## Finding the Error

- Unit tests cannot find the source of an error
- Idea: "Visualize" the program with print statements

```
def last_name_first(n):
    """Returns: copy of <n> in form <last>, <first>"""
    end_first = n.find(' ')
    print(end_first)
    first = n[:end_first]
    print('first is '+str(first))
    last  = n[end_first+1:]
    print('last is '+str(last))
    return last+', '+first
```

Print variable after each assignment

**Optional**: Annotate value to make it easier to identify

## Types of Testing

### Black Box Testing

- Function is "opaque"
  - Test looks at what it does
  - **Fruitful**: what it returns
  - **Procedure**: what changes
- **Example**: Unit tests
- **Problems**:
  - Are the tests everything?
  - What caused the error?

### White Box Testing

- Function is "transparent"
  - Tests/debugging takes place inside of function
  - Focuses on where error is
- **Example**: Use of print
- **Problems**:
  - Much harder to do
  - Must remove when done

## Structure vs. Flow

### Program Structure

- Way statements are presented
  - Order statements are listed
  - Inside/outside of a function
  - Will see other ways…
- Indicate possibilities over **multiple executions**

### Program Flow

- Order statements are executed
  - Not the same as structure
  - Some statements duplicated
  - Some statements skipped
- Indicates what really happens in a **single execution**

Have already seen this difference with functions

## Structure vs. Flow: Example

### Program Structure

```
def foo():
    print('Hello')

# Script Code
foo()
foo()
foo()
```

Statement listed once

### Program Flow

```
>>> python foo.py
'Hello'
'Hello'
'Hello'
```

Statement executed 3x

Bugs can occur when we get a flow other than one that we where expecting

## Conditionals: If-Statements

### Format

```
if <boolean-expression>:
    <statement>
    ...
    <statement>
```

### Example

```
# Put x in z if it is positive
if x > 0:
    z = x
```

**Execution**:

if <*boolean-expression*> is true, then execute all of the statements indented directly underneath (until first non-indented statement)

## Conditionals: If-Else-Statements

### Format

```
if <boolean-expression>:
    <statement>
    ...
else:
    <statement>
    ...
```

### Example

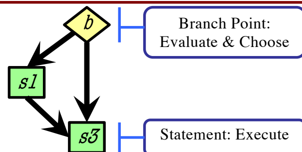
```
# Put max of x, y in z
if x > y:
    z = x
else:
    z = y
```

**Execution**:

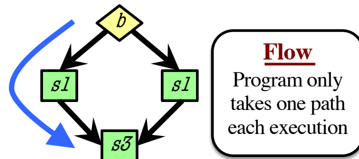
if <*boolean-expression*> is true, then execute statements indented under if; otherwise execute the statements indented under elsec

## Conditionals: "Control Flow" Statements

```
if b :
    s1 # statement
s3
```




```
if b :
    s1
else:
    s2
s3
```



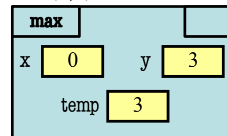
**Flow**
Program only takes one path each execution

## Program Flow vs. Local Variables

```
def max(x,y):
    """Returns: max of x, y"""
    # swap x, y
    # put the larger in y
    if x > y:
        temp = x
        x = y
        y = temp

    return y
```

- temp is needed for swap
  - x = y loses value of x
  - "Scratch computation"
  - Primary role of local vars
- max(3,0):




## Program Flow and Testing

- Call these tools **traces**
- No requirements on how to implement your traces
  - Less print statements ok
  - Do not need to word them exactly like we do
  - Do what ever is easiest for you to see the flow
- **Example**: flow.py

```
# Put max of x, y in z
print('before if')
if x > y:
    print('if x>y')
    z = x
else:
    print('else x<=y')
    z = y
print('after if')
```

## Watches vs. Traces

| Watch | Trace |
|---|---|
| • Visualization tool (e.g. print statement)<br>• Looks at **variable value**<br>• Often after an assignment<br>• What you did in lab | • Visualization tool (e.g. print statement)<br>• Looks at **program flow**<br>• Before/after any point where flow can change |

## Traces and Functions

**Example**: flow.py

```
print('before if')
if x > y:
    print('if x>y')
    z = y
    print(z)
else:
    print('else x<=y')
    z = y
    print(z)
print('after if')
```

## Conditionals: If-Elif-Else-Statements

**Format**

```
if <boolean-expression>:
    <statement>
    …
elif <boolean-expression>:
    <statement>
    …
…
else:
    <statement>
    …
```

**Example**

```
# Put max of x, y, z in w
if x > y and x > z:
    w = x
elif y > z:
    w = y
else:
    w = z
```