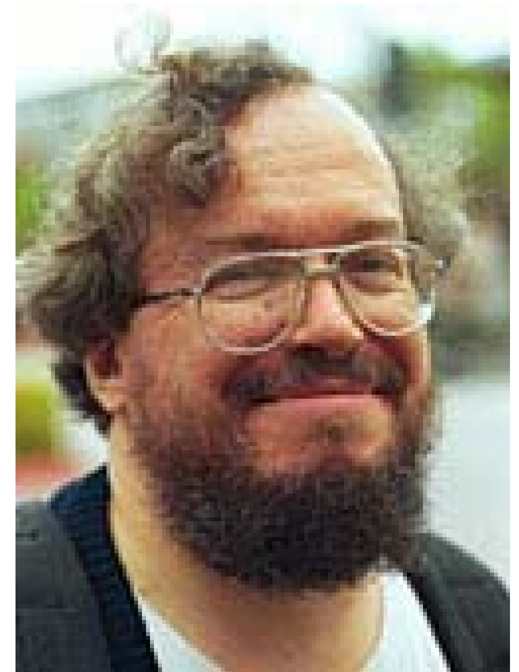
Topic 3
Pointers and Object Variables

"Thou shalt not follow the NULL pointer, for chaos and madness await thee at its end."

- Henry Spencer



Object Variables

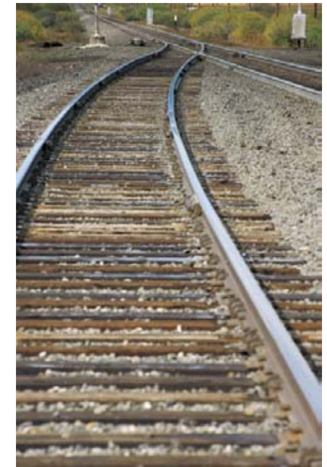
- object variables are declared by stating the class name / data type and then the variable name
  - same as primitives
  - in Java there are hundreds of built in classes.
    - show the API page
  - don't learn the classes, learn how to read and use a class interface (the users manual)
- objects are *complex* variables.
  - They have an internal *state* and various *behaviors* that can either change the state or simply tell something about the object

Object Variables

```
public void objectVaraiables()
{     Rectangle rect1;
      Rectangle rect2;
      // 2 Rectangle objects exist??
      // more code to follow
}
```

- So now there are 2 Rectangle objects right?
- Not so much.
- Object variables in Java are actually *references* to objects, not the objects themselves!
  – object variables store the memory address of an object of the proper type *not* an object of the proper type.
  – contrast this with primitive variables

The Pointer Sidetrack



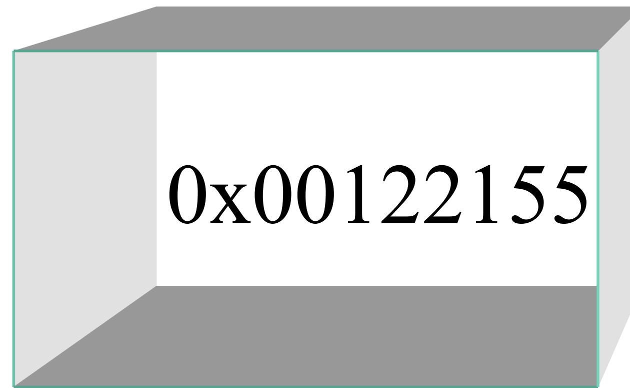
- IMPORTANT!! This material may seem a bit abstract, but it is often the cause of many a programmers logic error
- A pointer is a variable that stores the memory address of where another variable is stored
- In some languages you can have *bound* variables and dynamic variables of any type
  - a bound variable is one that is associated with a particular portion of memory that cannot be changed
- Example C++, can have an integer variable or a integer pointer (which is still a variable)

```
int intVar; // a int var
int * intPtr; //pointer to an int var
```

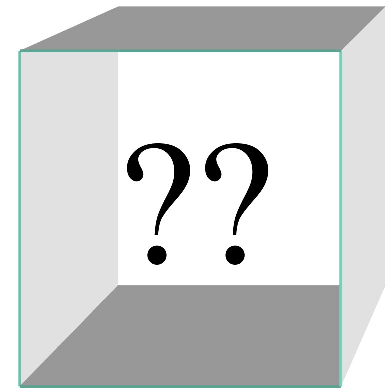
Pointer Variables in C++

```
int intVar = 5; // a int var
int * intPtr; //pointer to an int var
intPtr = new int;
/* dynamically allocate an space to store an int.
intPtr holds the memory address of this space*/
```

intVar



intPtr



space for an int in memory
assume memory address 0x00122155

Pointer Complications

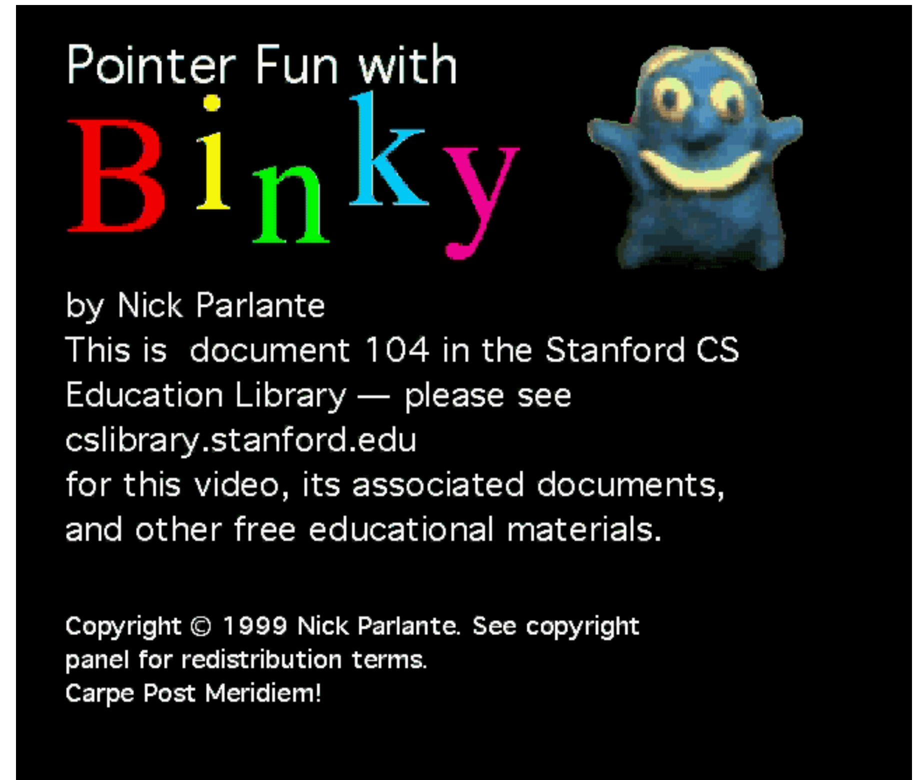
- C++ allows actual variables and pointers to variables of any type. Things get complicated and confusing very quickly

```
int intVar = 5; // a int var
int * intPtr; //pointer to an int var
intPtr = new int; // allocate memory
*intPtr = 12; /* assign the integer being
     pointed to the value of 12.  Must
     dereference the pointer.  i.e. get to
     the thing being pointed at*/
cout << intPtr << "\t" << *intPtr << "\t"
     << &intPtr << endl;
// 3 different ways of manipulating intPtr
```

- In C++ you can work directly with the memory address stored in intPtr
  – increment it, assign it other memory addresses, pointer “arithmetic”

And Now for Something Completely Different…

- Thanks Nick…
- Link to Bink

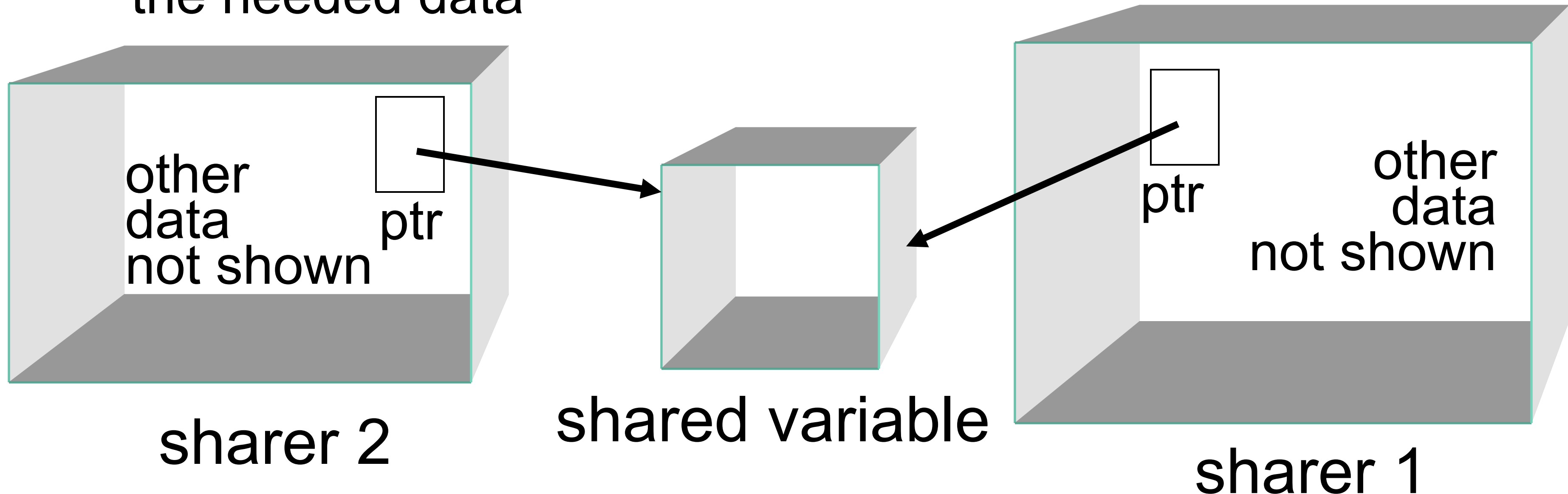


Benefit of Pointers

- Why have pointers?
- To allow the sharing of a variable
  - If several variables(objects, records, structs) need access to another single variable two alternatives

    1. keep multiple copies of variable.

    2. share the data with each variable keeping a reference to the needed data



More Benefits

- Allow dynamic allocation of memory
  - get it only when needed (*stack* memory and *heap* memory)
- Allow linked data structures such as *linked lists* and *binary trees*
  - incredibly useful for certain types of problems
- Pointers are in fact necessary in a language like Java where *polymorphism* is so prevalent (more on this later)
- Now the good news
  - In Java most of the complications and difficulties inherent with dealing with pointers are removed by some simplifications in the language

Dynamic Memory Allocation

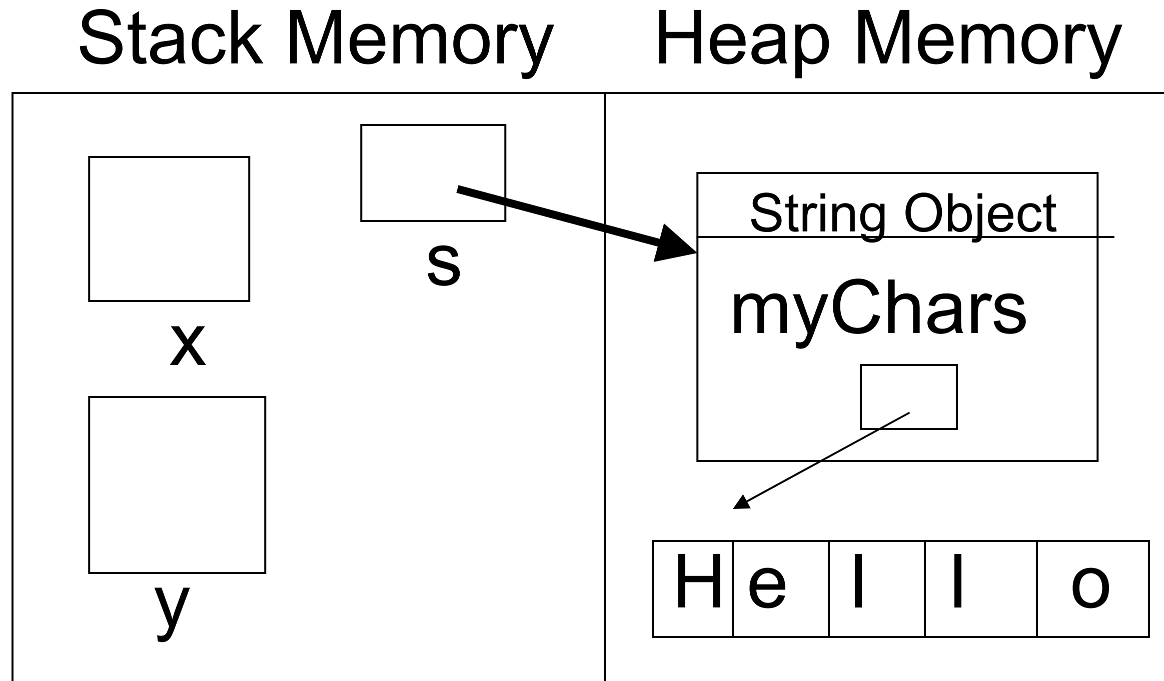
Your program has two chunks of memory to work with: *Stack memory* (or the *runtime Stack*) and *Heap memory*

When a Java program starts it receives two chunks of memory one for the Stack and one for the Heap.

Things that use Stack memory: local variables, parameters, and information about methods that are in progress.

Things that use Heap memory: everything that is allocated using the `new` operator.

The Picture




```
void toyCodeForMemory(int x)
{    int y = 10;
     x += y;
     String s = new String("Hello");
     System.out.println(x + " " + y + s);
}
```

How Much Memory?

How big is the Heap?

```
System.out.println("Heap size is " +
Runtime.getRuntime().totalMemory());
```

How much of the Heap is available?

```
System.out.println("Available memory: " +
Runtime.getRuntime().freeMemory());
```

Pointers in Java

- In Java all primitive variables are value variables. (real, actual, direct?)
  - it is impossible to have an integer pointer or a pointer to any variable of one of the primitive data types
- All object variables are actually *reference variables* (pointers, memory addresses) to objects.
  - it is impossible to have anything but pointers to objects. You can never have a plain object variable

Back to the Rectangle Objects

- rect1 and rect2 are variables that store the memory addresses of Rectangle objects
- right now they are uninitialized and since they are local, variables may not be used until they are given some value

```
public void objectVaraiables()
{       Rectangle rect1;
        Rectangle rect2;
        // rect1 = 0;        // syntax error, C++ style
        // rect1 = rect2; // syntax error, unitialized
        rect1 = null;   // pointing at nothing
        rect2 = null;   // pointing at nothing
}
```

- `null` is used to indicate an object variable is not pointing / naming / referring to any Rectangle object.

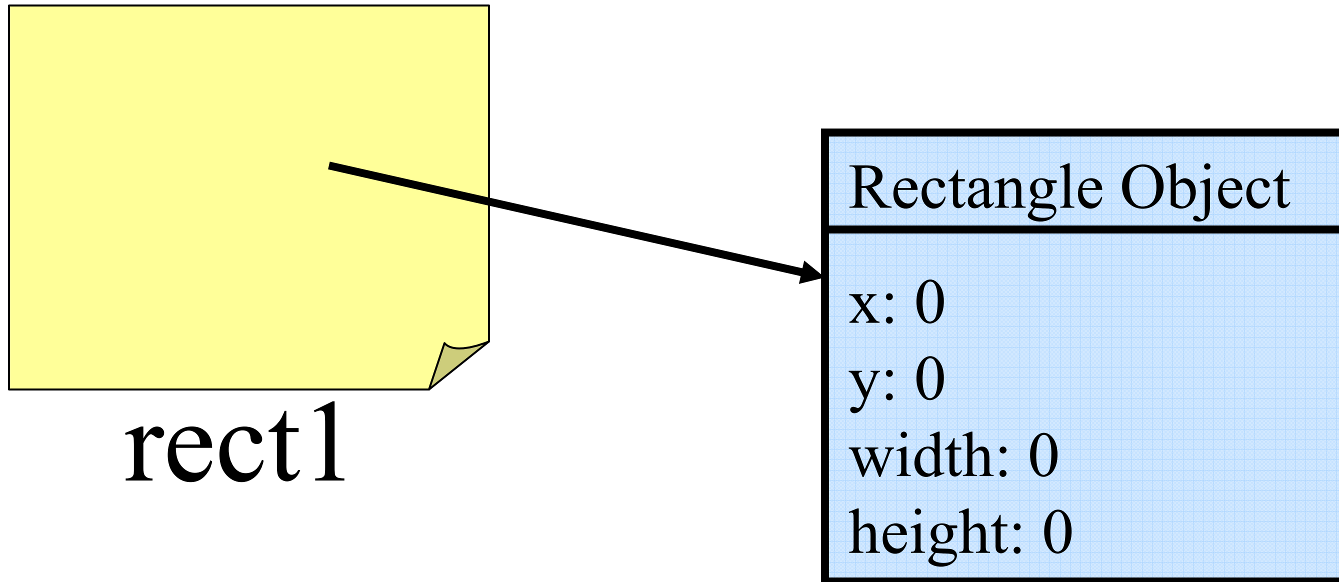
Creating Objects

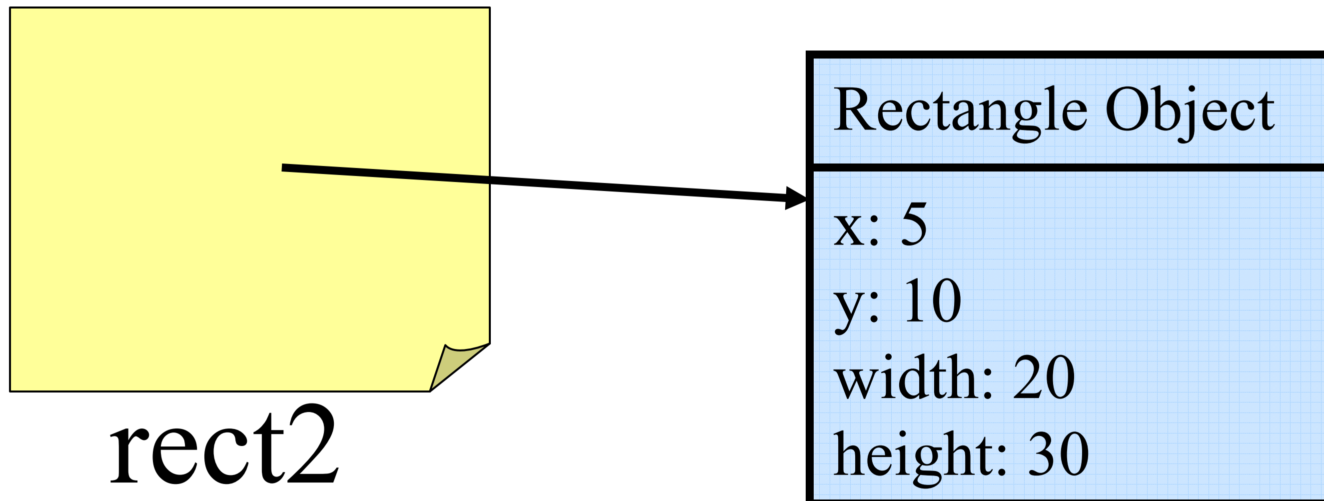
- Declaring object variables does *not* create objects.
  - It merely sets aside space to hold the memory address of an object.
  - The object must be created by using the `new` operator and calling a *constructor* for that object

```
public void objectVaraiables()
{     Rectangle rect1;
      rect1 = new Rectangle();
      Rectangle rect2 = new Rectangle(5,10,20,30);
      // (x, y, width, height)
      // rect1 and rect2 now refer to Rectangle objects
}
```

- For all objects, the memory needed to store the objects, is allocated dynamically using the `new` operator and a constructor call. (Strings are a special case.)
  - constructors are similar to methods, but they are used to initialize objects

The Yellow Sticky Analogy





Pointers in Java

- Is this easier?
  - primitives one thing, objects another?
- can't get at the memory address the pointer stores as in C++

  although try this:

```
Object obj = new Object();
System.out.println( obj.toString() );
```

- dereferencing occurs automatically
- because of the consistency the distinction between an object and an object reference can be blurred
  - "pass an object to the method" versus "pass an object reference to the method
- Need to be clear when dealing with memory address of object and when dealing with the object itself

Working with Objects

- Once an object is created and an object variable points to it then Object may be manipulated via its methods

```
Rectangle r1 = new Rectangle();
r1.resize(100, 200);
r1.setLocation(10, 20);
int area = r1.getWidth() * r1.getHeight();
Rectangle r2 = null;
r2.resize( r1.getWidth(), r1.getHeight() * 2 );
// uh-oh!
```

- Use the dot operator to deference an object variable and *invoke* one of the objects behaviors
- Available behaviors are spelled out in the class of the object, (the data type of the object)

What's the Output?

(Or, do you understand how object variables and pointers work?)

```
public void objectVariables(String[] args)
{       Rectangle rect1 = new Rectangle(5, 10, 15, 20);
        Rectangle rect2 = new Rectangle(5, 10, 15, 20);;
        System.out.println("rect 1: " + rect1.toString() );
        System.out.println("rect 2: " + rect2.toString() );
        System.out.println("rect1 == rect2:  " + (rect1 == rect2));
        rect1 = rect2;
        rect2.setSize(50, 100); // (newWidth, newHeight)
        System.out.println("rect 1: " + rect1.toString() );
        System.out.println("rect 2: " + rect2.toString() );
        System.out.println("rect1 == rect2:  " + (rect1 == rect2));
        int x = 12;
        int y = 12;
        System.out.println("x == y: " + (x == y) );
        x = 5;
        y = x;
        x = 10;
        System.out.println("x == y: " + (x == y) );
        System.out.println("x value: " + x + "\ty value: " + y);
}
```

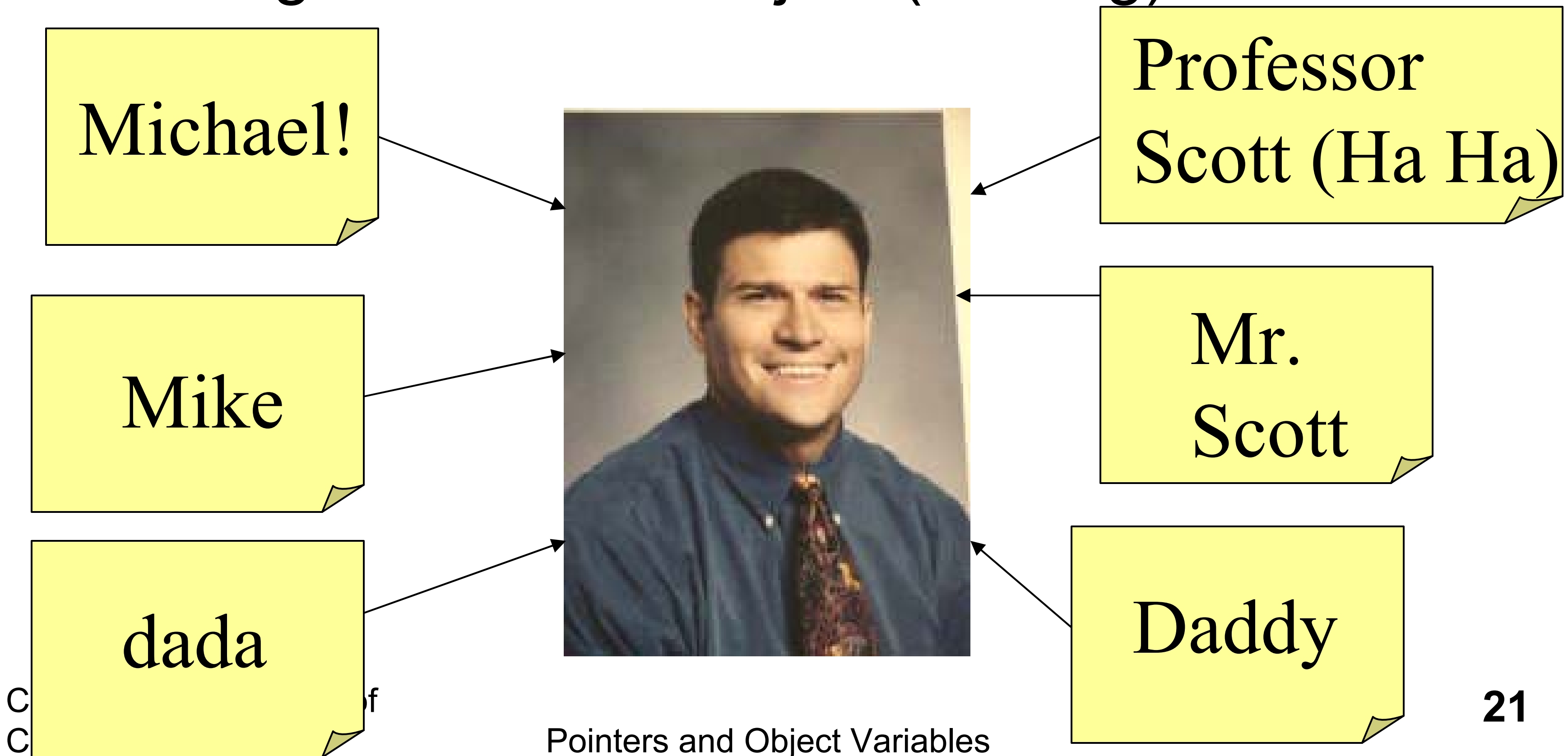
Equality versus Identity

A man walks into a pizza parlor, sits down, and tells the waiter, "I'll have what that lady over there is eating." The waiter walks over to the indicated lady, picks up the pizza that is resting in front of her, and sets it back down in from of the man's table.

- confusion over equality and identity
- identity: two things are in fact the same thing
- equality: two things are for all practical purposes alike, but not the exact same thing
- == versus the .equals method
  - use the .equals method when you want to check the contents of the pointee, use == when you want to check memory addresses

Just Like the Real World

- Objects variables are merely names for objects
- Objects may have multiple names
  - meaning there are multiple object variables referring to the same object (sharing)



The Garbage Collector

```
Rectangle rect1 = new Rectangle(2,4,10,10);
Rectangle rect2 = new Rectangle(5,10,20,30);
// (x, y, width, height)
rect1 = rect2;
/*    what happened to the Rectangle Object
      rect1 was pointing at?
*/
```

- If objects are allocated dynamically with new how are they deallocated?
  - `delete` in C++
- If an object becomes isolated (no longer is in scope), that is has no references to it, it is garbage and the Java Virtual Machine *garbage collector* will reclaim this memory AUTOMATICALLY!

Objects as Parameters

- All parameters in Java are *value* parameters
- The method receives a copy of the parameter, not the actual variable passed
- Makes it impossible to change a primitive parameter
- implications for objects? (which are references)
  - behavior that is similar to a reference parameter, with a few minor, but crucial differences
  - "Reference parameter like behavior for the pointee."

Immutable Objects

- Some classes create *immutable* objects
- Once created these objects cannot be changed
  - note the difference between objects and object variables
- Most immediate example is the String class
- String objects are immutable
- Why might this be useful?

```
String name = "Mike";
String sameName = name;
name += " " + "David" + " " + "Scott";
System.out.println( name );
System.out.println( sameName );
```