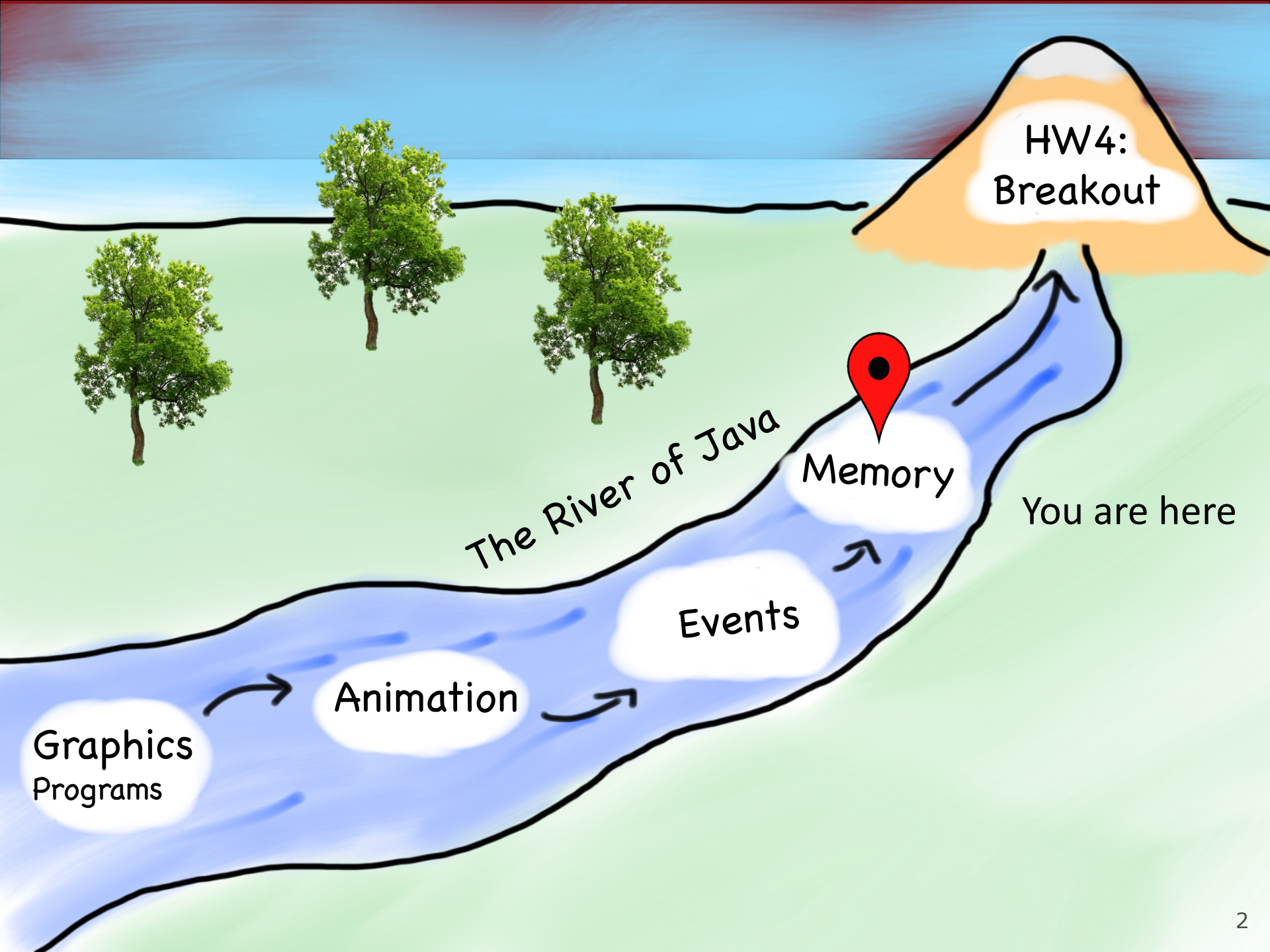
CS 106A, Lecture 15
Events and Memory


HW4:
Breakout
The River of Java
Memory
You are here
Events
Animation
Graphics
Programs

Plan for Today

- Announcements
- Review: Null, Events and Instance Variables
- Extra Practice: Googley Eyes
- A Boolean Aside
- Memory
- Revisiting Whack-A-Mole

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Null

Null is a special variable value that objects can have that means "nothing". Primitives cannot be null.

If a method returns an object, it can return **null** to signify "nothing". (just say `return null;`)

```
// may be a GObject, or null if nothing at (x, y)
GObject maybeAnObject = getElementAt(x, y);
```

Objects have the value **null** before being initialized.

```
Scanner myScanner; // initially null
```

Null

You can check if something is null using == and !=.

```
// may be a GObject, or null if nothing at (x, y)
GObject maybeAnObject = getElementAt(x, y);
if (maybeAnObject != null) {
      // do something with maybeAnObject
} else {
      // null – nothing at that location
}
```

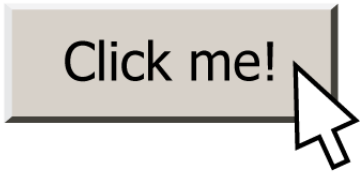
Null

Calling methods on an object that is **null** will crash your program!

```
// may be a GObject, or null if nothing at (x, y)
GObject maybeAnObject = getElementAt(x, y);
if (maybeAnObject != null) {
      int x = maybeAnObject.getX(); // OK
} else {
      int x = maybeAnObject.getX(); // CRASH!
}
```

Events

- **event**: Some external stimulus that your program can respond to.



- **event-driven programming**: A coding style (common in graphical programs) where your code is executed in response to user events.

Events

```
public void run() {
    // Java runs this when program launches
}

public void mouseClicked(MouseEvent event) {
    // Java runs this when mouse is clicked
}

public void mouseMoved(MouseEvent event) {
    // Java runs this when mouse is moved
}
```

Types of Mouse Events

- There are many different types of mouse events.
  - Each takes the form:
    `public void` ***`eventMethodName`***`(MouseEvent event) { ...`

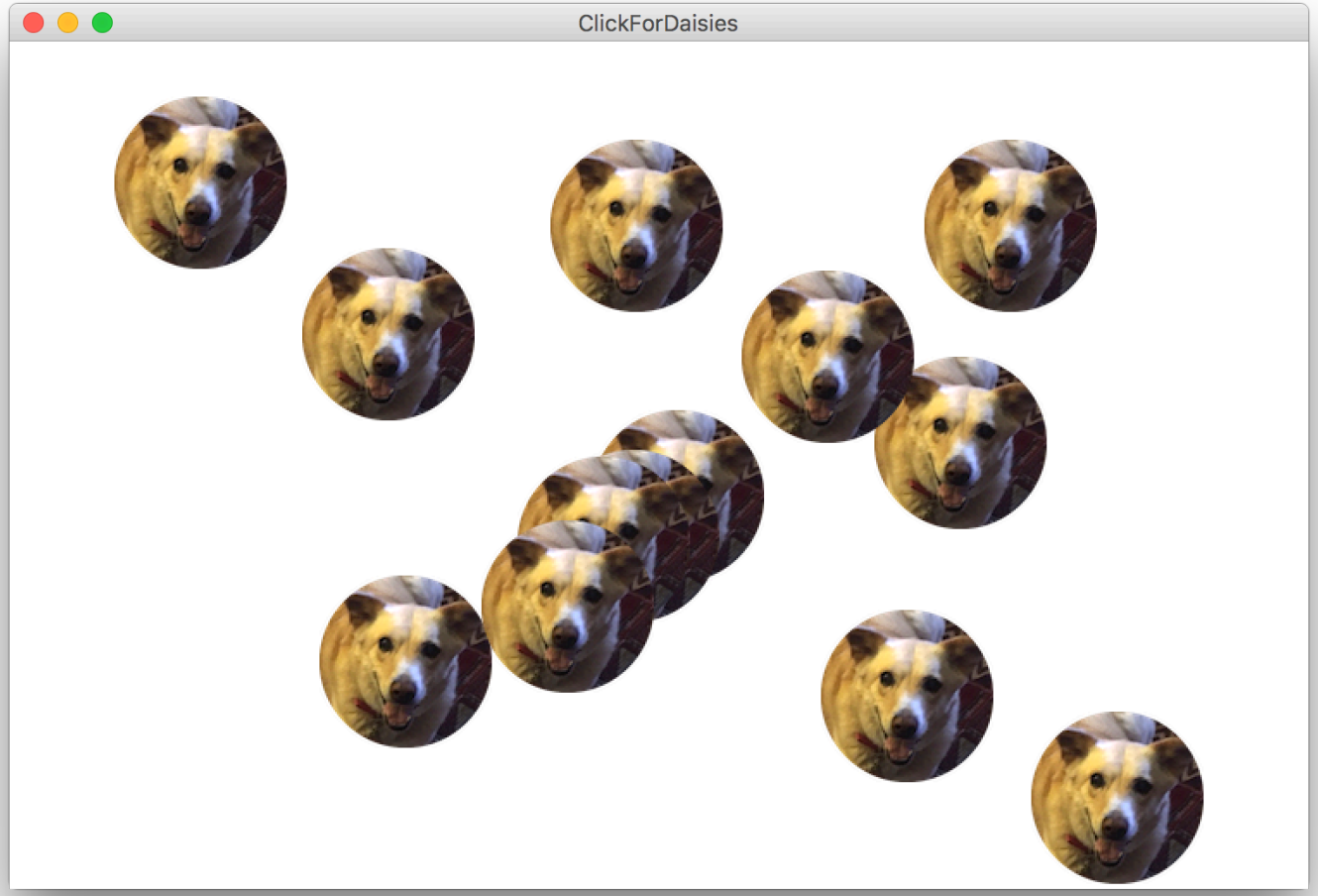
Method	Description
`mouseMoved`	mouse cursor moves
`mouseDragged`	mouse cursor moves while button is held down
`mousePressed`	mouse button is pressed down
`mouseReleased`	mouse button is lifted up
`mouseClicked`	mouse button is pressed and then released
`mouseEntered`	mouse cursor enters your program's window
`mouseExited`	mouse cursor leaves your program's window

MouseEvent Objects

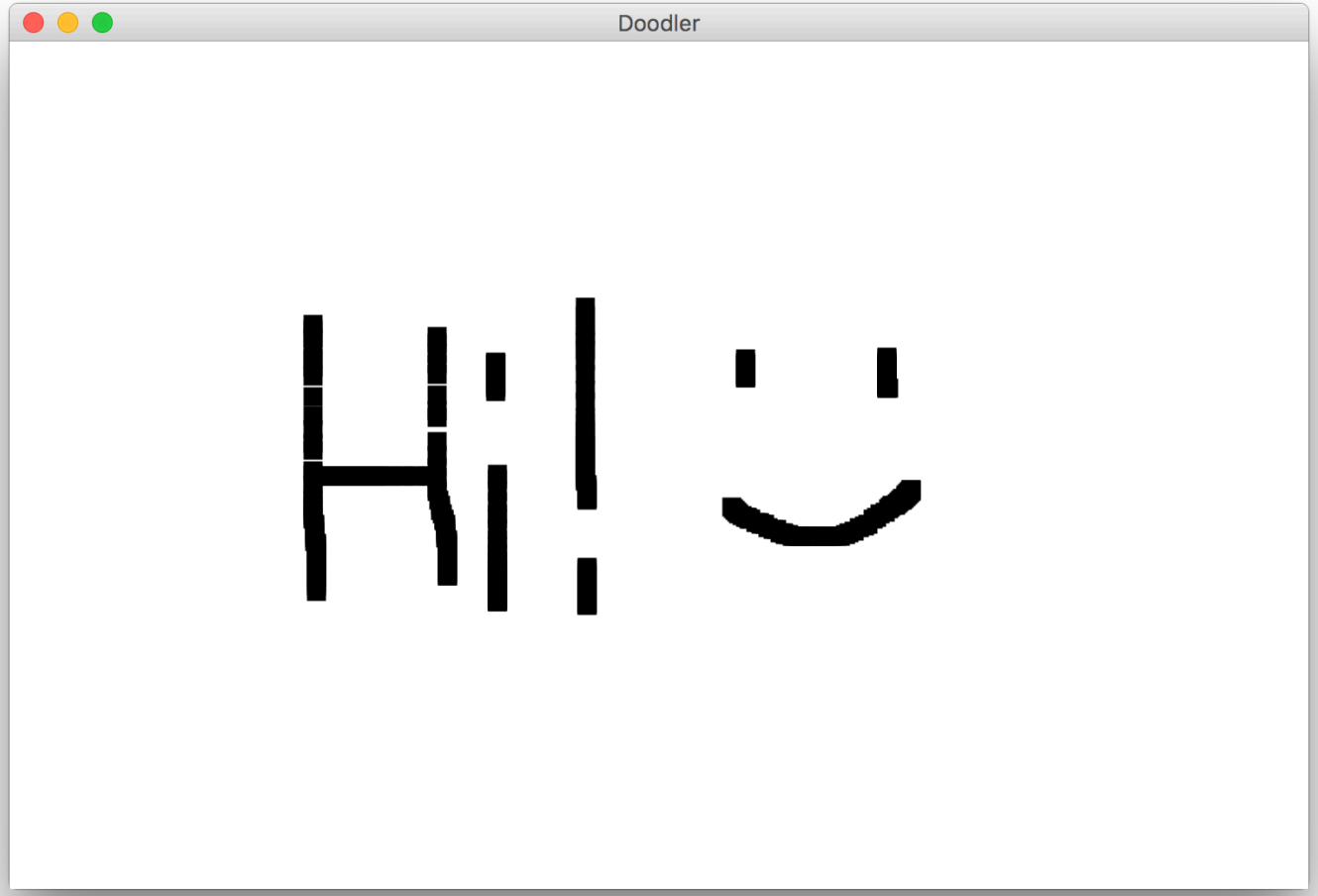
- A `MouseEvent` contains information about the event that just occurred:

Method	Description
***e*.`getX()`**	the *x*-coordinate of mouse cursor in the window
***e*.`getY()`**	the *y*-coordinate of mouse cursor in the window

Example: ClickForDaisies



Example: Doodler



Doodler

```
public void mouseDragged(MouseEvent event) {
    double mouseX = event.getX();
    double mouseY = event.getY();
    double rectX = mouseX – SIZE / 2.0;
    double rectY = mouseY – SIZE / 2.0;
    GRect rect = new GRect(rectX, rectY, SIZE, SIZE);
    rect.setFilled(true);
    add(rect);
}
```

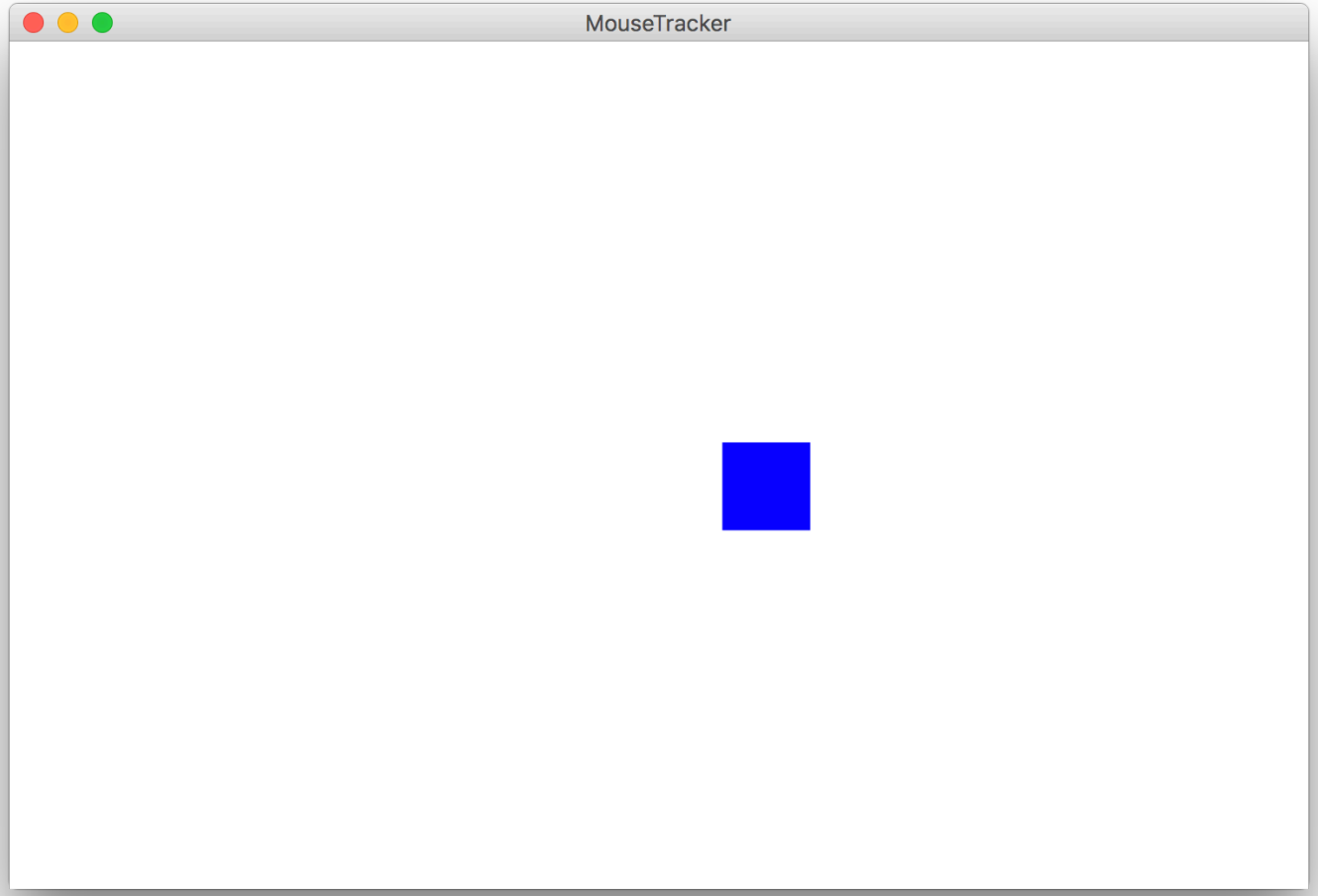
What if we wanted the *same* GRect to track the mouse, instead of making a new one each time?

Instance Variables

```
private type name;  // declared outside of any method
```

- **Instance variable**: A variable that lives outside of any method.
  - The *scope* of an instance variable is throughout an entire file (class).
  - Useful for data that must persist throughout the program, or that cannot be stored as local variables or parameters (event handlers).
  - *It is bad style to overuse instance variables*

Example: MouseTracker



Whack-A-Mole

We used instance variables and events to make Whack-A-Mole!

- A mole should appear every second at a random location, and stop once the user has gotten at least 10 points.
- If the user clicks a mole, remove it and increase their score by 1
- There should be a GLabel in the left corner showing their score

Exception

- If the user clicks an area with no mole, the program crashes.
  - A program crash in Java is called an **exception**.
  - When you get an exception, Eclipse shows red error text.
  - The error text shows the line number where the error occurred.
  - Why did this error happen?
  - How can we avoid this?

Problems | Javadoc | Declaration | Console

```
WhackAMole [Java Application] /Library/Java/JavaVirtualMachines/jdk1.8.0_121.jdk/Contents/Home/bin/java (Apr 27, 2017, 10:46:49 PM)
Exception in thread "AWT-EventQueue-0" java.lang.NullPointerException
        at acm.graphics.GObjectList.remove(GContainer.java:187)
        at acm.graphics.GCanvas.remove(GCanvas.java:518)
        at acm.program.GraphicsProgram.remove(GraphicsProgram.java:215)
        at WhackAMole.mouseClicked(WhackAMole.java:52)
        at java.awt.AWTEventMulticaster.mouseClicked(AWTEventMulticaster.java:270)
        at java.awt.Component.processMouseEvent(Component.java:6536)
        at javax.swing.JComponent.processMouseEvent(JComponent.java:3324)
        at java.awt.Component.processEvent(Component.java:6298)
```

Whack-A-Null?

```
public void mouseClicked(MouseEvent event) {
    double mouseX = event.getX();
    double mouseY = event.getY();
    GObject mole = getElementAt(mouseX, mouseY);

    remove(mole);
    score++;
    scoreLabel.setText("Score: " + score);
}
```

Whack-A-Null?

```
public void mouseClicked(MouseEvent event) {
    double mouseX = event.getX();
    double mouseY = event.getY();
    GObject mole = getElementAt(mouseX, mouseY);

    remove(mole);
    score++;
    scoreLabel.setText("Score: " + score);
}
```

Problem: **mole** may be null if the user doesn't click on a mole! Removing null will crash ☹

Whack-A-Mole!

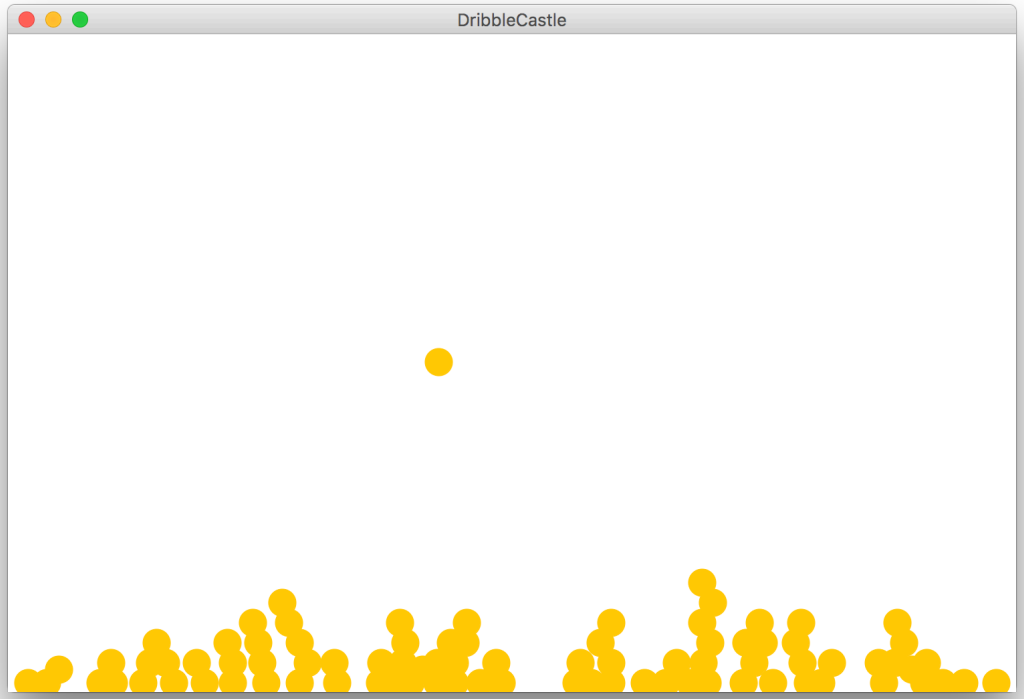
```
public void mouseClicked(MouseEvent event) {
    double mouseX = event.getX();
    double mouseY = event.getY();
    GObject mole = getElementAt(mouseX, mouseY);

    if (mole != null) {
        remove(mole);
        score++;
        scoreLabel.setText("Score: " + score);
    }
}
```

Revisiting DribbleCastle

We wrote a program called **DribbleCastle** that simulates wet sand falling and forming cool shapes.

But we left out one part: how do we stop the animation if one dribble collides with another?



DribbleCastle

```
private void dropOneDribble() {
  GOval dribble = makeDribble();
  add(dribble);

  while (!hasHitBottom(dribble) &&
         !hasHitSomethingElse(dribble)) {
    dribble.move(0, Y_VELOCITY);
    pause(PAUSE_TIME);
  }
}
```

DribbleCastle

```
private void dropOneDribble() {
  GOval dribble = makeDribble();
  add(dribble);

  while (!hasHitBottom(dribble) &&
         !hasHitSomethingElse(dribble)) {
    dribble.move(0, Y_VELOCITY);
    pause(PAUSE_TIME);
  }
}
```

DribbleCastle

```
private void dropOneDribble() {
  GOval dribble = makeDribble();
  add(dribble);

  while (!hasHitBottom(dribble) &&
         !hasHitSomethingElse(dribble)) {
    dribble.move(0, Y_VELOCITY);
    pause(PAUSE_TIME);
  }
}
```

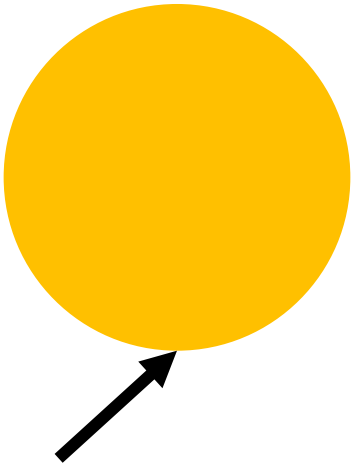
hasHitSomethingElse

```
private boolean hasHitSomethingElse(GOval dribble) {
  double checkX = dribble.getX()
                  + dribble.getWidth() / 2.0;
  double checkY = dribble.getY()
                  + dribble.getHeight() + 1;
  GObject hit = getElementAt(checkX, checkY);
  return hit != null;
}
```

hasHitSomethingElse

```
private boolean hasHitSomethingElse(GOval dribble) {
  double checkX = dribble.getX()
                  + dribble.getWidth() / 2.0;
  double checkY = dribble.getY()
                  + dribble.getHeight() + 1;
  GObject hit = getElementAt(checkX, checkY);
  return hit != null;
}
```

Need to check *outside* of the GOval itself! Otherwise, getElementAt may return the dribble.



Check if something is here

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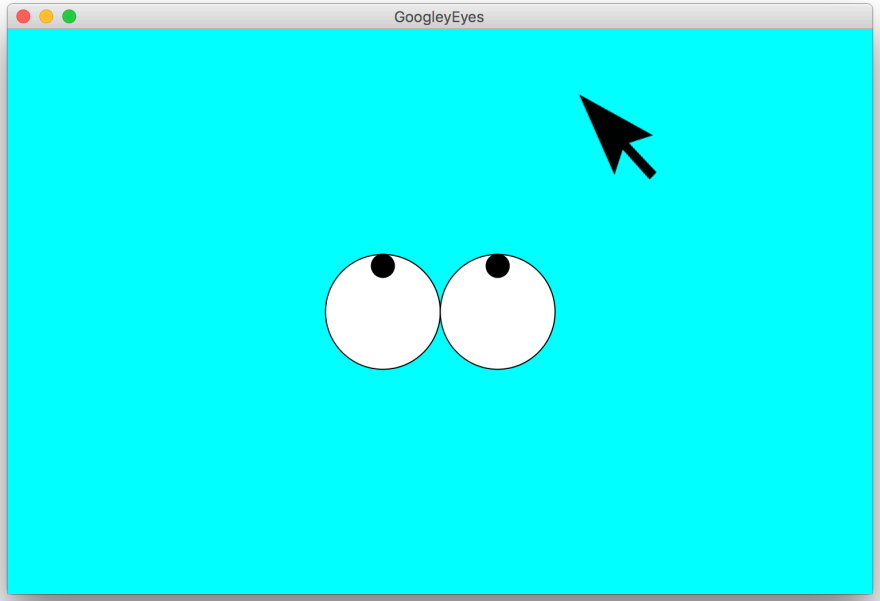
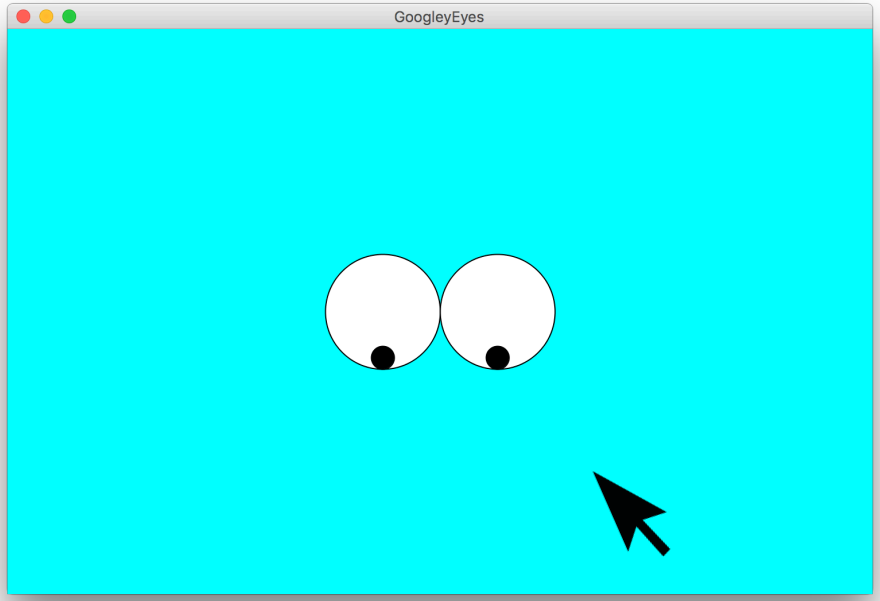
Extra Practice: GoogleyEyes

Let's write a program called **GoogleyEyes** that draws eyes whose pupils follow the user's mouse vertically as it moves around.





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A Boolean Aside

There is one helpful property of how Java evaluates boolean expressions, called **short-circuit evaluation**.

When evaluating boolean expressions, Java only evaluates *as much of the expression as it needs to* in order to evaluate it to be true or false.

A Boolean Aside

```
String str = readLine("? ");

if (str.length() > 0 && str.charAt(0) == 'A') {
      ...
}
```

A Boolean Aside

```
String str = readLine("? "); // what about “”!

if (str.length() > 0 && str.charAt(0) == 'A') {
      ...
}
```

A Boolean Aside

```
String str = readLine("? "); // what about “”!

if (str.length() > 0 && str.charAt(0) == 'A') {
      ...
}
```

A Boolean Aside

```
String str = readLine("? "); // what about “”!

if (str.length() > 0 && str.charAt(0) == 'A') {
      ...
}
```

Java only executes this if the first part is **true**! This means it never crashes.

A Boolean Aside

```
GObject obj = getElementAt(x, y);

if (obj == null || obj.getX() == 0) {
      ...
}
```

A Boolean Aside

```
GObject obj = getElementAt(x, y); // what about null!

if (obj == null || obj.getX() == 0) {
      ...
}
```

A Boolean Aside

```
GObject obj = getElementAt(x, y); // what about null!

if (obj == null || obj.getX() == 0) {
      ...
}
```

A Boolean Aside

```
GObject obj = getElementAt(x, y); // what about null!

if (obj == null || obj.getX() == 0) {
      ...
}
```

Java only executes this if the first part is **false**! This means it never crashes.

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A Variable love story

By Chris Piech

A Variable ~~love~~ origin story

By ~~Chris Piech~~ Nick Troccoli

Chapter 1: Birth

Once upon a time…

...a variable x was born!

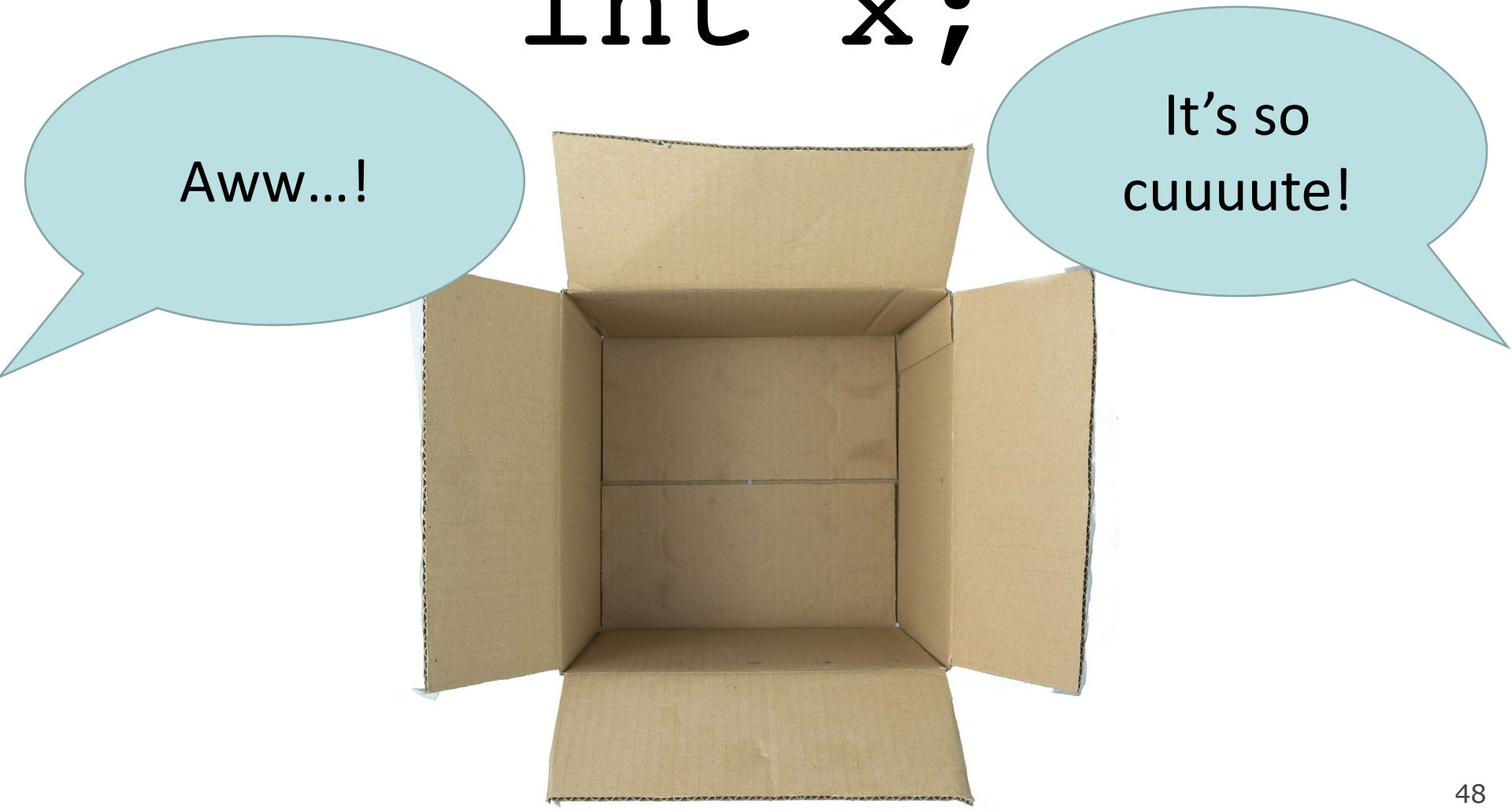
```
int x;
```

...a variable x was born!

```
int x;
```

x was a primitive variable…

```
int x;
```



...and its parents loved it very much.

```
int x;
```

We should give it.... value 27!

...and its parents loved it very much.

```
x = 27;
```

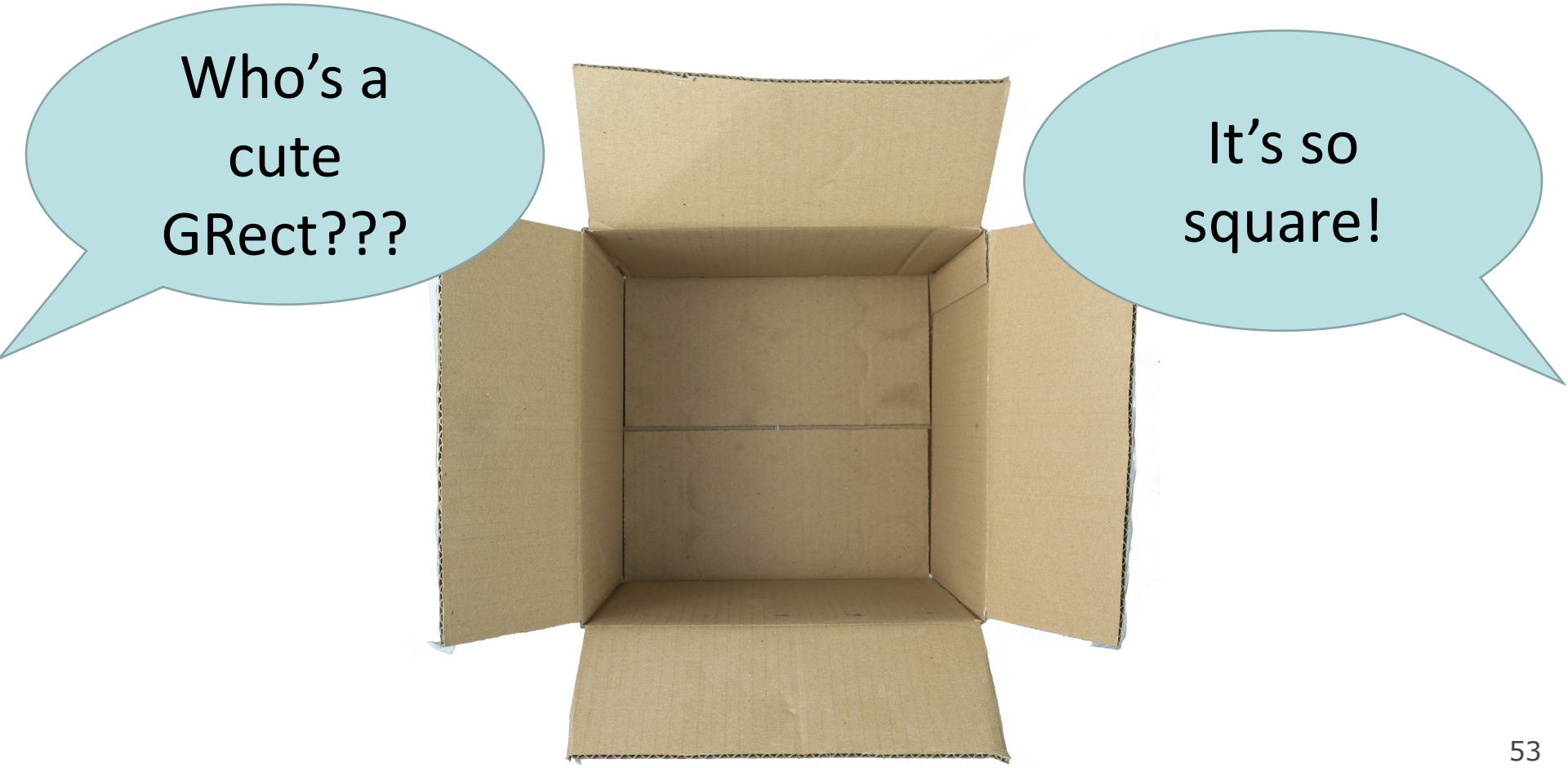
A few years later, the parents decided to have another variable.

...and a variable rect was born!

```
GRect rect;
```

rect was an object variable…

```
GRect rect;
```



...and its parents loved it very much.

```
GRect rect;
```

We should make it.... a big, strong GRect!

...and its parents loved it very much.

```
GRect rect = new Grect(0, 0, 50, 50);
```

We should make it.... a big, strong GRect!

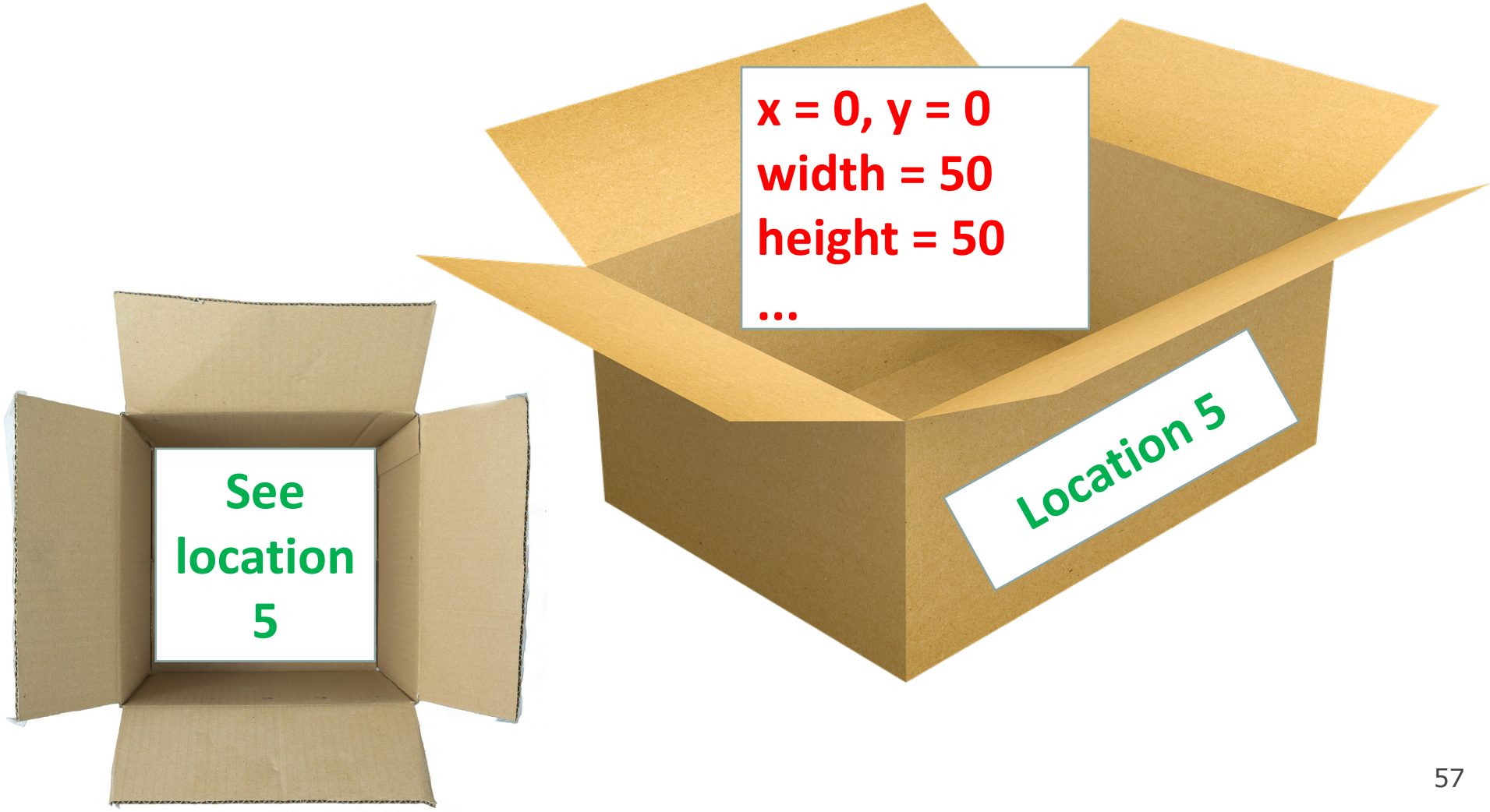
...but rect's box was not big enough for an object!

```
GRect rect = new Grect(0, 0, 50, 50);
```

That box isn't big enough to store everything about a GRect!

...so they stored the information in a bigger box somewhere else.

```
GRect rect = new Grect(0, 0, 50, 50);
```



Chapter 2: Friends

...x makes a new friend!

```
int y = 27;
```

...x makes a new friend!

```
int y = 27;
```

...x makes a new friend!

```
int y = 27;
```

...x makes a new friend!

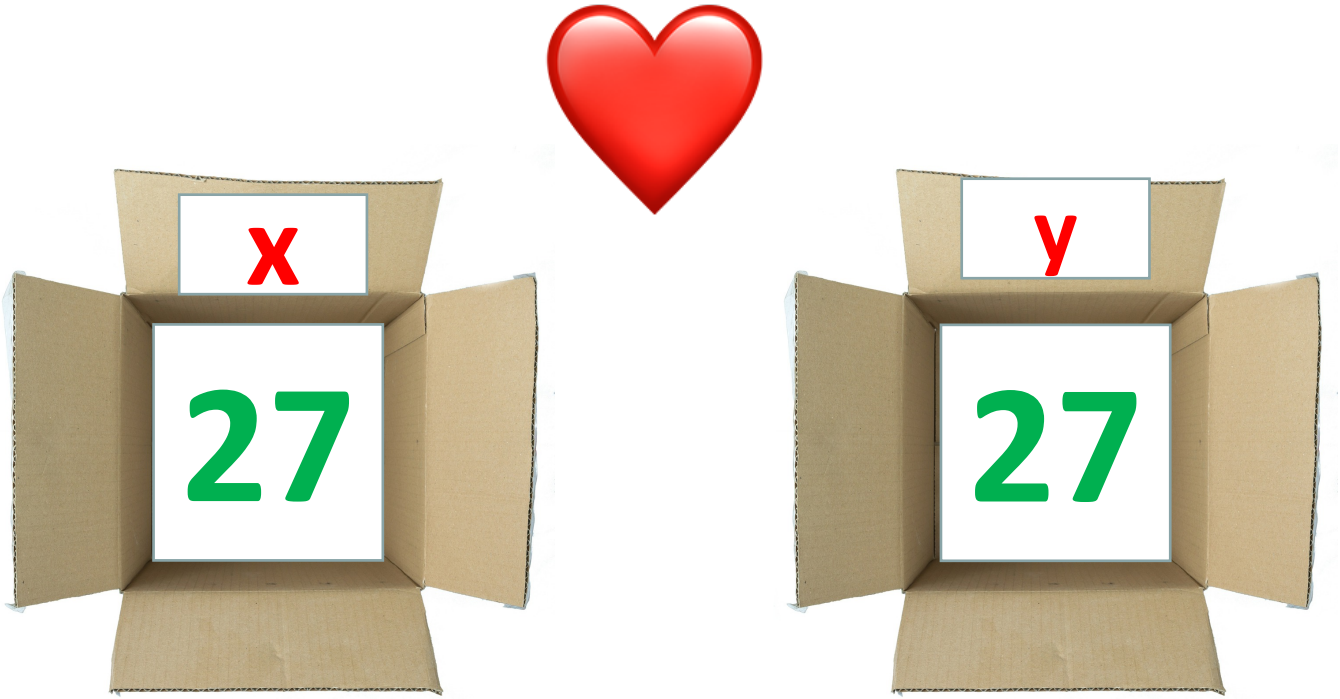
```
int y = 27;
```

They can use == to compare values.

```
if (x == y) { // true!
    ...
}
```

They can use == to compare values.

```
if (x == y) { // true!
    ...
}
```



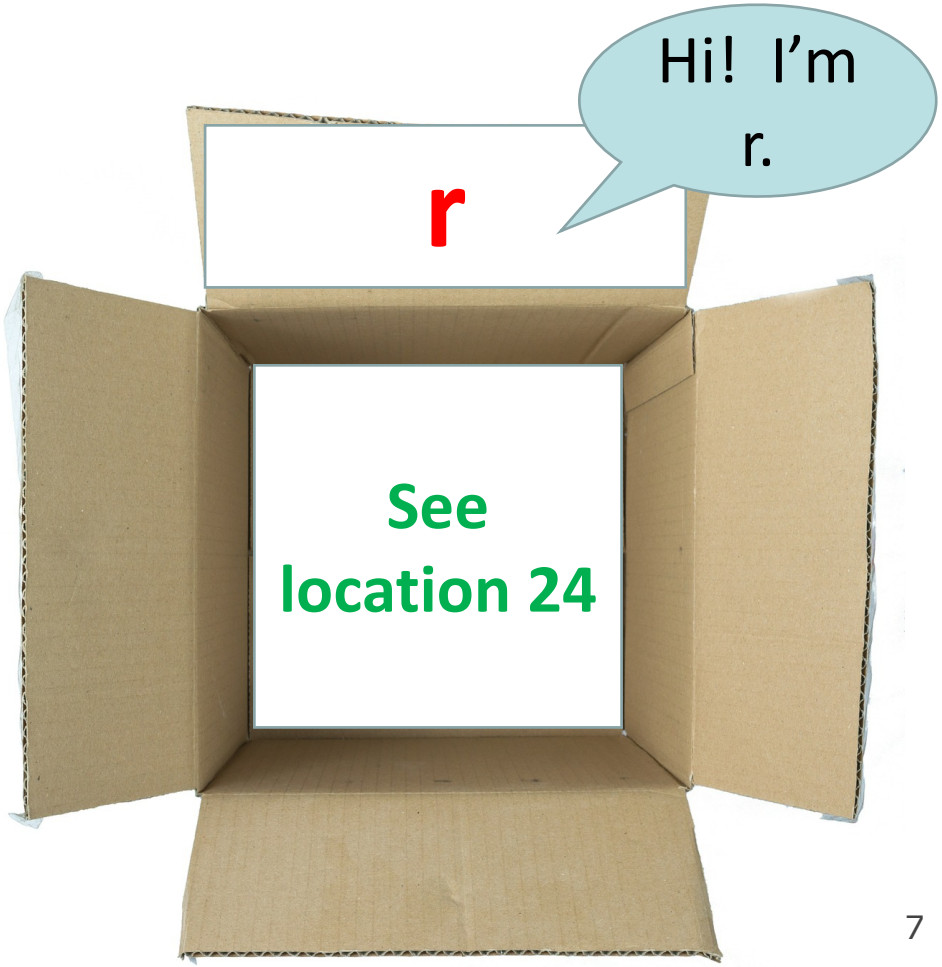
See “A Variable Love Story” for more...

rect also makes a new friend!

```
GRect r = new Grect(0, 0, 50, 50);
```

Rect also makes a new friend!

```
GRect r = new Grect(0, 0, 50, 50);
```

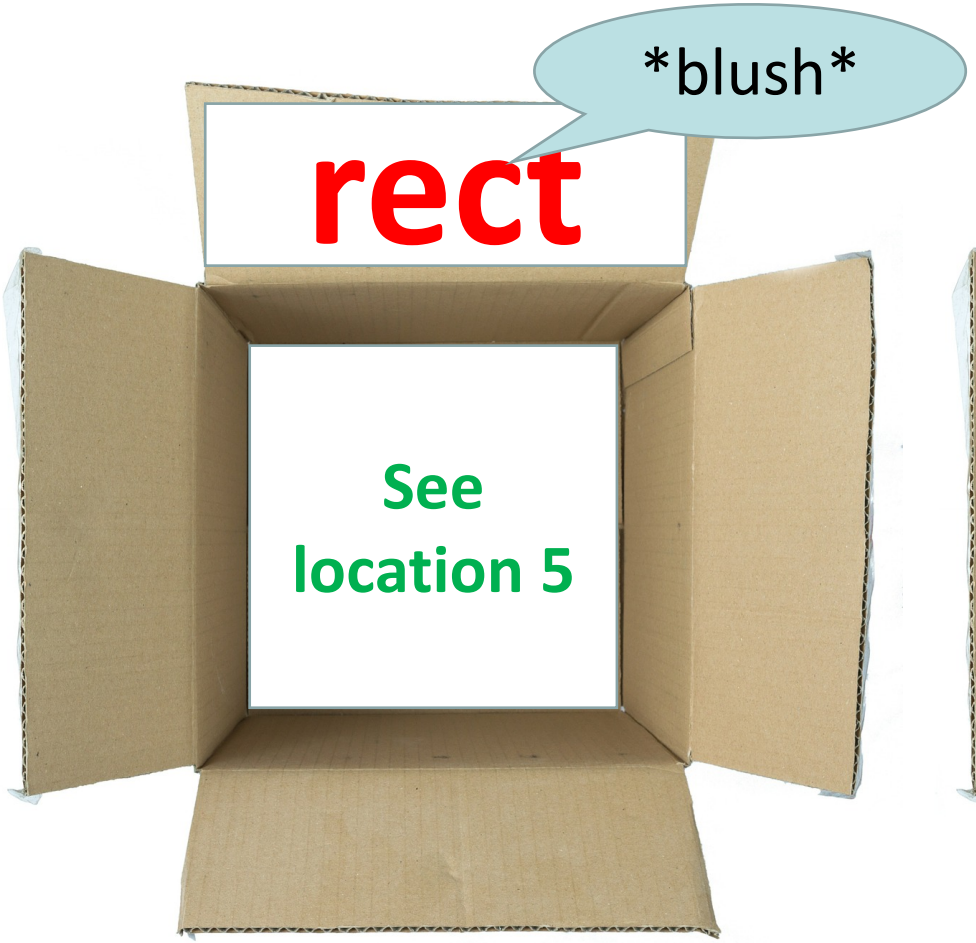


Rect also makes a new friend!

```
GRect r = new Grect(0, 0, 50, 50);
```

Rect also makes a new friend!

```
GRect r = new Grect(0, 0, 50, 50);
```



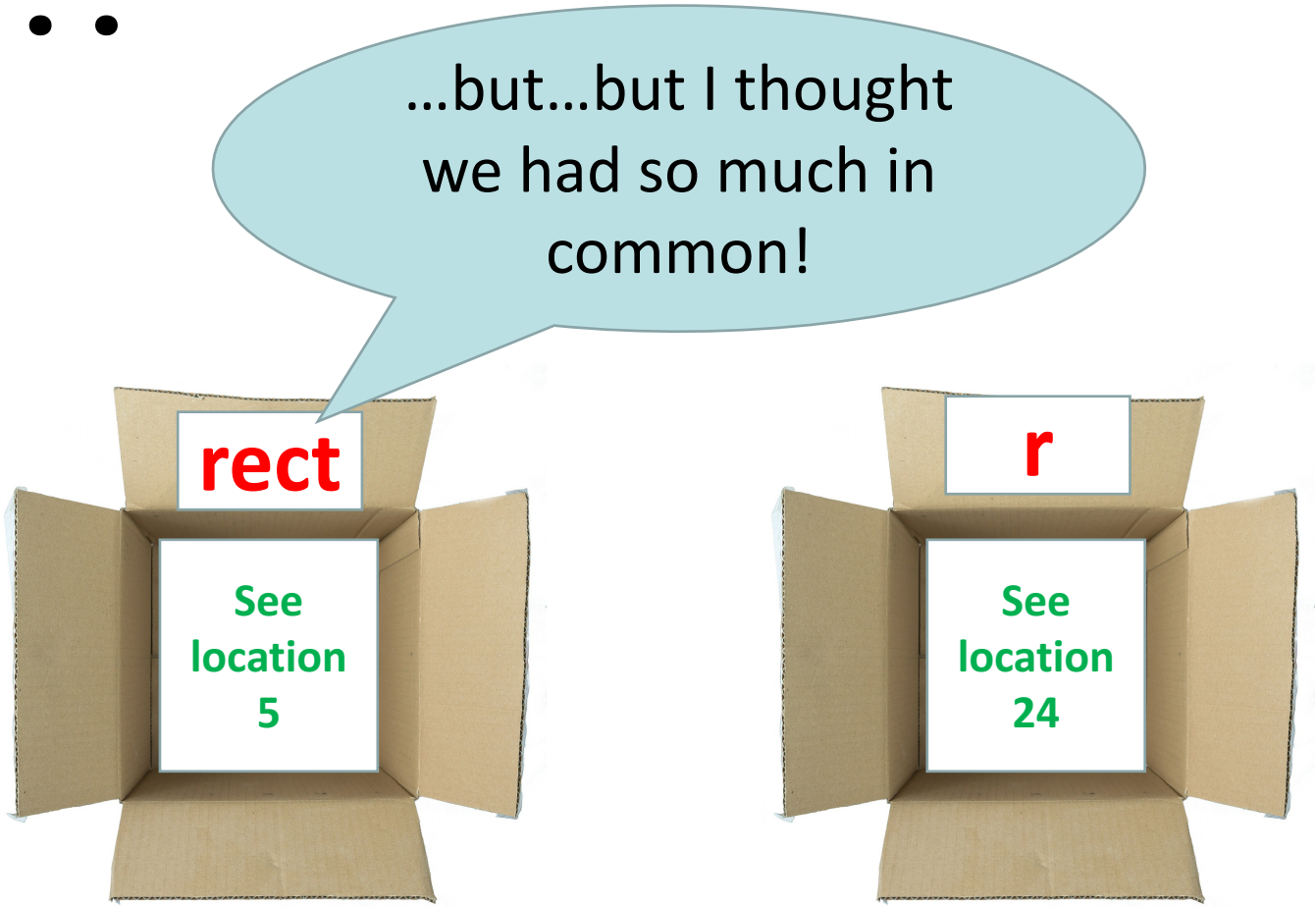
But when they use == to compare values...

...something goes wrong.

```
if (rect == r) { // false!
    ...
}
```

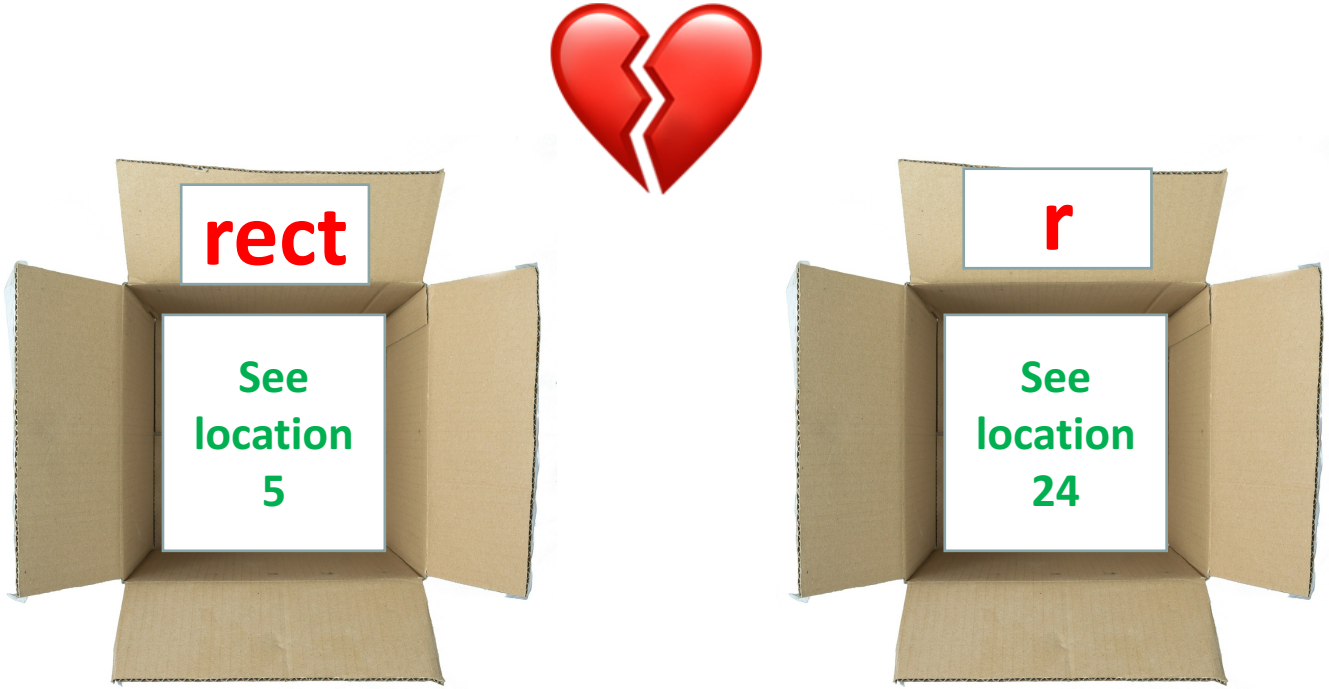
...something goes wrong.

```
if (rect == r) { // false!
    ...
}
```



...something goes wrong.

```
if (rect == r) { // false!
    ...
}
```



...something goes wrong.

```
if (rect == r) { // false!
    ...
}
```

You see, == compares what is in *each variable's box.*

...something goes wrong.

```
if (rect == r) { // false!
    ...
}
```

Primitives store their *actual value* in their box.

...something goes wrong.

```
if (rect == r) { // false!
    ...
}
```

But objects store the *location* where all their information lives.

...something goes wrong.

```
if (rect == r) { // false!
    ...
}
```

This means == on objects compares their *locations*, which is not what we want here!

Chapter 3: Twins

One day, they wanted a twin.

Wow, what an awesome int! Let's make another one.

One day, they wanted a twin.

Wow, what an awesome int! Let's make another one.

```
int x2 = x;
```

...so x2 was born!

Wow, what an awesome int! Let's make another one.

```
int x2 = x;
```

...so x2 was born!

But let's increment this one by 2.

```
int x2 = x;
x2 += 2;
```

...so x2 was born!

```
int x2 = x;
x2 += 2;
```

Cool, I'm 29 now!

...so x2 was born!

And I'm still 27!

```
int x2 = x;
x2 += 2;
```

Then, they wanted a twin for rect, too.

Wow, what an awesome GRect! Let's make another one.

...so rect2 was born!

Wow, what an awesome GRect! Let's make another one.

```
GRect rect2 = rect;
```

...so rect2 was born!

Wow, what an awesome GRect! Let's make another one.

```
GRect rect2 = rect;
```

...so rect2 was born!

But let's make this one BLUE.

```
GRect rect2 = rect;
rect2.setColor(Color.BLUE);
```

...so they went to location 5 and changed the color to blue.

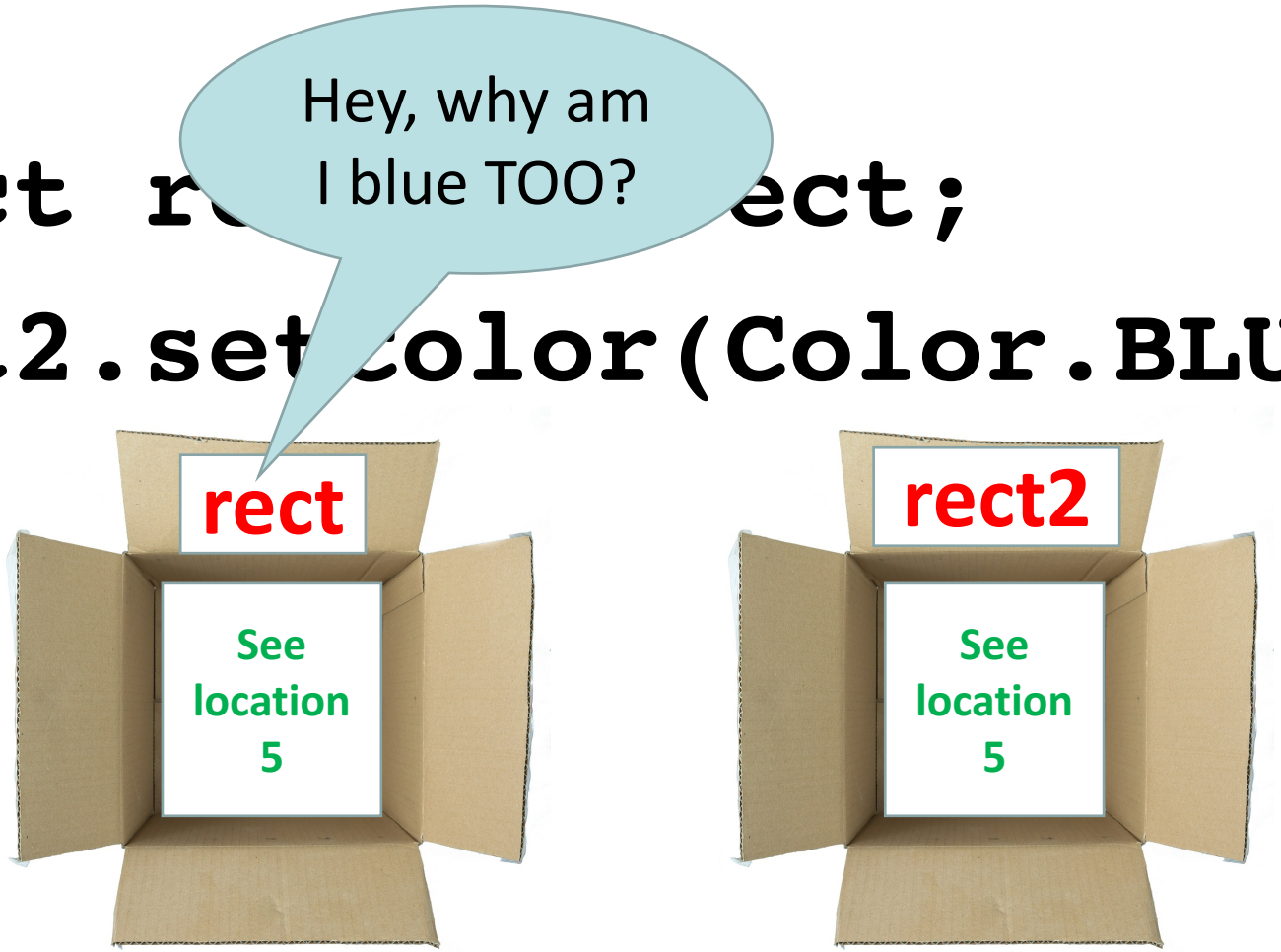
But something went wrong…

Cool, I'm blue!

```
GRect rect2 = rect
rect2.setColor(Color.BLUE);
```

But something went wrong…

```
GRect r      ect;
rect2.set Color(Color.BLUE);
```



But something went wrong…

You see, when you set one variable equal to another, the value *in its box* is copied over.

```
GRect rect2 = rect;
rect2.setColor(Color.BLUE);
```

But something went wrong…

For primitive variables, this just means we copy their value.

```
GRect rect2 = rect;
rect2.setColor(Color.BLUE);
```

But something went wrong…

But for objects, we copy its *location* instead.

```
GRect rect2 = rect;
rect2.setColor(Color.BLUE);
```

But something went wrong…

Therefore, both rect and rect2 think their information is at location 5.

```
GRect rect2 = rect;
rect2.setColor(Color.BLUE);
```

But something went wrong…

When you change information for an object, you go to its location first, and then update the information.

```
GRect rect2 = rect;
rect2.setColor(Color.BLUE);
```

But something went wrong…

Since rect and rect2 reference the same location, when you change information for one of them, it changes for both!

```
GRect rect2 = rect;

rect2.setColor(Color.BLUE);
```

Chapter 4: Leaving the Nest

X grew up, and went to college.

```
college(x);
```

X grew up, and went to college.

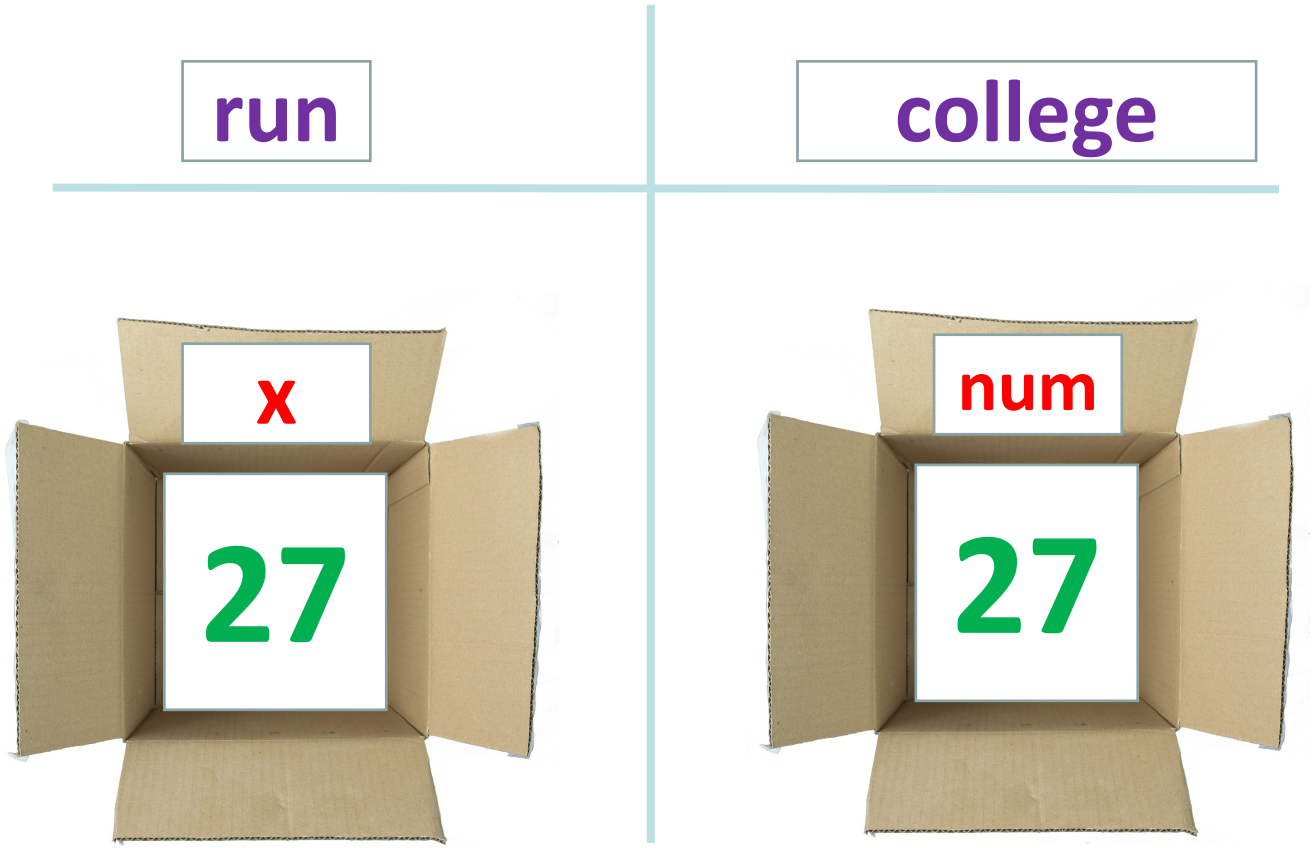
```
college(x);
```

We'll miss you, honey! Don't forget to call! Don't stay up too late! Watch out for rogue bicyclists!

Bye everyone! I'm going to college.

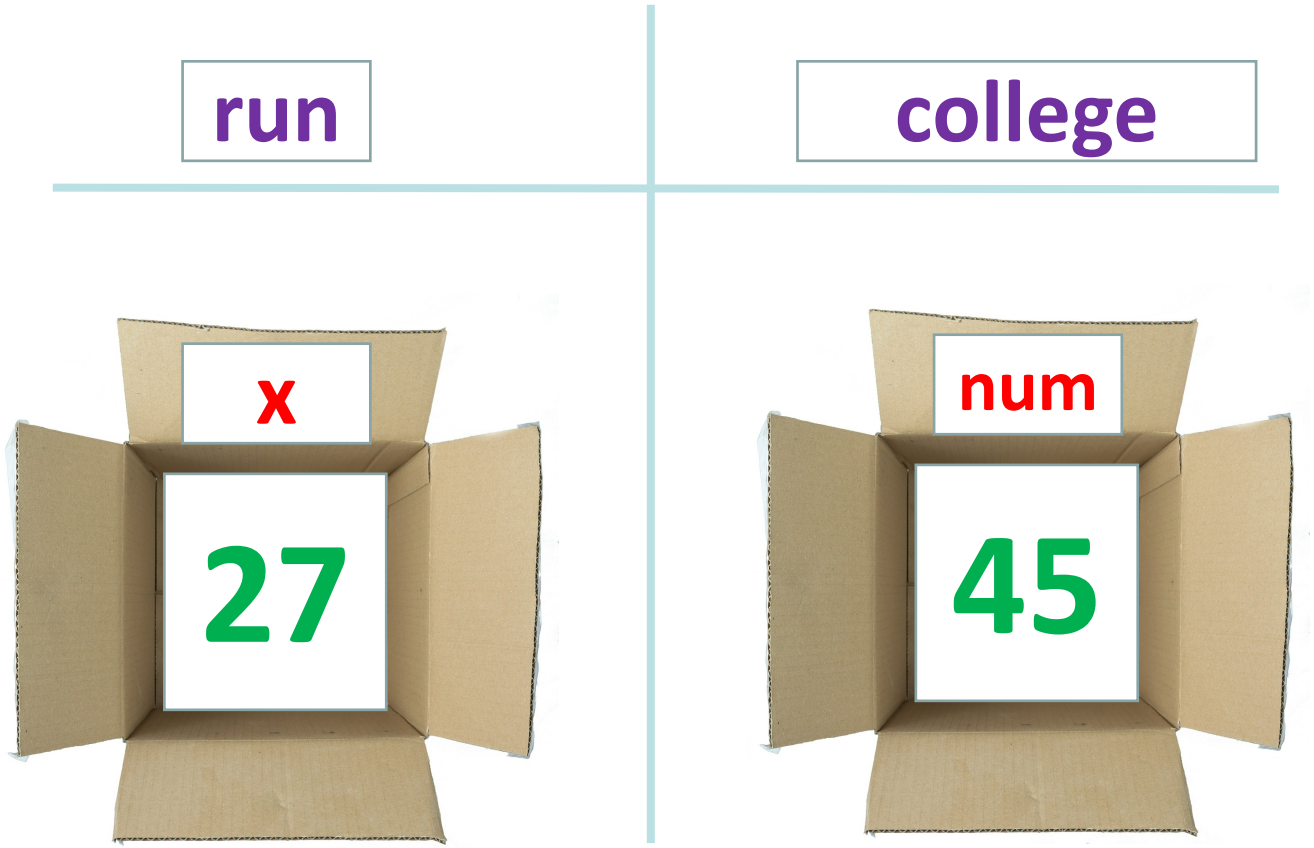
X grew up, and went to college.

```
private void college(int num) {
    ...
}
```



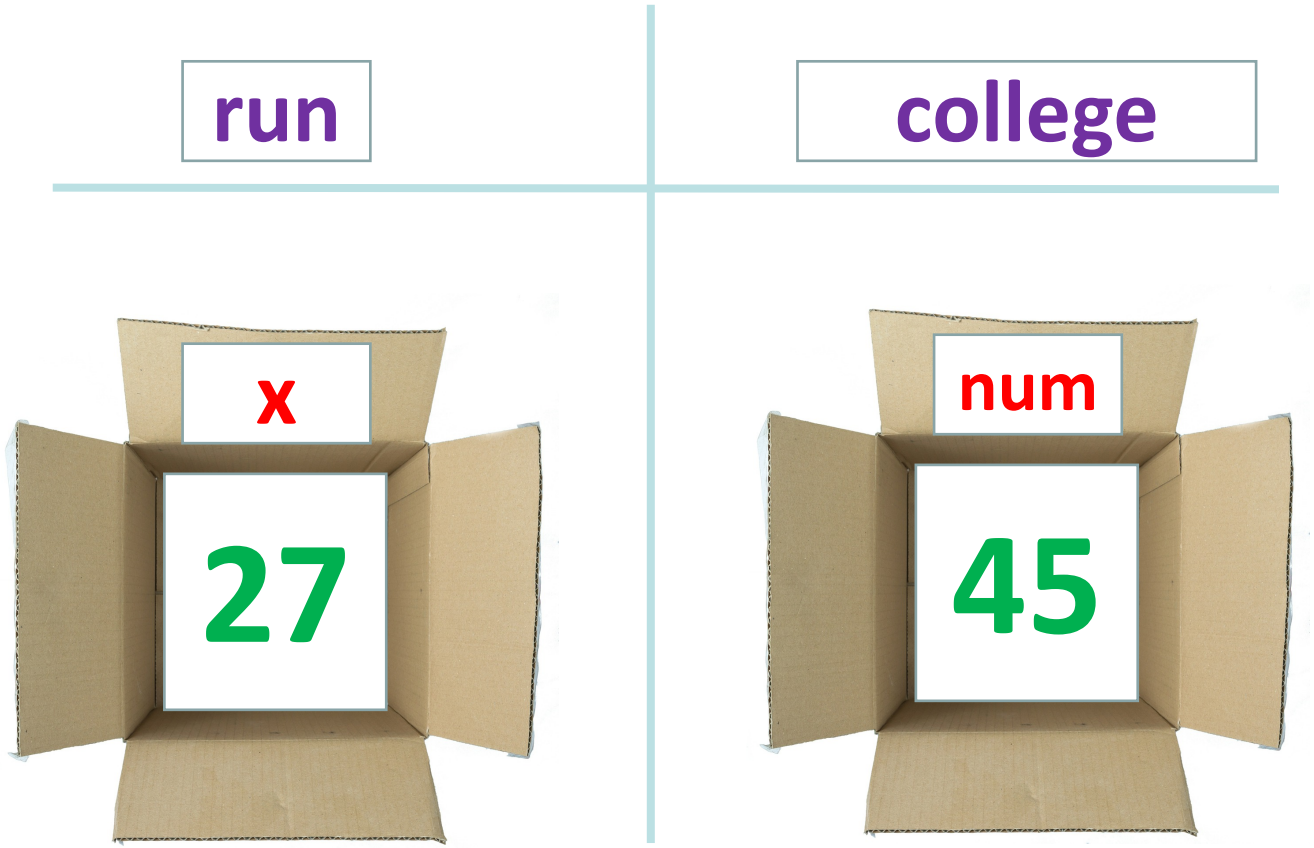
x had an amazing college experience…

```
private void college(int num) {
    num = 45;
}
```



...but ultimately returned home the same.

```
private void college(int num) {
    num = 45;
}
```



...but ultimately returned home the same.

```
college(x);
println(x);
```

...but ultimately returned home the same.

```
college(x);
println(x);
```

Ohhhh honey! You'll always be our little 27.

I'm baaaaack! And I'm still 27.

rect grew up too, and also went to college.

```
college2(rect);
```

rect grew up too, and also went to college.

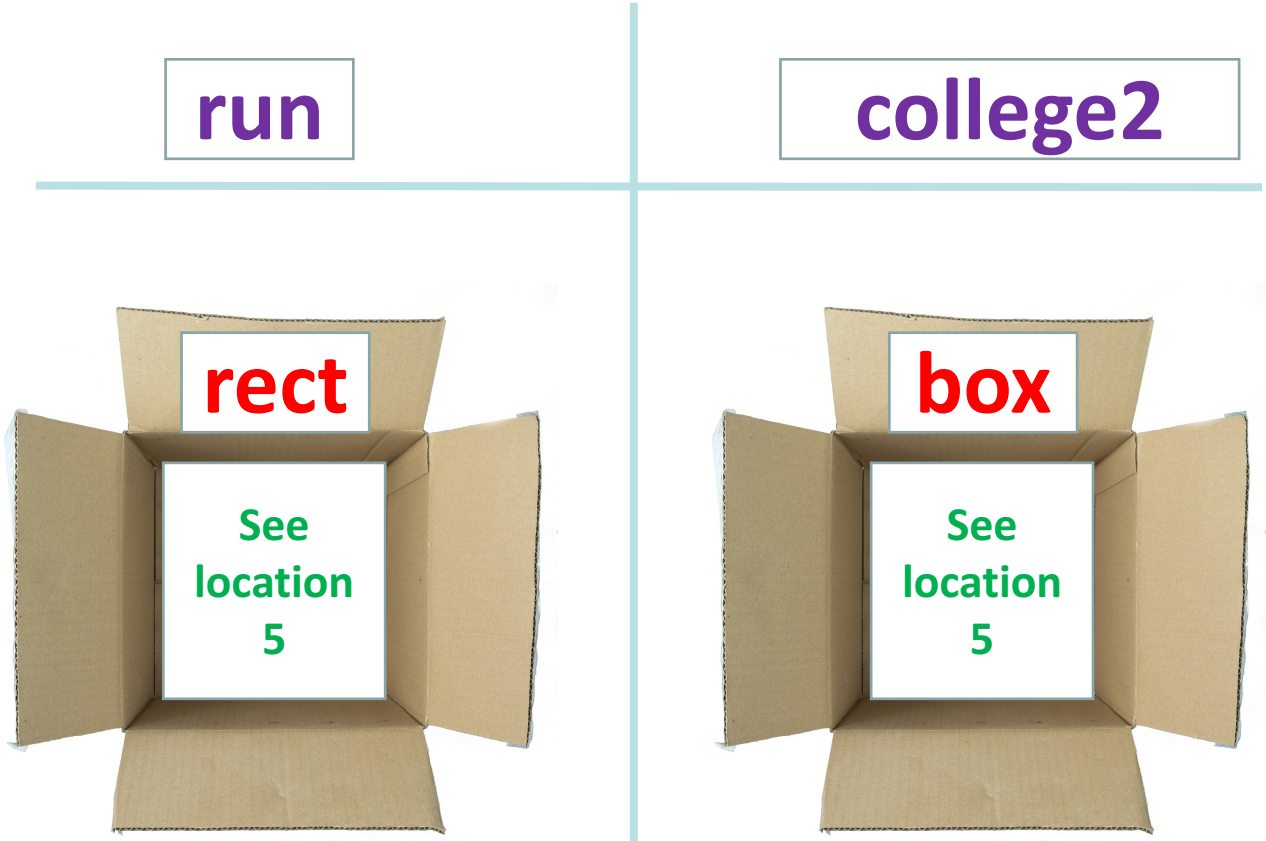
```
college2(rect);
```

Not you too, rect! We are empty nesters now…

Bye everyone! I'm going to college.

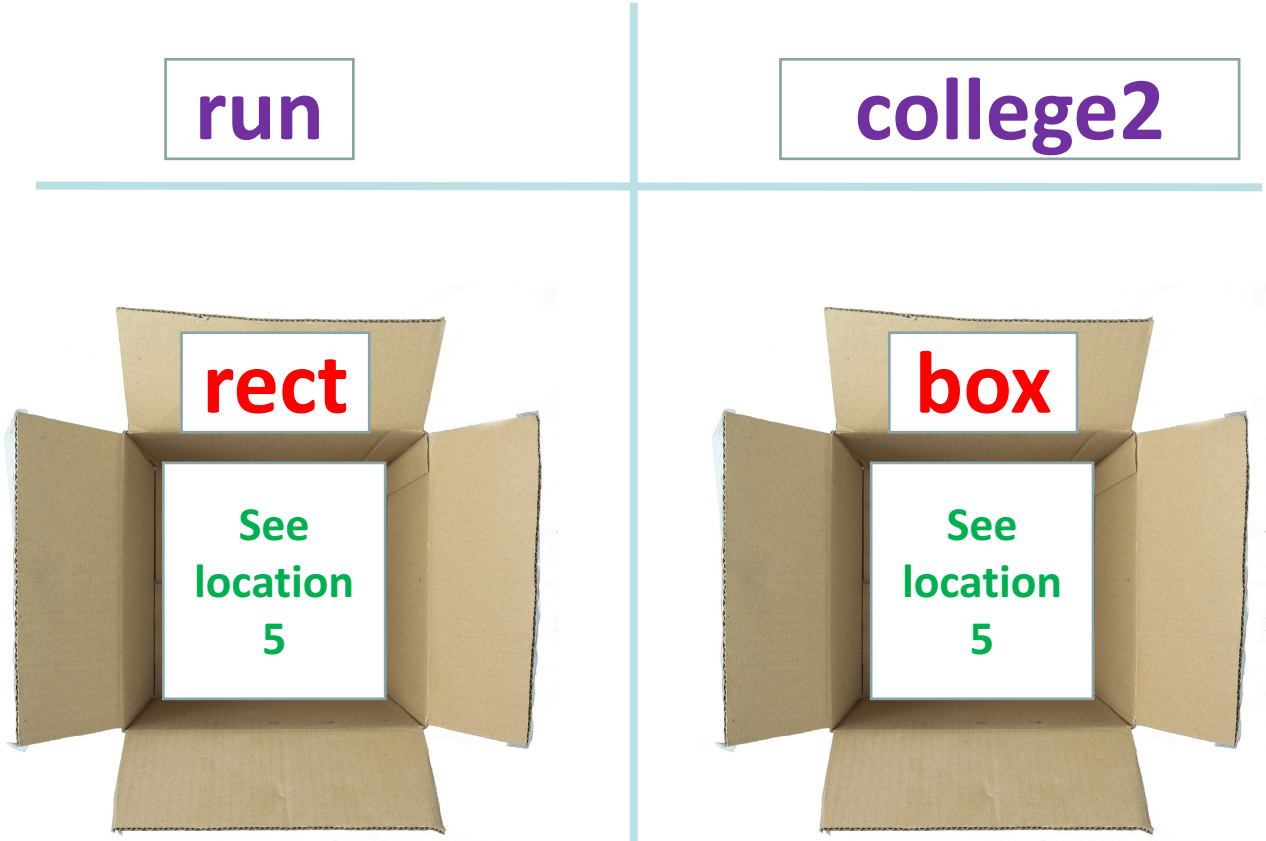
rect grew up too, and also went to college.

```
private void college2(GRect box) {
    ...
}
```



rect also had an amazing college experience…

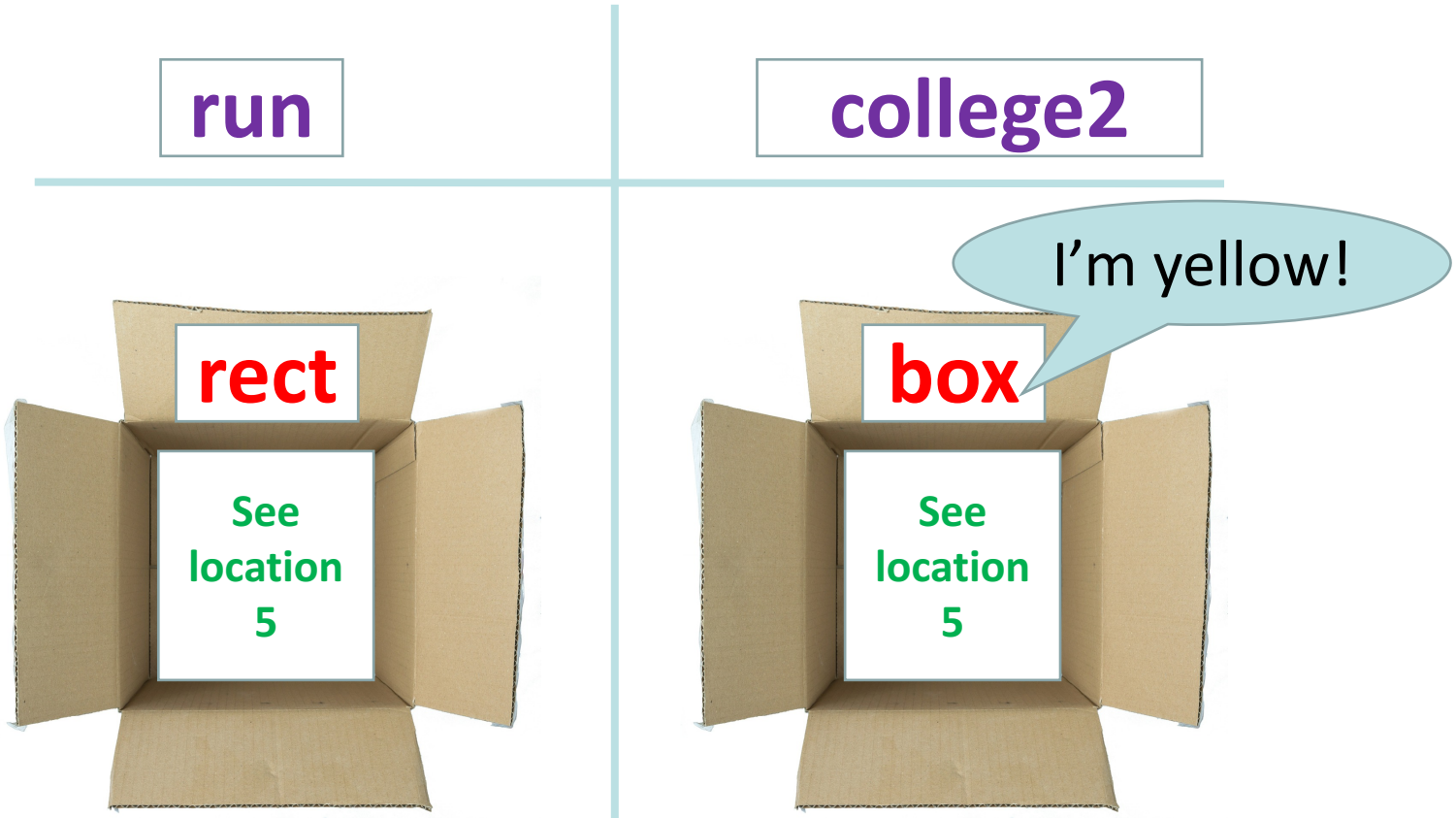
```
private void college2(GRect box) {
    box.setColor(Color.YELLOW);
}
```



rect also had an amazing college experience…

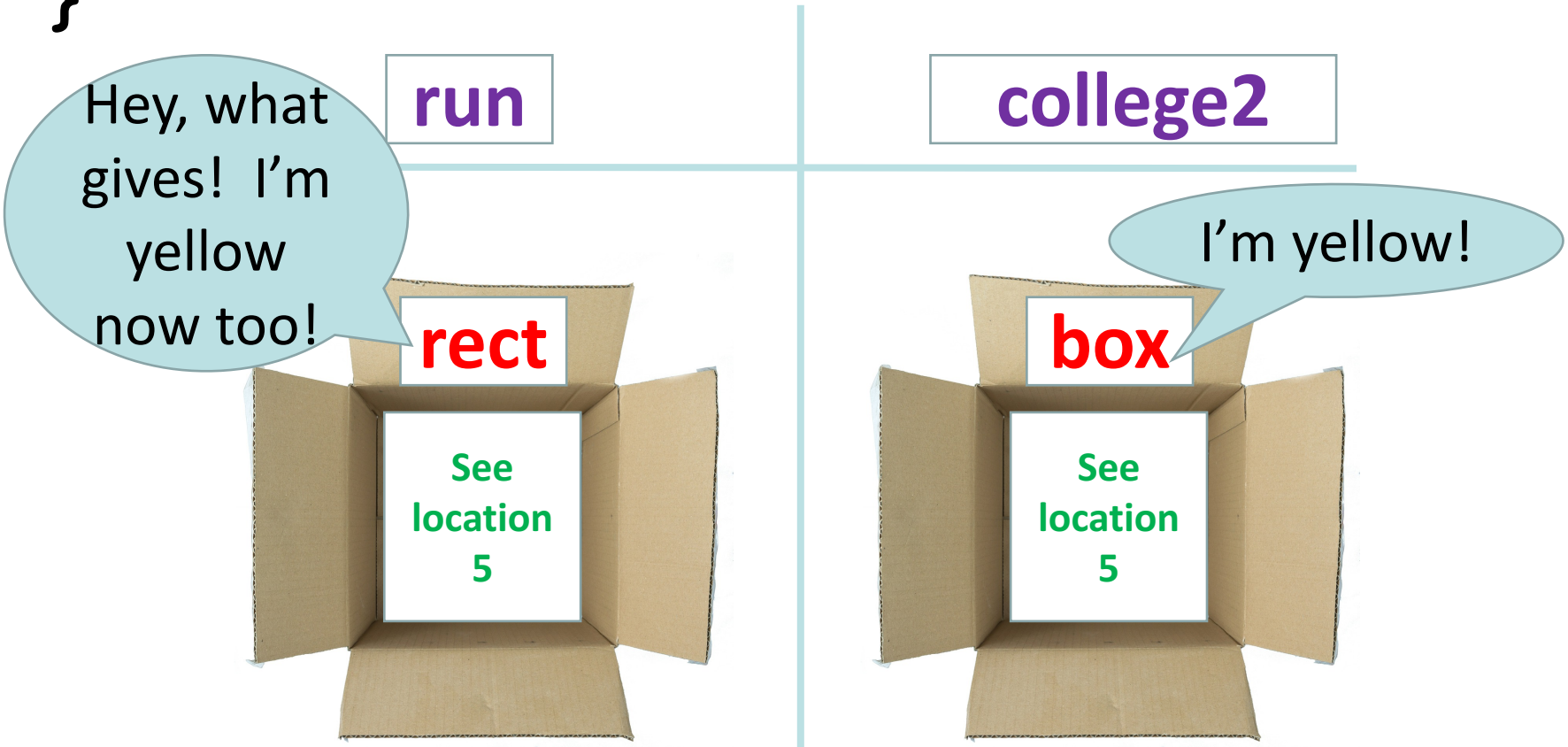
...but it returned home different.

```
private void college2(GRect box) {
    box.setColor(Color.YELLOW);
}
```



...but it returned home different.

```
private void college2(GRect box) {
    box.setColor(Color.YELLOW);
}
```



...but it returned home different.

```
college(rect);
add(rect);
```

...but it returned home different.

```
college(rect);
add(rect);
```

Oh my gosh….what *happened* to you??!

I'm baaaaack! But now I'm yellow…

...but it returned home different.

```
college(rect);
add(rect);
```

You see, when a variable is passed as a parameter, the value *inside its box* is copied and given to the method.

...but it returned home different.

```
college(rect);
add(rect);
```

For primitives, we make a copy of their *actual value*. Therefore, changes to a parameter do not affect the original.

...but it returned home different.

```
college(rect);
add(rect);
```

However, for objects we make a copy of their *location*. So changes to the parameter *do affect the original*!

The End

Primitives vs. Objects

- **Primitives** store their *actual value* in their variable box. You can compare values with == and !=, and the original does not change when passed as a parameter and changed.
- **Objects** store their *location* in their variable box. You can't compare properties of an object via ==, and the original *does* change when passed as a parameter and changed.
- **Primitives** are *passed by value*, **Objects** are *passed by reference*

Practice — Chapter 2: Friends

Practice

```
public void run() {
    int x = 5;
    int y = 5;
    println(x == y);
}
```

Does this print out **true** or **false**?

Practice

```
public void run() {
    GRect first = new GRect(20, 30);
    GRect second = new GRect(20, 30);
    println(first == second);
}
```

Does this print out **true** or **false**?

Practice — Chapter 3: Twins

Practice

```
public void run() {
    int x = 5;
    int y = x;
    y += 2;
    println(y);
    println(x);
}
```

What is printed out?

Practice

```
public void run() {
    GOval oval = new GOval(0, 0, 50, 50);
    GOval oval2 = oval1;
    oval2.setColor(Color.BLUE);
    add(oval2);
    add(oval);
}
```

What color are oval and oval2?

Practice — Chapter 4: Leaving the Nest

Practice

```
public void run() {
    int x = 2;
    addFive(x);
    println(x);
}

private void addFive(int num) {
    num += 5;
}
```

What is printed out?

Practice

```
public void run() {
    GRect rect = new GRect(0, 0, 50, 50);
    makeBlue(rect);
    add(rect);
}

private void makeBlue(GRect box) {
    box.setColor(Color.BLUE);
}
```

What color is rect?

Primitives vs. Objects

Primitives store their actual values. **Objects** store their *locations*.

This affects how your code behaves!

getElementAt

getElementAt returns a *reference* to an object.

```
GRect rect = new GRect(0, 0, 50, 50);
add(rect);
...

GObject obj = getElementAt(25, 25);
println(obj == rect);
```

This prints **true**!

Plan for Today

- Announcements
- Review: Null, Events and Instance Variables
- Extra Practice: Googley Eyes
- A Boolean Aside
- Memory
- Revisiting Whack-A-Mole

Revisiting Whack-A-Mole

Let's revisit our Whack-A-Mole program to add some new functionality using what we just learned.

Recap

- Announcements
- Review: Null, Events and Instance Variables
- Extra Practice: Googley Eyes
- A Boolean Aside
- Memory
- Revisiting Whack-A-Mole

Good luck on the midterm!