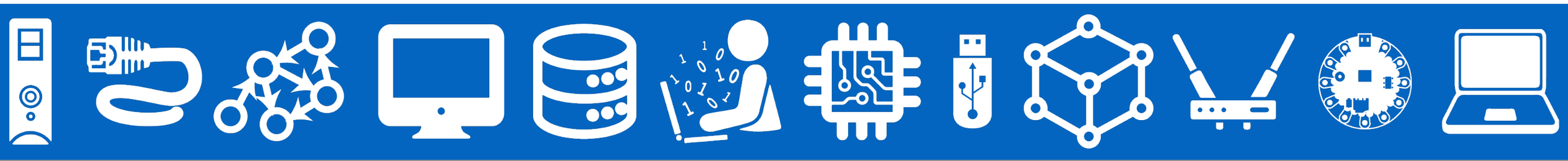
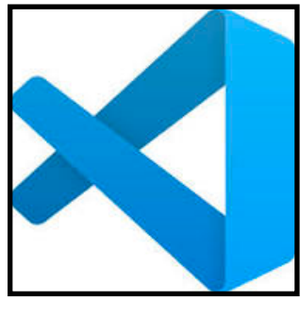
CS134:
Functions

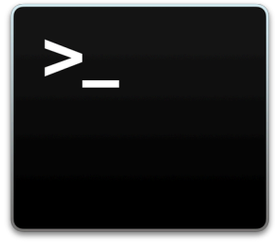


Check-in After First Lab!

- You have all survived your first computer science lab session
  - **Congratulations!**
- Software tools that you used:
  - **VS Code** as a text editor for code
  - **Terminal** as a text-based interface to the computer
  - **Git** for retrieving
  - **Gradescope** for submitting your work
  - **Python**, of course!

Do You Have Any Questions?





Announcements & Logistics

Can work in **TCL 216/217A** anytime there is no scheduled class

- **Lab 1**
  - Due today at 10 pm (for Mon labs), tomorrow at 10 pm (for Tues labs)
  - How to submit: Download .zip from evolene.cs.williams.edu
    - Upload on Gradescope
- **HW 2** will be released today, due next Monday at 10 pm
  - Open book/notes/computer. There is no time limit.
- ***Optional*** Personal machine setup (Mac/Windows): Step-by-step guide on website
- Lots of help hours if you have questions!
  - Today 1-4 pm (TCL 3rd floor), 4-6 pm and 7-10 pm (in **TCL 216**)
  - Tomorrow 2-4 pm (TCL 3rd floor), 4-6 pm and 7-10 pm (in **TCL 217A**)

Do You Have Any Questions?

Last Time

- Discussed **data types** and **variables** in Python
  - int, float, boolean, string
- Learned about basic **operators**
  - arithmetic, assignment
- Experimented with built-in Python functions
  - `input(), print(), int()`
- Discussed different ways to run and interact with Python
  - Create a file using an editor (VS Code), run as a script from Terminal
  - Interactively execute Python from Terminal (or Jupyter notebook)

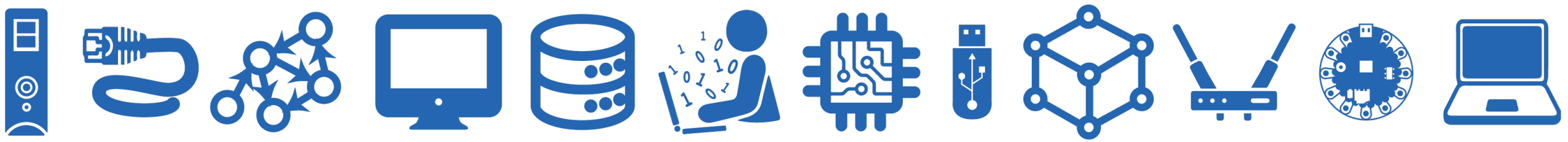
Today's Plan

- Discuss functions in greater detail
- Review the built-in functions we (briefly) saw last time and in lab
    - `input()`, `print()`, `int()` all expect **argument(s)** within the parens
    - We will examine these a bit more today
- Learn how to define our own functions

Review:
Python Built-in Functions

`input()`, `print()`

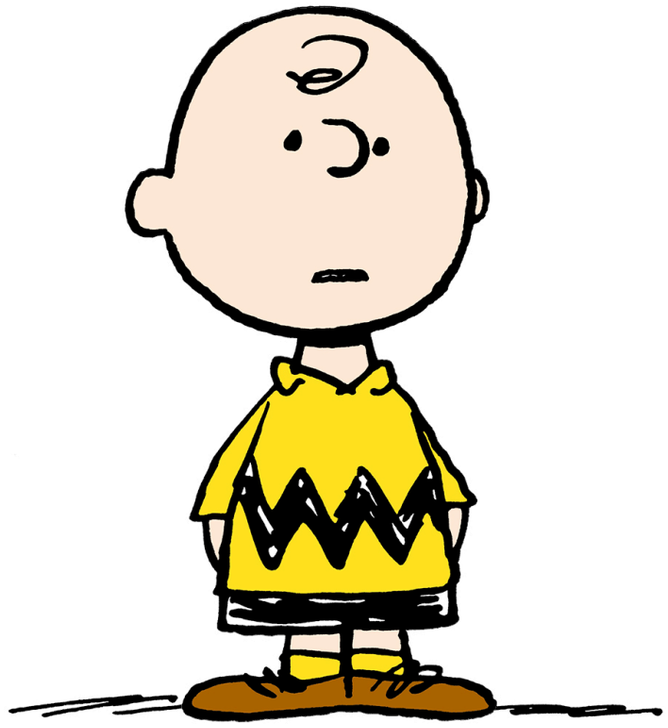
`int()`, `float()`, `str()`



Built-in functions: input()

- `input()` displays its single argument as a prompt on the screen and waits for the user to input text, followed by **Enter/Return**
- It interprets the entered value as a **string** (a sequence of characters)

```
>>> input('Enter your name: ')
Enter your name: Charlie Brown
'Charlie Brown'
>>> age = input('Enter your age: ')
Enter your age: 8
>>> age
'8'
```



Prompts in Maroon. User input in blue.
Inputted values are by default a **string**

Built-in functions: print()

- `print()` displays a character-based representation of its argument(s) on the screen/Terminal.

```
>>> name = 'Peppermint Patty'
>>> print('Your name is', name)
Your name is Peppermint Patty
```

Comma as a separator adds a space

```
>>> age = input('Enter your age : ')
Enter your age: 7
>>> print('The age of ' + name + ' is ' + age)
The age of Peppermint Patty is 7
```

Can also add spaces through string *concatenation*

Built-in functions: int()

When given a string that's a sequence of digits, optionally preceded by `+` or `-`, `int()` returns the corresponding *integer*

- On any other string, `int()` raises a `ValueError`
- When given a *float*, `int()` returns the integer that results after truncating the fractional part (rounds towards zero)
- When given an integer, `int()` returns that same integer

```
>>> int('42')
42
>>> int('-5')
-5
>>> int('3.141')
ValueError
```

Built-in functions: float()

When given a string that's a sequence of digits, optionally preceded by **+** or **–**, and optionally including one decimal point, **`float()`** returns the corresponding floating point number.

- On any other string **`float()`** raises a **`ValueError`**
- When given an *integer*, **`float()`** converts it to a floating point number.
- When given a floating point number, float returns that number

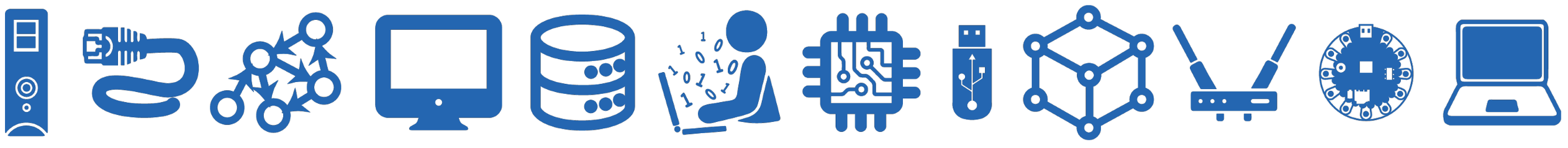
```
>>> float('3.141')
3.141
>>> float('-273.15')
-273.15
>>> float('3.1.4')
ValueError
```

Built-in functions: str()

- Converts a given type to a `string` and returns it
- Returns a syntax error when given invalid input

```
>>> str(3.141)
'3.141'
>>> str(None)
'None'
>>> str(134)
'134'
>>> str($)
SyntaxError: invalid syntax
```

Today:
User-defined Functions



Organizing Code with Functions

- So far we have:
    - Written simple **expressions** in Python
    - Created small scripts to perform certain tasks
- This is fine for small computations!
    - Need more organization and structure for larger problems
- Structured code is good for:
    - Keeping track of which part of our code is doing what actions
    - Keeping track of what information needs to supplied where
    - **Reusability!** Specifically, reusing blocks of code

Abstracting with Functions

- **Abstraction**: Reduce code complexity by ignoring (or hiding) some implementations details
    - Allows us to **decompose** and **reuse** parts of our code
- **Real life example**: a video projector
    - We know how to switch it on and off **(public interface)**
    - We know how to connect it to our computer **(input/output)**
    - We don't know how it works internally **(information hiding)**
- **Key idea:** We don't need to know much about the internals of a projector to be able to use it
    - Same is true with **functions**!

Decomposition

- Divide **individual tasks** in our code into **separate functions**
    - Functions are **self-contained** and **reusable**
        - Each function is a **small piece** of a **larger task**
        - Keeps code **organized** and **coherent**

- We have already seen some built-in examples (`int()`, `input()`, `print()`, etc.)
- Now we will learn how to **decompose** our Python code and hide small details using **user-defined functions**
- Later we will learn a new abstraction which achieves a greater level of decomposition and information hiding: **classes**

Anatomy of a Function

- Function **definition** characteristics:
  - Has a **header** consisting of:
    - **name** of the function
    - **parameters** (optional)
    - **docstring** (optional, but strongly recommended)
  - Has a **body** (indented and required)
  - Always **returns** something (with or without an explicit `return` statement)
- Statements within the body of a function are not run in a program until they are "called" or "invoked" through a **function call** (like calling `print()` or `int()` in your program)

Function Example

All of this is the function's header

Function definition

```
def print_message():
    print("Hello hello.")
    print("I don't know why you say hello...")
```

Function Calls/Invocations

```
>>> print_message()
Hello hello.
I don't know why you say hello...
```

Function Example

Function definition

Function's **name** is `print_message`

```
def print_message():
    print("Hello hello.")
    print("I don't know why you say hello...")
```

Function Calls/Invocations

```
>>> print_message()
Hello hello.
I don't know why you say hello...
```

Function Example

Function definition

```
def print_message():
    print("Hello hello.")

    print("I don't know why you say hello...")
```

This is the body of the function.

Notice the indentation. This is very important!

Function Calls/Invocations

```
>>> print_message()
Hello hello.
I don't know why you say hello...
```

Function Example

Function definition

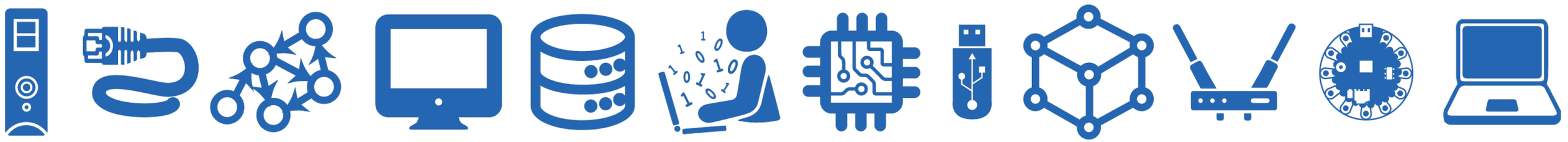
```
def print_message():
    print("Hello hello.")
    print("I don't know why
```

Function Calls/Invocations

```
>>> print_message()
Hello hello.
I don't know why you say hello...
```

When we call/invoke the function, the program refers to the function definition on what to do.

Value Returning Functions



Function Example

Function definition

Function's **name** is `square`

```
def square(x):
    '''Takes a number x and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Notice the indentation.
This whitespace is very important!

Function Example

`square` has one **parameter**, `x`, which is the expected input to the function.

Function definition

```
def square(x):
    '''Takes a number x and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

Function definition

```
def square(x):
    '''Takes a number x and returns its square'''
    return x*x
```

This is the **docstring**, which is enclosed in triple quotes. It is a short description of the function.

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

Function definition

All of this is the function's header

```
def square(x):
    '''Takes a number x and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

Function definition

```
def square(x):
    '''Takes a number and returns its square'''
    return x*x
```

This is the body of the function. Notice the use of an explicit **return** statement.

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

Function definition

```
def square(x):
    '''Takes a number and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

When we call/invoke the function, 5 is the **argument** value. Function is evaluated using x=5.

Function Example

Function definition

```
def square(x):
    '''Takes a number and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Summary:

- Indent in function body (required)
- Colon after function name (required)
- Docstring (recommended, good style)
- `x` in function definition is a parameter
- Single line body which returns the result of the expression `x * x`
- `return` always ends execution!
- A function is defined once and can be called any number of times!

A Closer Look At Parameters

- **Parameters** are "placeholders" in the body of a function that will be filled in with **argument values** during each invocation
- A particular name for a parameter is irrelevant, as long as we use it consistently in the body (just like *f(x)* and *f(y)* in math)
    - All `square` function definitions below work exactly the same way!
    - Invocation would also look exactly the same: `square(5)`

```
def square(x):
    return x*x
```

```
def square(apple):
    return apple*apple
```

```
def square(num):
    return num*num
```

Rule of thumb: Choose parameter names that make sense and convey meaning

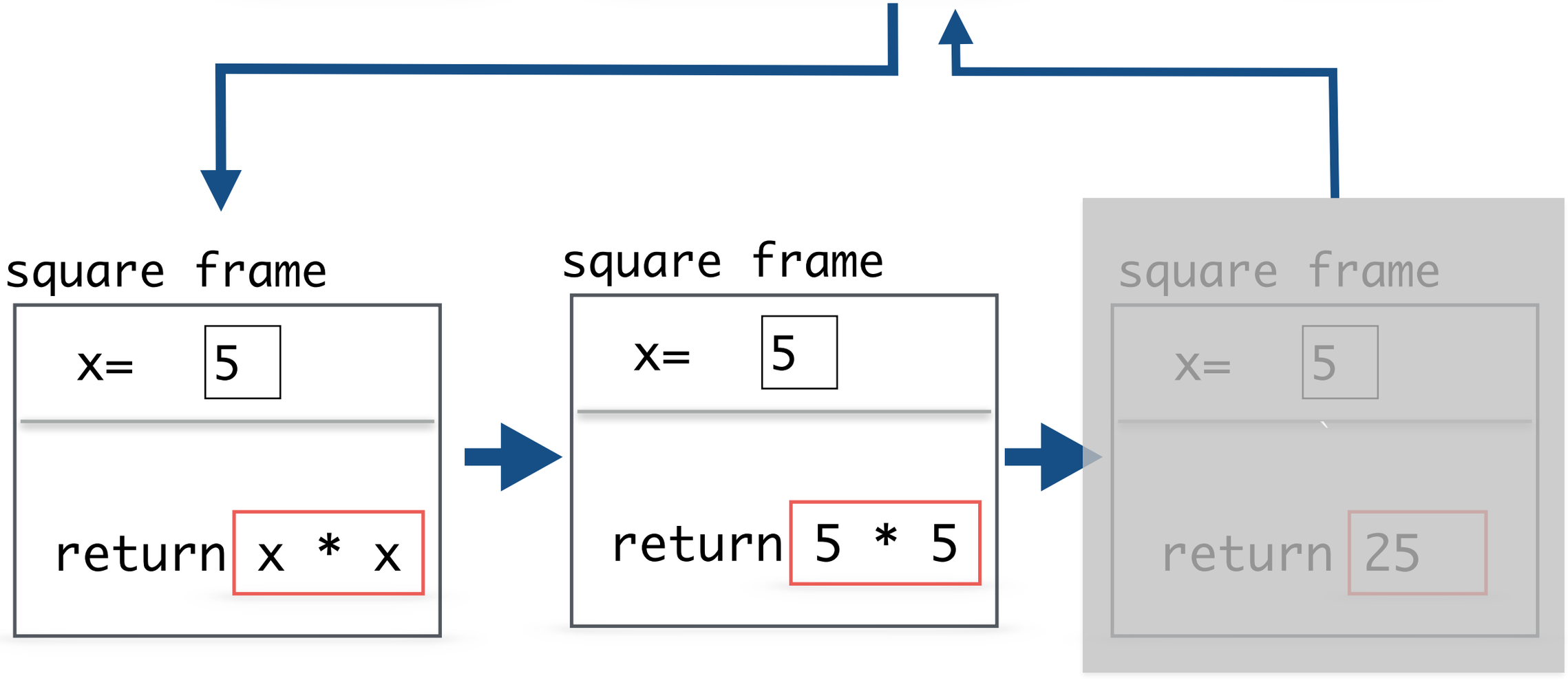
Python Function Call Model

Function frame: Model for understanding how a function call works

```
def square(x):
    return x*x
```

Return value replaces the function call!

square (2+3) → square (5) → 25



Function Call Replaced by Return Value

```
17 + square (2+3)
```

```
17 + square (5)
```

```
17 + 25
```

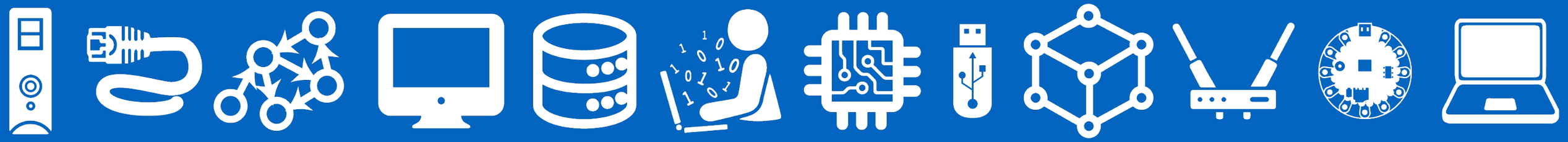


```
42
```

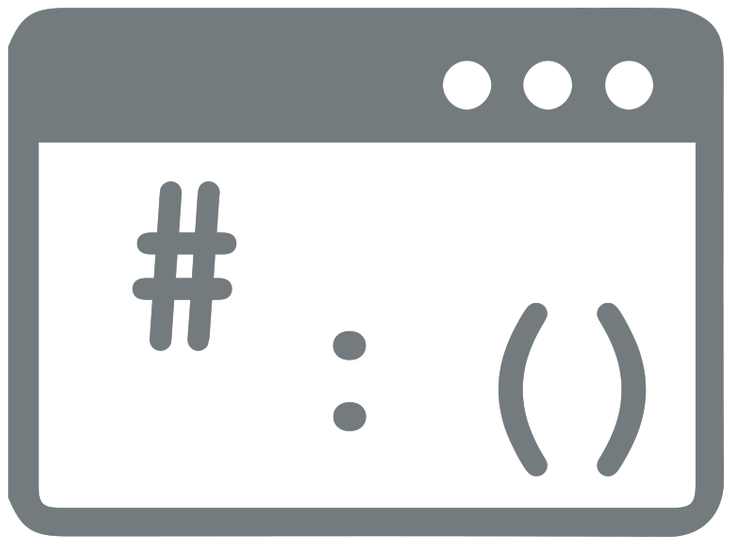
When to return a value versus not?

Sometimes, we want to compute/transform data

In those cases, we usually want to return that transformed data



Interactive Python:
Let's See Some Examples



The end!