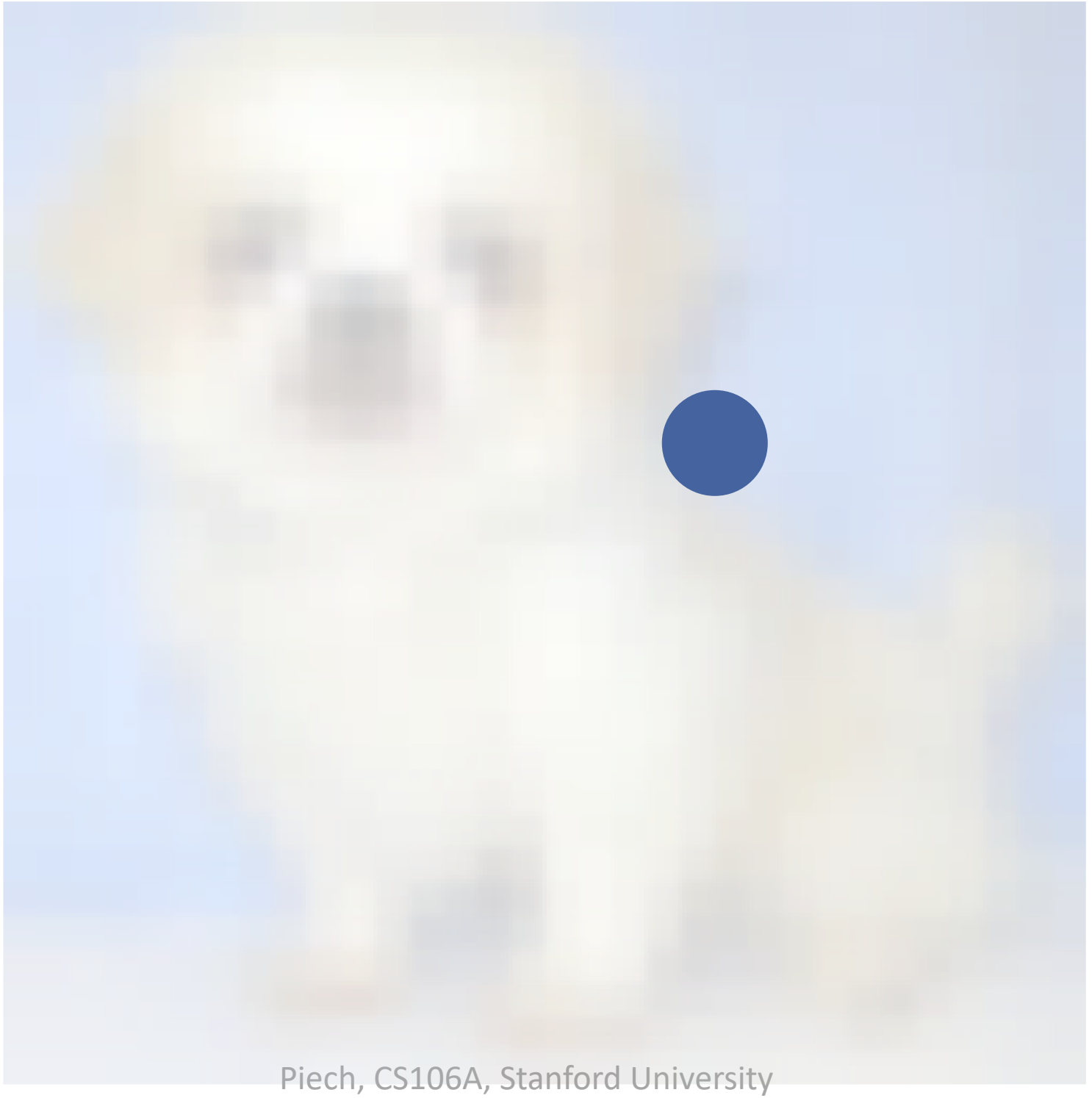
c = 36

r = 24



c = 36

r = 24



c = 21

r = 38

c = 21

r = 38