CMPU 100 · Programming with Data

Functions

Class 4

Where are we?

See notebook.

Defining and evaluating functions

Recall how you used functions in middle-school math:

Given $f(x) = |x| + 2$

The parameter x stands for varying values

$$
\begin{aligned}
f(-3) &= |-3| + 2 \\
&= 3 + 2 \\
&= 5
\end{aligned}
$$

Python functions work much the same way:

```
def f(x): return abs(x) + 2
```

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f(-3)
```

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```
def f(x): return abs(x) + 2

f(-3)
```

Directory

Name	***Value***
x	-3

Python functions work much the same way:

```
def f(x): return abs(x) + 2

  f(-3)
→ abs(x) + 2
```

Directory

Name	***Value***
x	-3

Python functions work much the same way:

```
  def f(x): return abs(x) + 2

  f(-3)
→ abs(x) + 2
→ abs(-3) + 2
```

Directory

Name	***Value***
x	-3

Python functions work much the same way:

```
def f(x): return abs(x) + 2
```

```
  f(-3)
→ abs(x) + 2
→ abs(-3) + 2
→ 3 + 2
```

Directory

Name	***Value***
x	-3

Python functions work much the same way:

```
def f(x): return abs(x) + 2

   f(-3)
→  abs(x) + 2
→  abs(-3) + 2
→  3 + 2
→  5
```

Directory

Name	***Value***
x	`-3`

Example

Mary Berry needs to know how many cakes to bake for her cake shop.

To avoid running out or having too many, she wants to bake two cakes more than the number she sold the previous day.

E.g., if Mary sells eight cakes on Monday, she makes ten cakes on Tuesday.

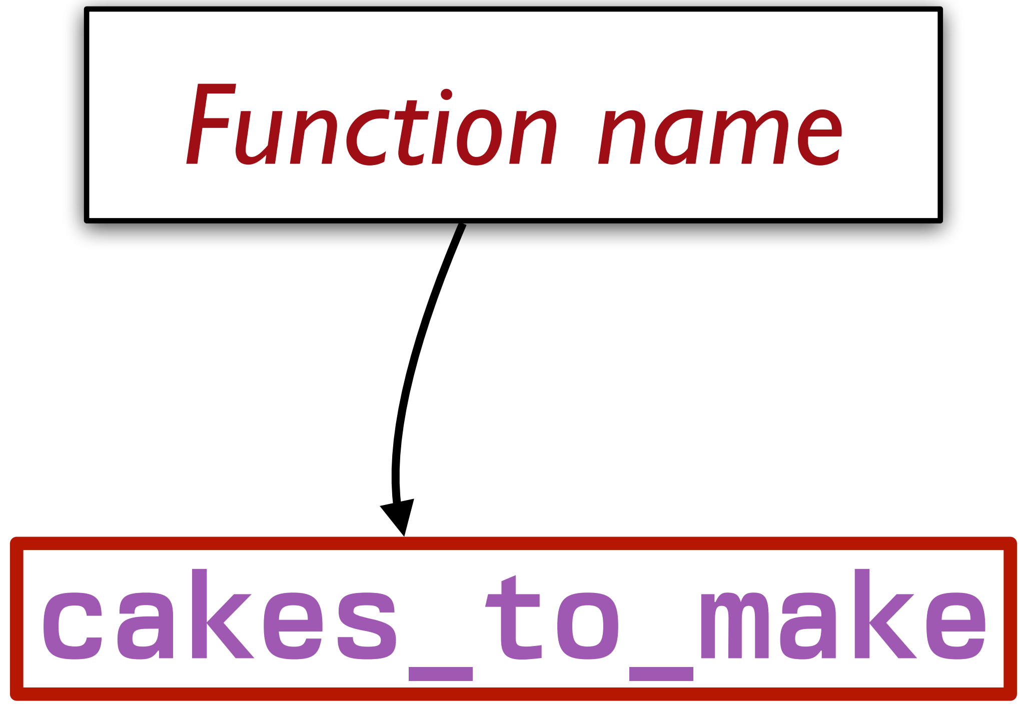
Let's write some code to help Mary!

```python
def cakes_to_make(num_sold):
    return num_sold + 2
```

*Keyword to **def**ine a function*

```python
def cakes_to_make(num_sold):
    return num_sold + 2
```

```python
def cakes_to_make(num_sold):
    return num_sold + 2
```



Function name

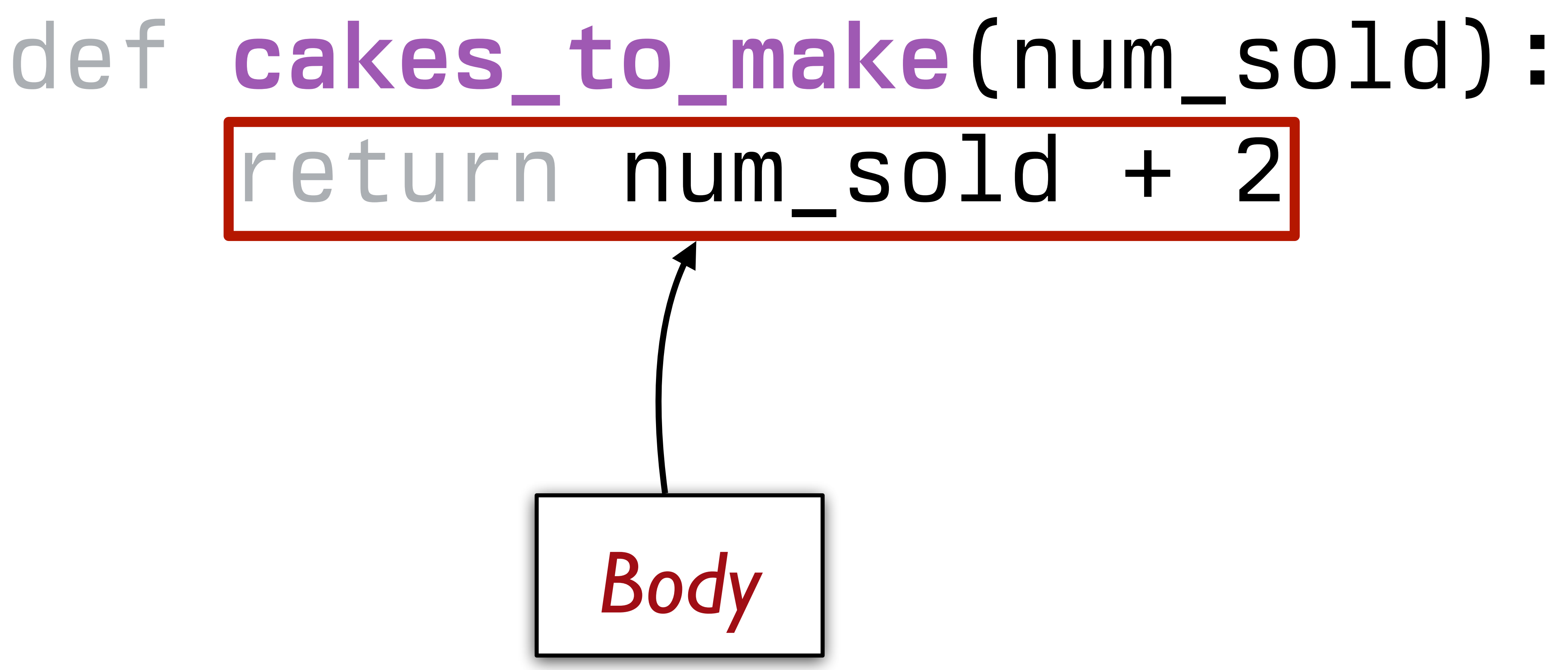
```
def cakes_to_make(num_sold):
    return num_sold + 2
```

```python
def cakes_to_make(num_sold):
    return num_sold + 2
```

Parameter names

```python
def cakes_to_make(num_sold):
    return num_sold + 2
```

```python
def cakes_to_make(num_sold):
    return num_sold + 2
```



```python
def cakes_to_make(num_sold):
    return num_sold + 2
```

Body

```python
def cakes_to_make(num_sold):
    return num_sold + 2
```

Note that the parameter names are only defined inside the function body:

```python
def cakes_to_make(num_sold):
    return num_sold + 2
```

```python
cakes_to_make(10)
```

→ 12

```python
num_sold
```

→ *Error!*

Once the function is finished, the names are removed from the directory.

Calling a function

```
yesterday = 10
already_made = 5

to_make = (
    cakes_to_make(yesterday)
    - already_made
)
```

Directory

Name	Value

Calling a function

```
yesterday = 10
already_made = 5

to_make = (
    cakes_to_make(yesterday)
    - already_made
)
```

Directory

Name	Value
yesterday	10

Calling a function

```
yesterday = 10
already_made = 5

to_make = (
    cakes_to_make(yesterday)
    - already_made
)
```

Directory

Name	***Value***
yesterday	10
already_made	5

Calling a function

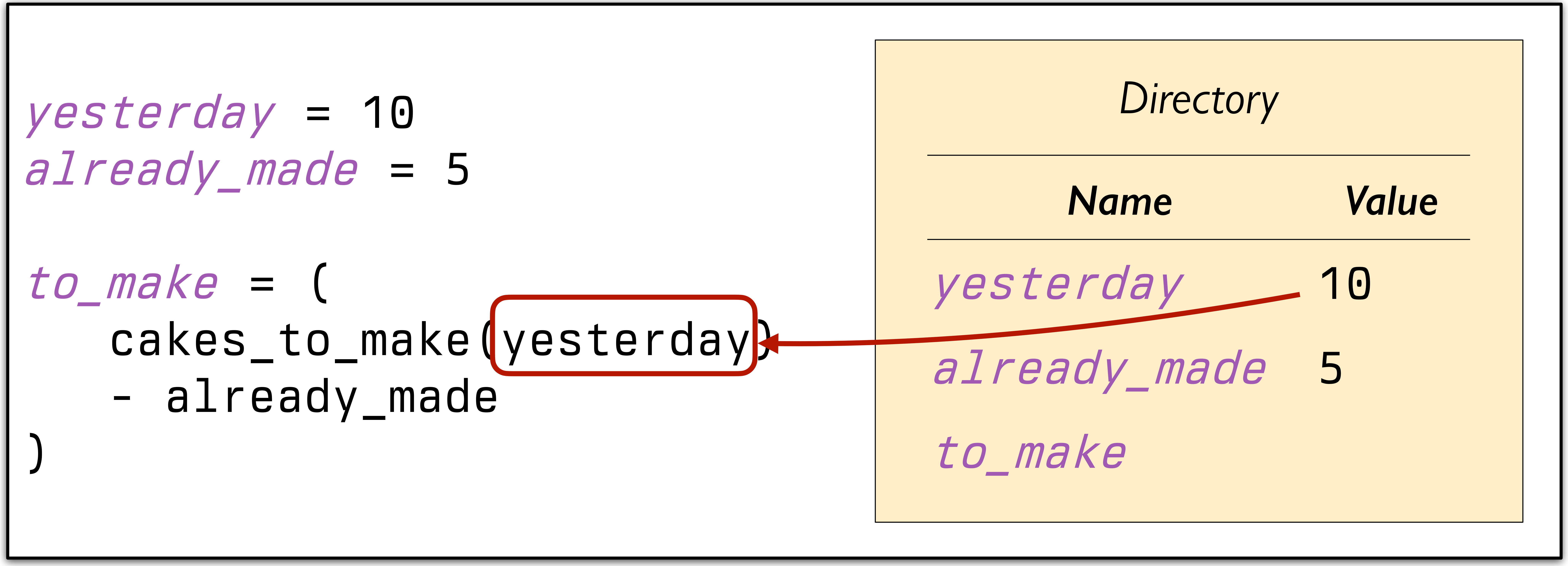
```
yesterday = 10
already_made = 5

to_make = (
    cakes_to_make(yesterday)
    - already_made
)
```

Directory

Name	*Value*
yesterday	10
already_made	5
to_make	

Calling a function



```
yesterday = 10
already_made = 5

to_make = (
    cakes_to_make(yesterday)
    - already_made
)
```

Directory

Name	Value
yesterday	10
already_made	5
to_make	

Calling a function

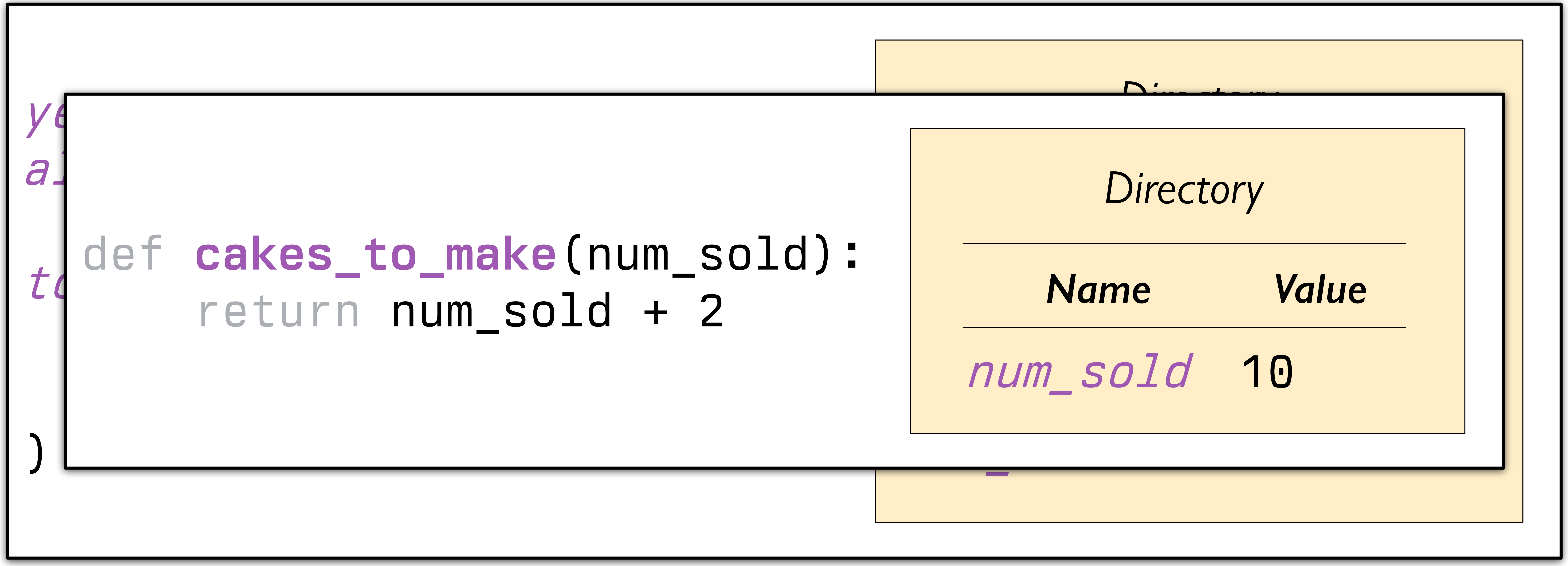
```
yesterday = 10
already_made = 5

to_make = (
    cakes_to_make(10)
    - already_made
)
```

Directory

Name	**Value**
yesterday	10
already_made	5
to_make	

Calling a function

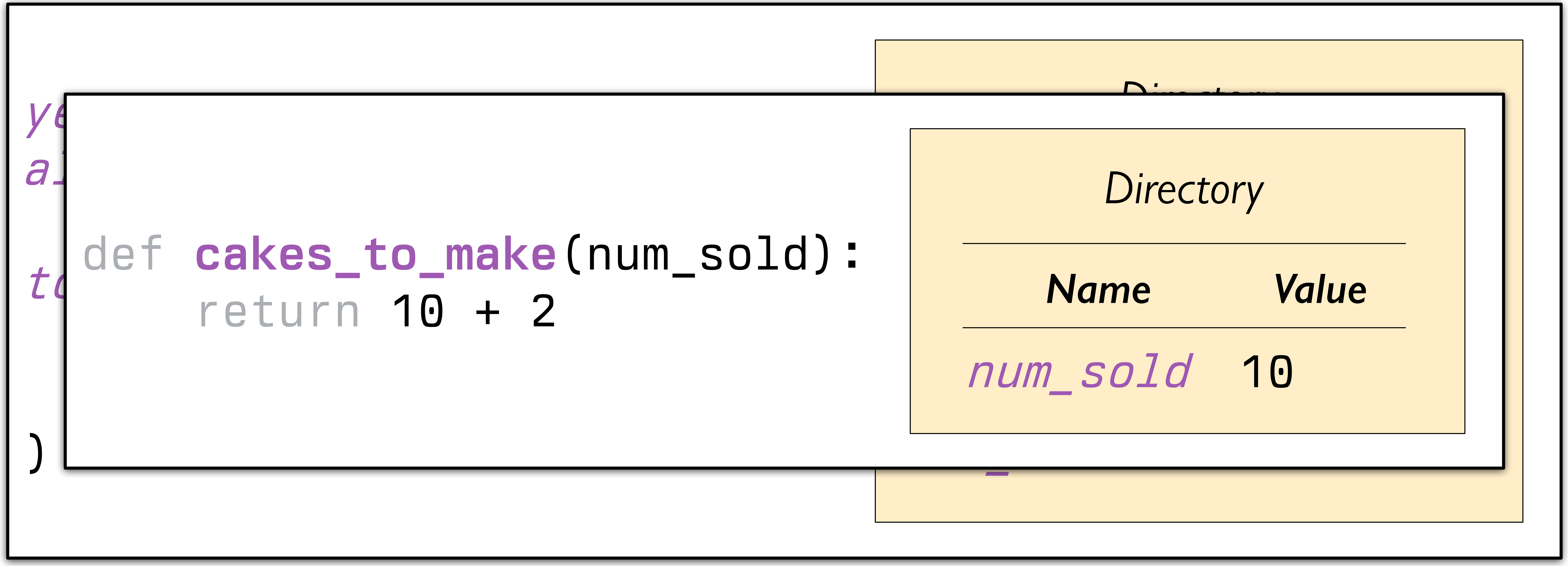


```
def cakes_to_make(num_sold):
    return num_sold + 2
```

Directory

Name	*Value*
num_sold	10

Calling a function

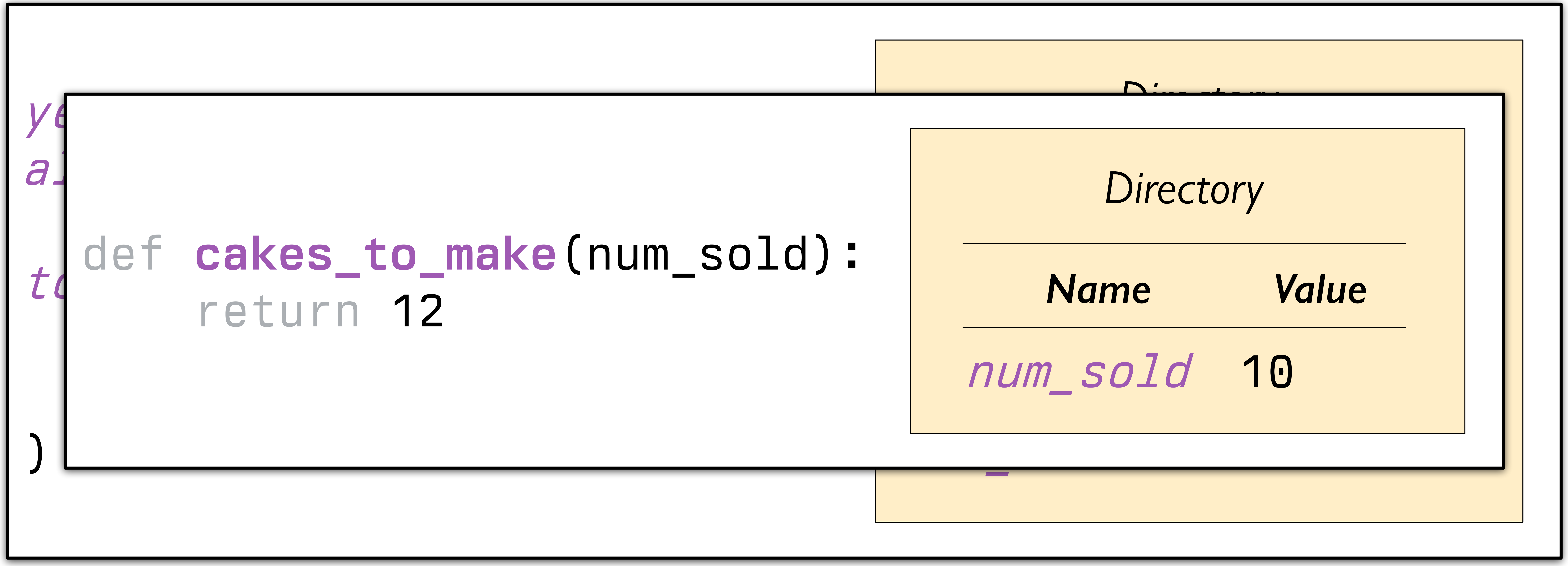


```
def cakes_to_make(num_sold):
    return 10 + 2
```

Directory

Name	Value
num_sold	10

Calling a function



```
def cakes_to_make(num_sold):
    return 12
```

Directory

Name	Value
num_sold	10

Calling a function

```
yesterday = 10
already_made = 5

to_make = (
    12
    - already_made
)
```

Directory

Name	Value
yesterday	10
already_made	5
to_make	

Calling a function

```
yesterday = 10
already_made = 5

to_make = (
    12
    - 5
)
```

Directory

Name	Value
yesterday	10
already_made	5
to_make	

Calling a function

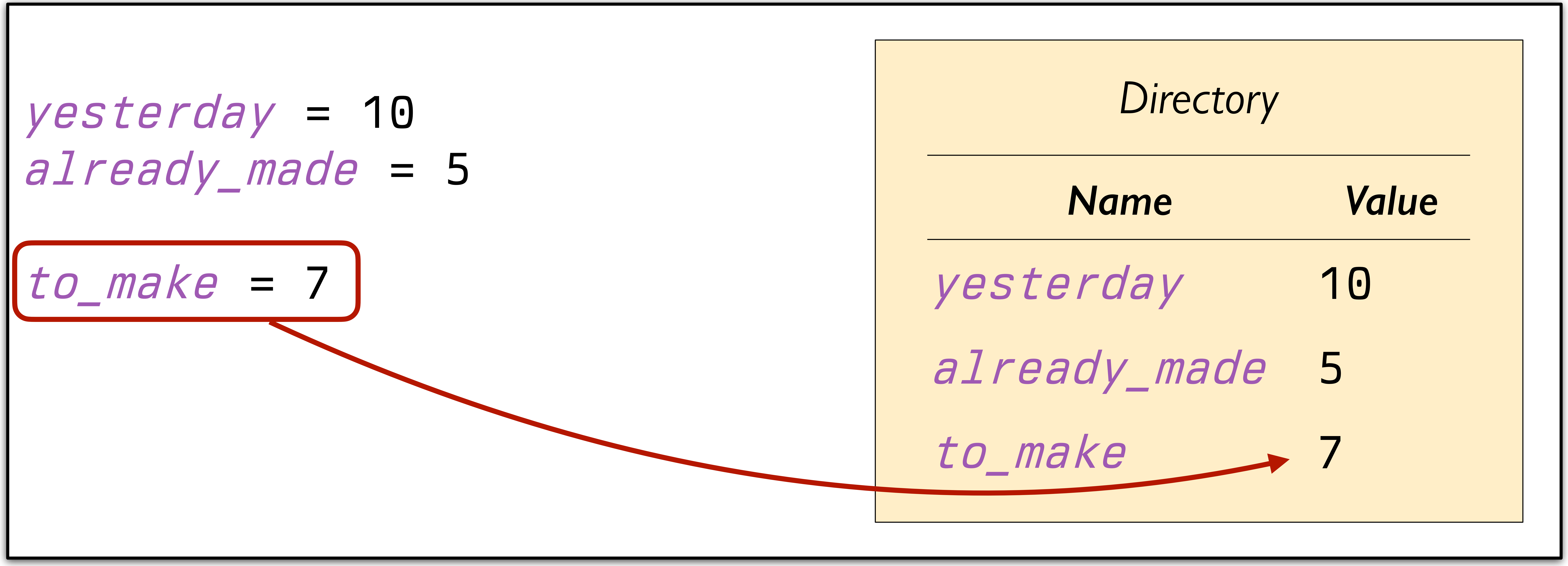
```
yesterday = 10
already_made = 5

to_make = 7
```

Directory

Name	Value
yesterday	10
already_made	5
to_make	

Calling a function



```
yesterday = 10
already_made = 5

to_make = 7
```

Directory

Name	Value
yesterday	10
already_made	5
to_make	7

We say a parameter name has only *local scope*, while names defined outside a function have *global scope*.

Formatting matters! A line of code is only part of the body of a function if it's indented:

```
def cakes_to_make(num_sold):
    tomorrow = num_sold + 2
return tomorrow
```

Error!

Formatting matters! A line of code is only part of the body of a function if it's indented:

```
def cakes_to_make(num_sold):
    tomorrow = num_sold + 2
    return tomorrow
```

Now this line is part of function, so `tomorrow` is defined!

Functions are abstractions over specific computations

For Mary’s cake shop, we want to determine the price of each cake based on the cost of the ingredients and the time to prepare it.

As the price, she uses twice the cost of the ingredients plus ¼ of the preparation time in minutes.

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Chocolate cake
Ingredients: $10
Prep. time: 20 min.

For Mary’s cake shop, we want to determine the price of each cake based on the cost of the ingredients and the time to prepare it.

As the price, she uses twice the cost of the ingredients plus ¼ of the preparation time in minutes.

Chocolate cake
Ingredients: $10
Prep. time: 20 min.

```
choc_cake_price = (2 * 10) + (1/4 * 20)
```

For Mary's cake shop, we want to determine the price of each cake based on the cost of the ingredients and the time to prepare it.

As the price, she uses twice the cost of the ingredients plus ¼ of the preparation time in minutes.

Chocolate cake
Ingredients: $10
Prep. time: 20 min.

```
choc_cake_price = (2 * 10) + (1/4 * 20)
```

Cheesecake
Ingredients: $15
Prep. time: 36 min.

For Mary’s cake shop, we want to determine the price of each cake based on the cost of the ingredients and the time to prepare it.

As the price, she uses twice the cost of the ingredients plus ¼ of the preparation time in minutes.

Chocolate cake
Ingredients: $10
Prep. time: 20 min.

```
choc_cake_price = (2 * 10) + (1/4 * 20)
```

Cheesecake
Ingredients: $15
Prep. time: 36 min.

```
cheesecake_price = (2 * 15) + (1/4 * 36)
```

We use functions to avoid repetitive code when we need to perform the same operations on different values.

```
choc_cake_price = (2 * 10) + (1/4 * 20)


cheesecake_price = (2 * 15) + (1/4 * 36)
```

We use functions to avoid repetitive code when we need to perform the same operations on different values.

```
choc_cake_price = (2 * 10) + (1/4 * 20)

cheesecake_price = (2 * 15) + (1/4 * 36)
```

```
(2 * ingredients_cost) + (1/4 * prep_time)
```

We use functions to avoid repetitive code when we need to perform the same operations on different values.

```
choc_cake_price = (2 * 10) + (1/4 * 20)

cheesecake_price = (2 * 15) + (1/4 * 36)
```

```
def cake_price(ingredients_cost, prep_time):
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

Parameters

```
def cake_price(ingredients_cost, prep_time):
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

The parameters are the values passed into the function that it needs to know for each operation.

```python
def cake_price(ingredients_cost, prep_time):
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

Statement computed each time the function is called

```
def cake_price(ingredients_cost, prep_time):
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

```
# Price of chocolate cake
cake_price(10, 20)

# Price of cheesecake
cake_price(15, 36)
```

To calculate the price of chocolate cake or cheesecake, you just call your function and pass in the relevant values!

Improving our function definitions

```
def c(x, y):
    return (2 * x) + (1/4 * y)
```

If you're looking at someone else's notebook and you see this function, you'd have no idea why they wrote it. What is this function used for? What are **x** *and* **y***?*

```python
def cake_price(ingredients_cost, prep_time):
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

Just using good names goes a long way!

```
def cake_price(
    ingredients_cost: float,
    prep_time: float
):
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

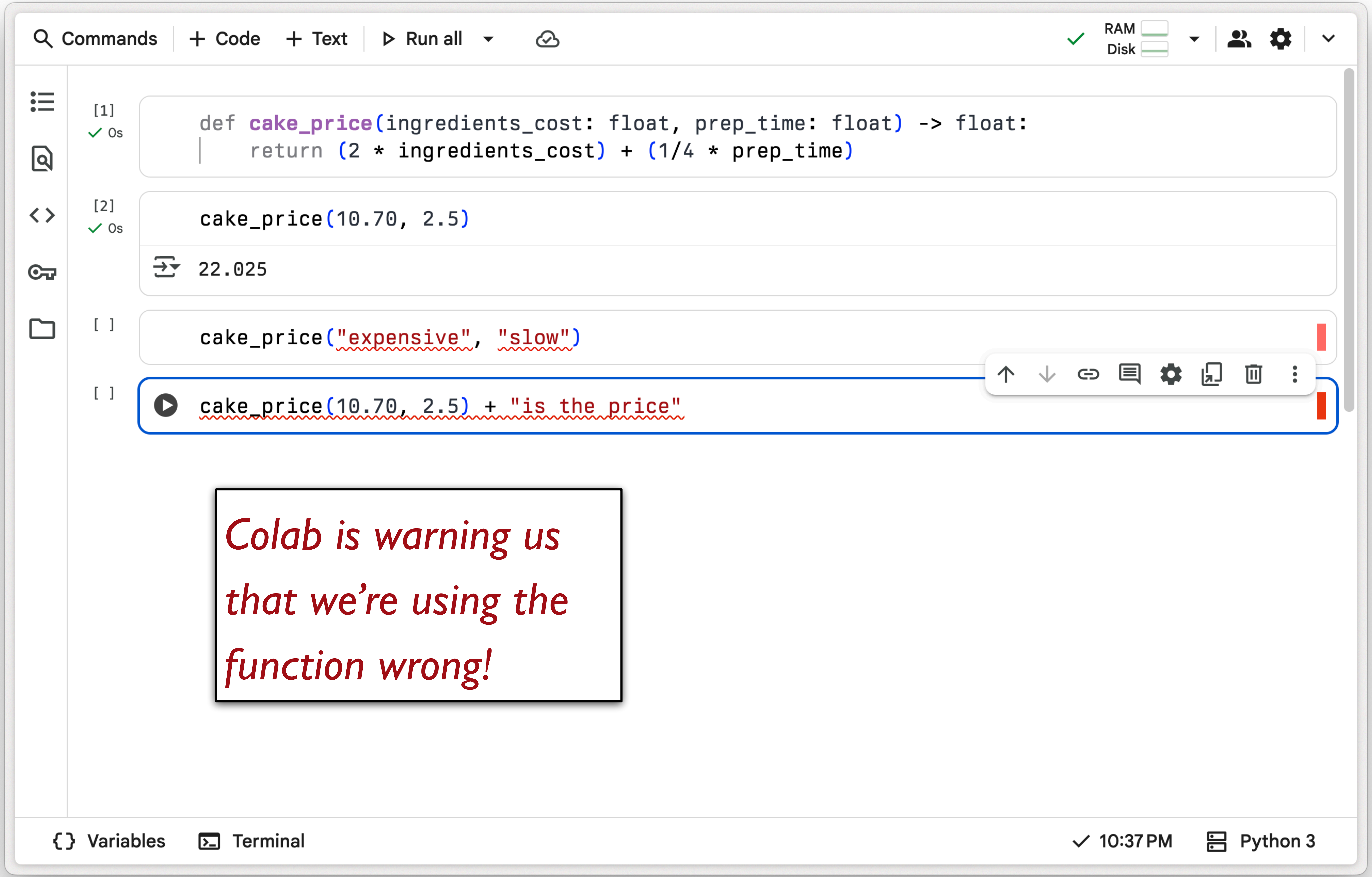
We specify the type of each parameter so that other people – or our future selves – know what kind of values the function expects.

✓ `cake_price(10.70, 2.5)`

✗ `cake_price("expensive", "slow")`

```python
def cake_price(
    ingredients_cost: float,
    prep_time: float
) -> float:
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

*And we can specify the type of value the function **returns**.*



```
def cake_price(ingredients_cost: float, prep_time: float) -> float:
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

```
cake_price(10.70, 2.5)
```

```
22.025
```

```
cake_price("expensive", "slow")
```

```
cake_price(10.70, 2.5) + "is the price"
```

Colab is warning us that we’re using the function wrong!

```
def cake_price(
    ingredients_cost: float,
    prep_time: float
) -> float:
    """Calculate price of cake based on ingredient
    cost and preparation time.
    """
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

Additionally, a docstring explains what the function does.

Practice

```
def triangle_area(b, h):
    return 1/2 * b * h
```

How can we improve this?

```
def triangle_area(base: float, height: float) -> float:
    """Return the area of the given triangle."""
    return 1/2 * base * height
```

Testing

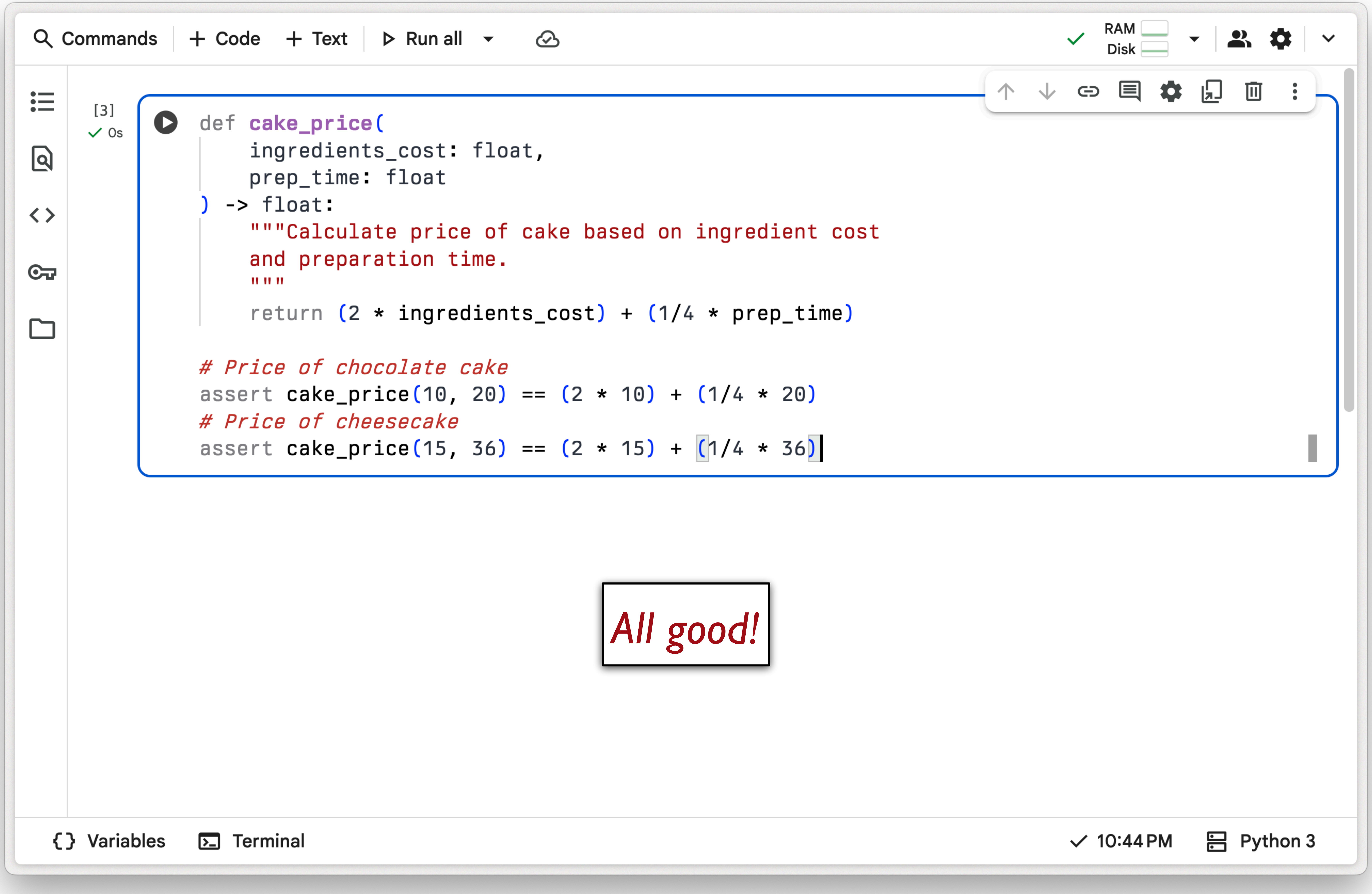
```python
def cake_price(
    ingredients_cost: float,
    prep_time: float
) -> float:
    """Calculate price of cake based on ingredient
    cost and preparation time.
    """
    return (2 * ingredients_cost) + (1/4 * prep_time)
```

*Our function looks good, but does it **work** correctly? We should test it!*

```python
def cake_price(
    ingredients_cost: float,
    prep_time: float
) -> float:
    """Calculate price of cake based on ingredient
    cost and preparation time.
    """
    return (2 * ingredients_cost) + (1/4 * prep_time)

# Price of chocolate cake
assert cake_price(10, 20) == (2 * 10) + (1/4 * 20)
# Price of cheesecake
assert cake_price(15, 36) == (2 * 15) + (1/4 * 36)
```

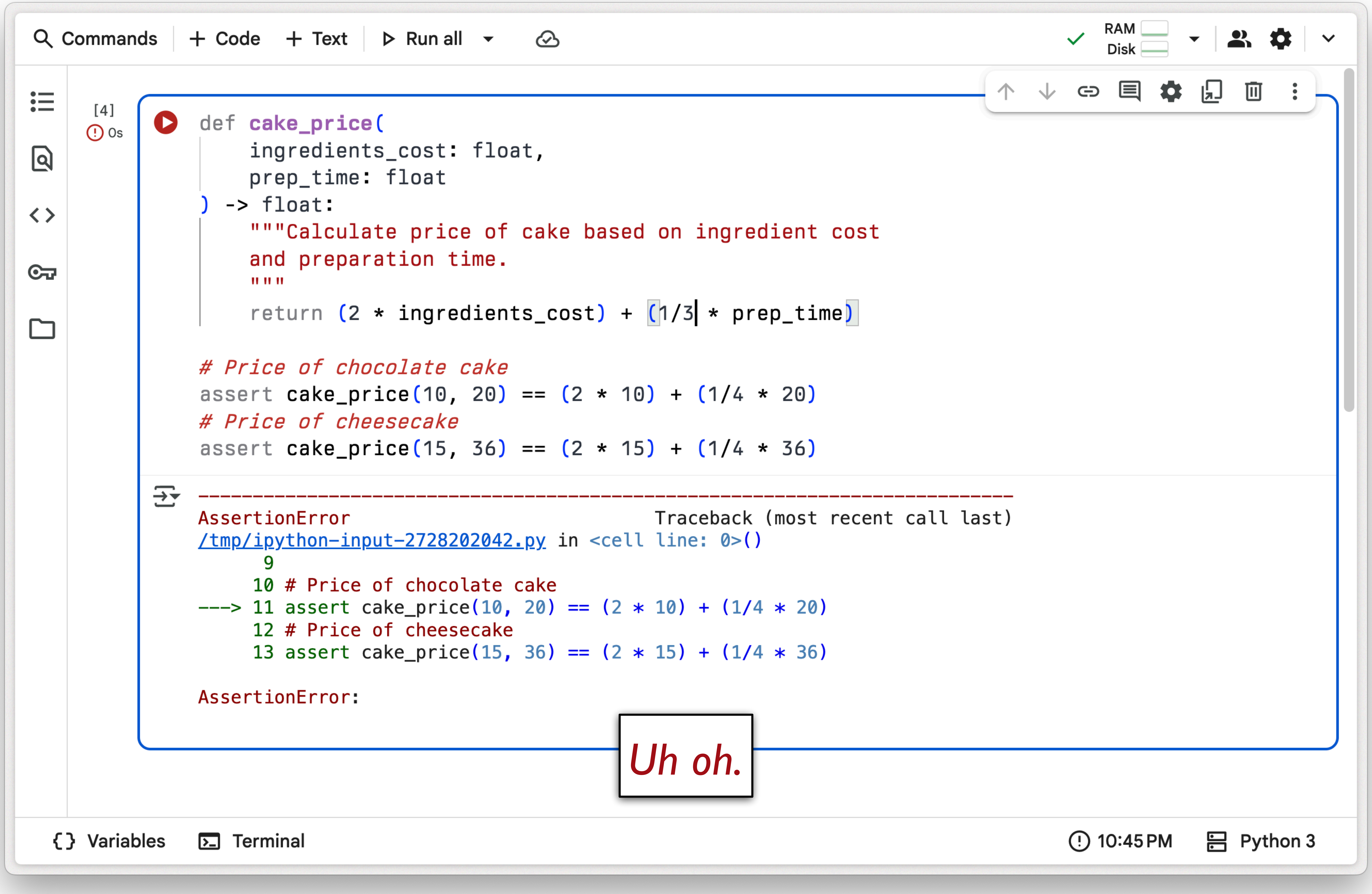
Our function looks good, but does it work correctly? We should test it!



```python
def cake_price(
    ingredients_cost: float,
    prep_time: float
) -> float:
    """Calculate price of cake based on ingredient cost
    and preparation time.
    """
    return (2 * ingredients_cost) + (1/4 * prep_time)

# Price of chocolate cake
assert cake_price(10, 20) == (2 * 10) + (1/4 * 20)
# Price of cheesecake
assert cake_price(15, 36) == (2 * 15) + (1/4 * 36)
```

All good!



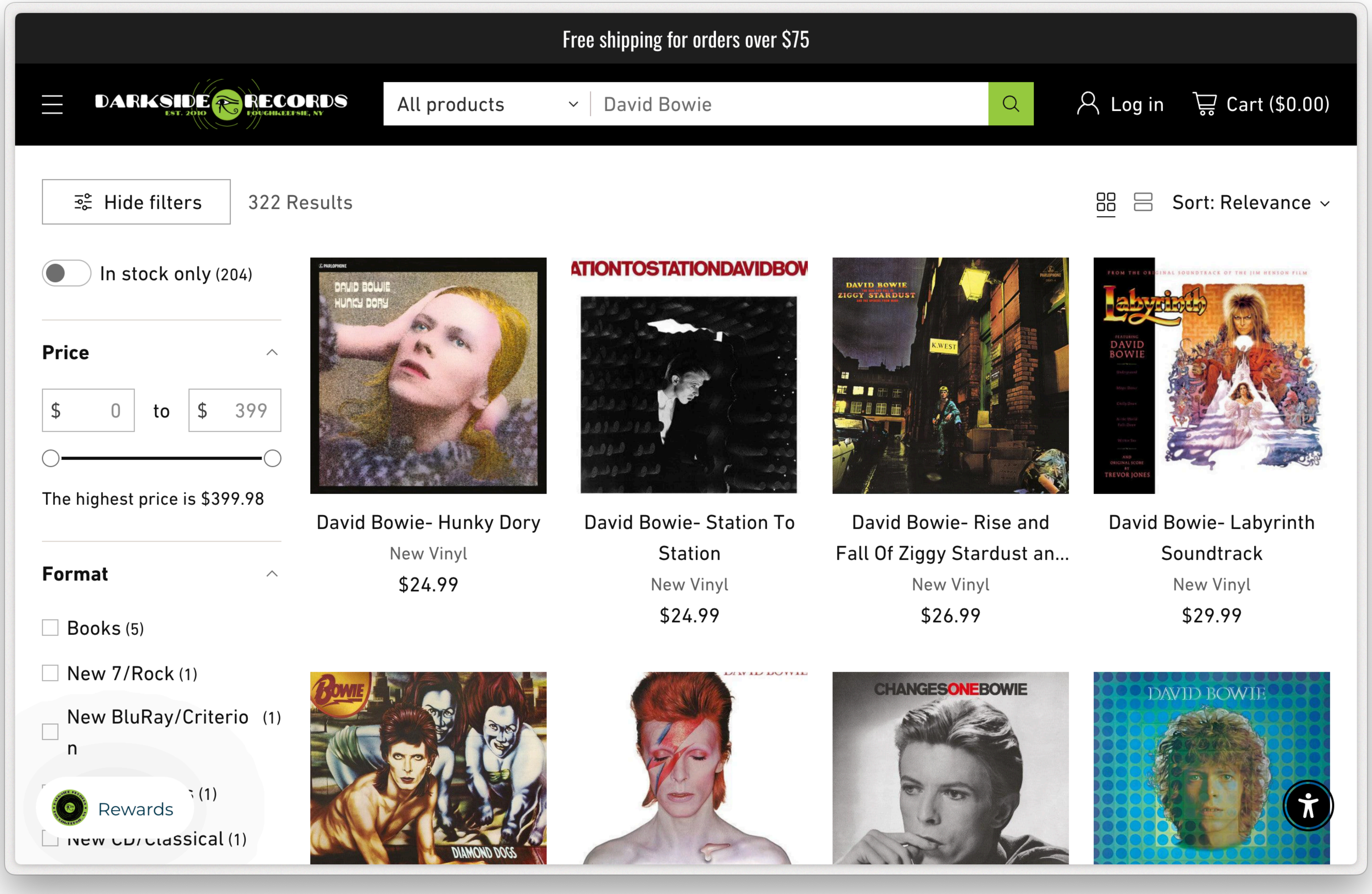
```
def cake_price(
    ingredients_cost: float,
    prep_time: float
) -> float:
    """Calculate price of cake based on ingredient cost
    and preparation time.
    """
    return (2 * ingredients_cost) + (1/3 * prep_time)

# Price of chocolate cake
assert cake_price(10, 20) == (2 * 10) + (1/4 * 20)
# Price of cheesecake
assert cake_price(15, 36) == (2 * 15) + (1/4 * 36)
```

```
---------------------------------------------------------------------------
AssertionError                            Traceback (most recent call last)
/tmp/ipython-input-2728202042.py in <cell line: 0>()
      9
     10 # Price of chocolate cake
---> 11 assert cake_price(10, 20) == (2 * 10) + (1/4 * 20)
     12 # Price of cheesecake
     13 assert cake_price(15, 36) == (2 * 15) + (1/4 * 36)

AssertionError:
```

Uh oh.



Free shipping for orders over $75

All products

David Bowie

Log in

Cart ($0.00)

Hide filters

322 Results

Sort: Relevance

○ In stock only (204)

Price

$ 0 to $ 399

The highest price is $399.98

Format

□ Books (5)

□ New 7/Rock (1)

□ New BluRay/Criterion (1)

(1)

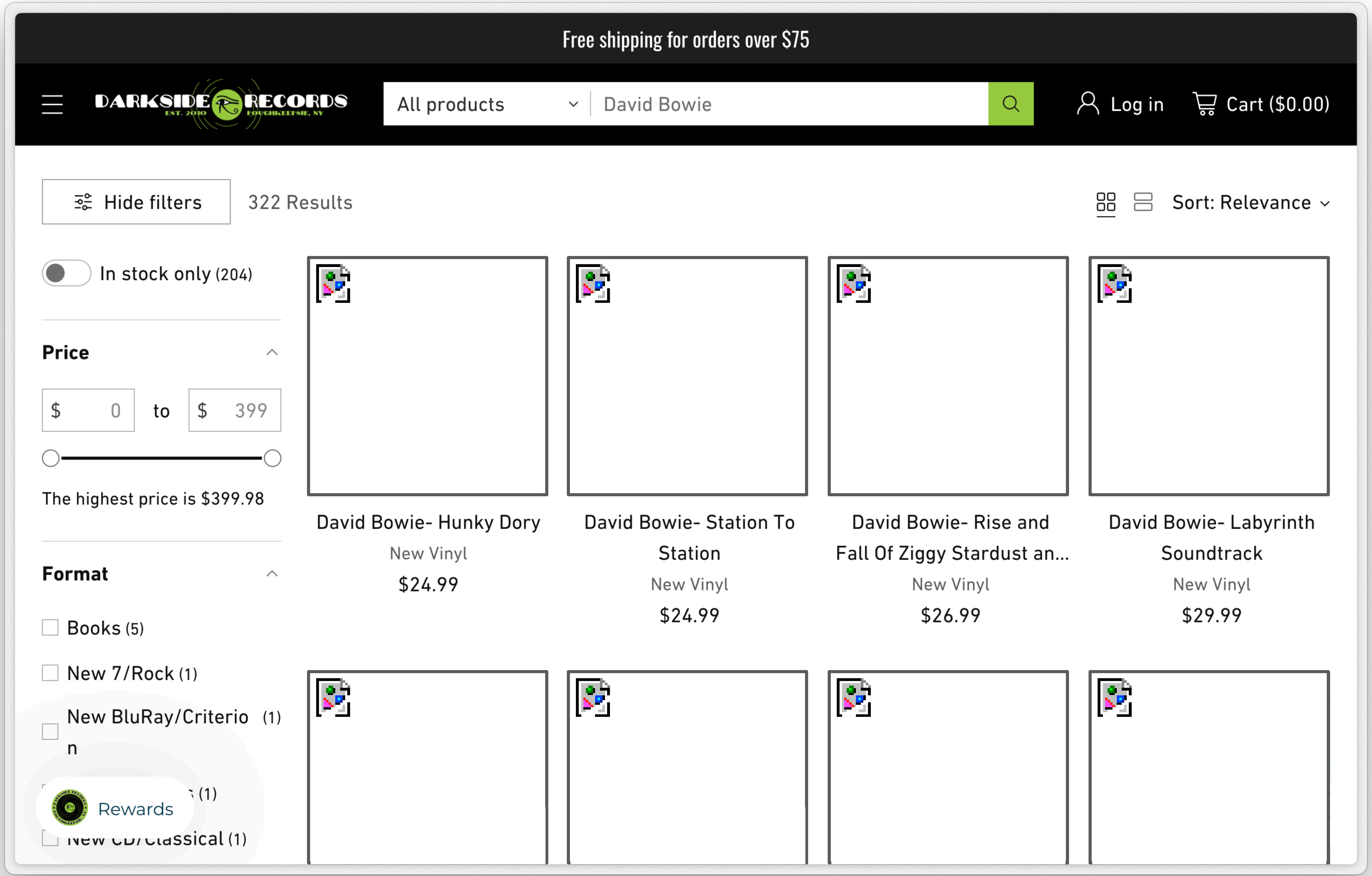
□ New CD/Classical (1)

David Bowie- Hunky Dory
New Vinyl
$24.99

David Bowie- Station To Station
New Vinyl
$24.99

David Bowie- Rise and Fall Of Ziggy Stardust an...
New Vinyl
$26.99

David Bowie- Labyrinth Soundtrack
New Vinyl
$29.99



Free shipping for orders over $75

All products | David Bowie

Log in | Cart ($0.00)

Hide filters | 322 Results

Sort: Relevance

In stock only (204)

Price

$ 0 to $ 399

The highest price is $399.98

Format

□ Books (5)

□ New 7/Rock (1)

□ New BluRay/Criterion (1)

(1)

□ New CD/Classical (1)

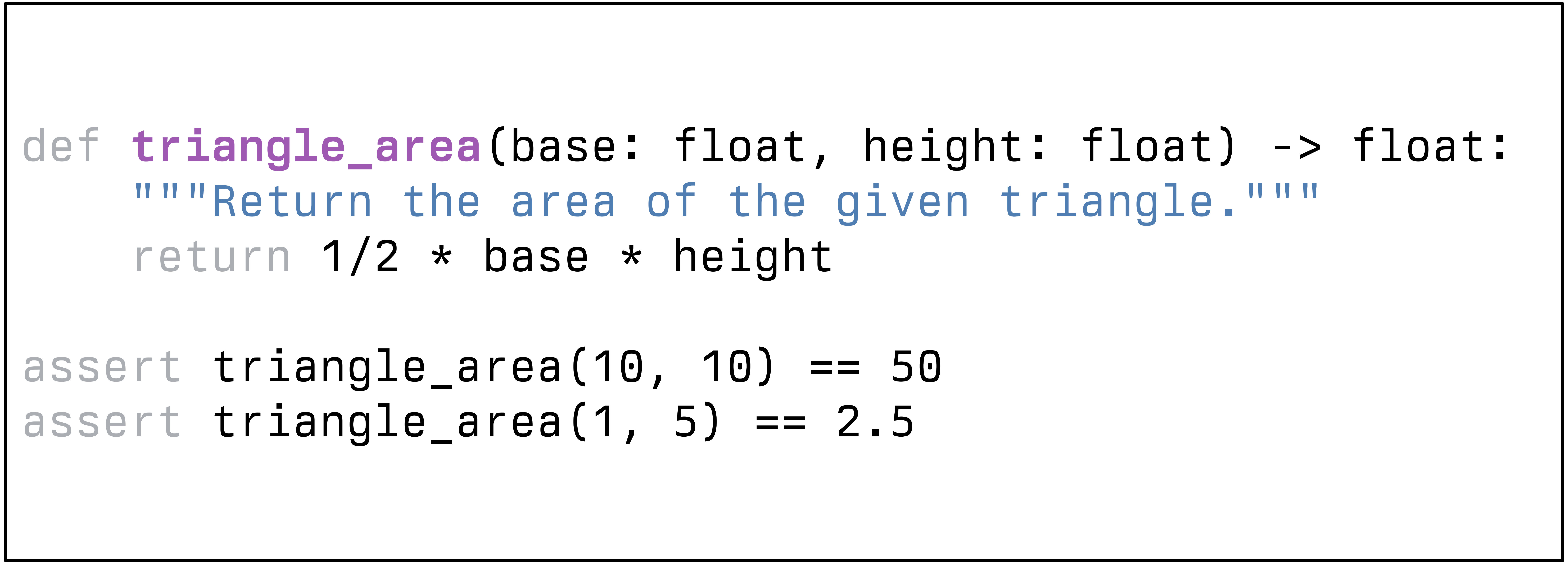
Rewards

David Bowie- Hunky Dory New Vinyl $24.99	David Bowie- Station To Station New Vinyl $24.99	David Bowie- Rise and Fall Of Ziggy Stardust an... New Vinyl $26.99	David Bowie- Labyrinth Soundtrack New Vinyl $29.99

Practice

```python
def triangle_area(base: float, height: float) -> float:
    """Return the area of the given triangle."""
    return 1/2 * base * height
```

What tests should we add?



```python
def triangle_area(base: float, height: float) -> float:
    """Return the area of the given triangle."""
    return 1/2 * base * height

assert triangle_area(10, 10) == 50
assert triangle_area(1, 5) == 2.5
```

Functions with comparisons and conditional statements

See notebook.

Exercise

Write a handful of **`assert`** statements to test the following function:

```
def letter_grade(score: int | float) -> str:
    """Given a score between 0 and 100, returns
    the letter grade of:
    - "A" if the score is 90 or greater,
    - "B" if the score is in the 80s,
    - "C" if the score is lower than 80.
    """
    ...
```

Which versions pass all of the tests?

```python
def letter_grade(score):
    if score >= 80:
        return "B"
    elif score >= 90:
        return "A"
    else:
        return "C"
```

```python
def letter_grade(score):
    if score > 90:
        return "A"
    elif score > 80:
        return "B"
    else:
        return "C"
```

```python
def letter_grade(score):
    if score >= 90:
        return "A"
    elif score >= 80:
        return "B"
    else:
        return "C"
```

Exercise

A year is a leap year if:

The year is divisible by 4 but not divisible by 100, or

The year is divisible by 400.

Complete the following function:

```
def is_leap_year(year):
    """Return True if year is a leap year."""
    ...
```

You can use the % operator to check if year is divisible by 4: `year % 4 == 0`

Acknowledgments

This class incorporates material from:

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Data 6, University of California, Berkeley (CC BY-NC-SA)

Data 8, University of California, Berkeley (CC BY-NC-SA)