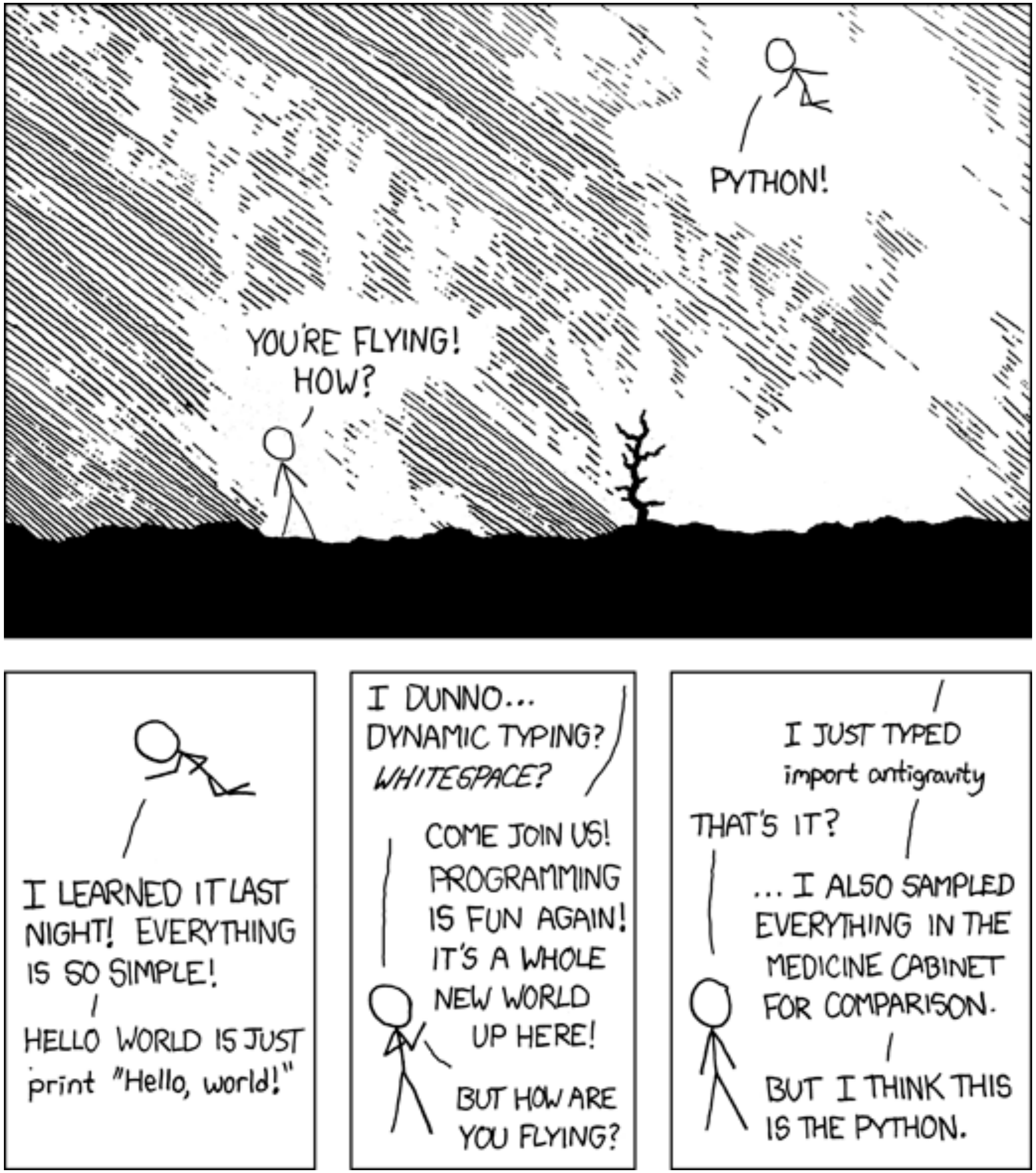
PYTHON!
YOU'RE FLYING! HOW?
I LEARNED IT LAST NIGHT! EVERYTHING IS SO SIMPLE!
HELLO WORLD IS JUST print "Hello, world!"
I DUNNO... DYNAMIC TYPING? WHITESPACE?
COME JOIN US! PROGRAMMING IS FUN AGAIN! IT'S A WHOLE NEW WORLD UP HERE!
BUT HOW ARE YOU FLYING?
I JUST TYPED import antigravity
THAT'S IT?
... I ALSO SAMPLED EVERYTHING IN THE MEDICINE CABINET FOR COMPARISON.
BUT I THINK THIS IS THE PYTHON.

Lecture 11:
`for` loops and the `range` function
Turtles!?

Happenings

- Slalom Information Session Tuesday, October 22nd
  - Information Booth 10:30-12:00 PM CF First Floor Foyer
  - Information Session 6:00-7:00 PM AW 204
- CS Mentors Program Present “GDB Workshop” Thursday, October 24th 3 PM CF 165
  - Perfect for students in CSCI 247 & 347
- Internship and Volunteer Fair Thursday, October 24th 12:00-4:00 PM VU Multipurpose Room
- Amazon Tuesday, October 29th
  - Info Table 10:30-12:00 PM at VU Lobby
  - Info Session 4:00-5:00 PM at AW 204
  - Resume Prep 5:15-7:00 PM at AW 204
  - Open to all of campus not just CS students
- PACCAR Career Day Wednesday, October 30th 10:00 AM-3:00 PM South Campus

Announcements

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- Exam is next Friday

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  - 50 minutes

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  - Closed-book; no notes

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  - No calculators (there won’t be any hard arithmetic)

Announcements

- Exam is next Friday
  - 50 minutes
  - Closed-book; no notes
  - No calculators (there won’t be any hard arithmetic)
- Sample programming questions will be released this afternoon.

Goals

- Know the syntax and behavior of the `for` statement (`for` loop)

- Know how to use the `range` function in the header of a `for` loop.

- Know how to use the turtle module to:

  - Create a Turtle object

  - Call the turtle object's methods (functions) to move it around the screen and draw simple shapes:
    (`forward, left, right, penup, pendown`)

Hot take: for some tasks, `while` loops are annoying.

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i = 0
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```

I don’t even care about `i`, it’s just bookkeeping!

- Wouldn’t it be great if we could:

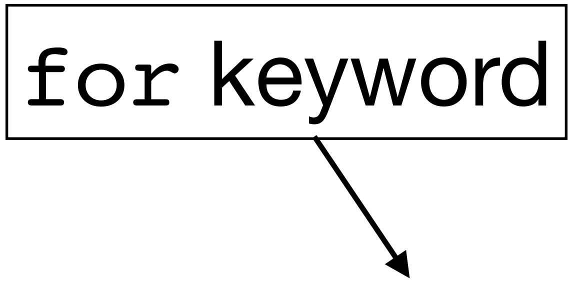
```
do 10 times:
    some_thing()
```

We (almost) can! Using `for` loops.

The for statement: syntax

```
for var_name in sequence:
    codeblock
```

The for statement: syntax



for keyword

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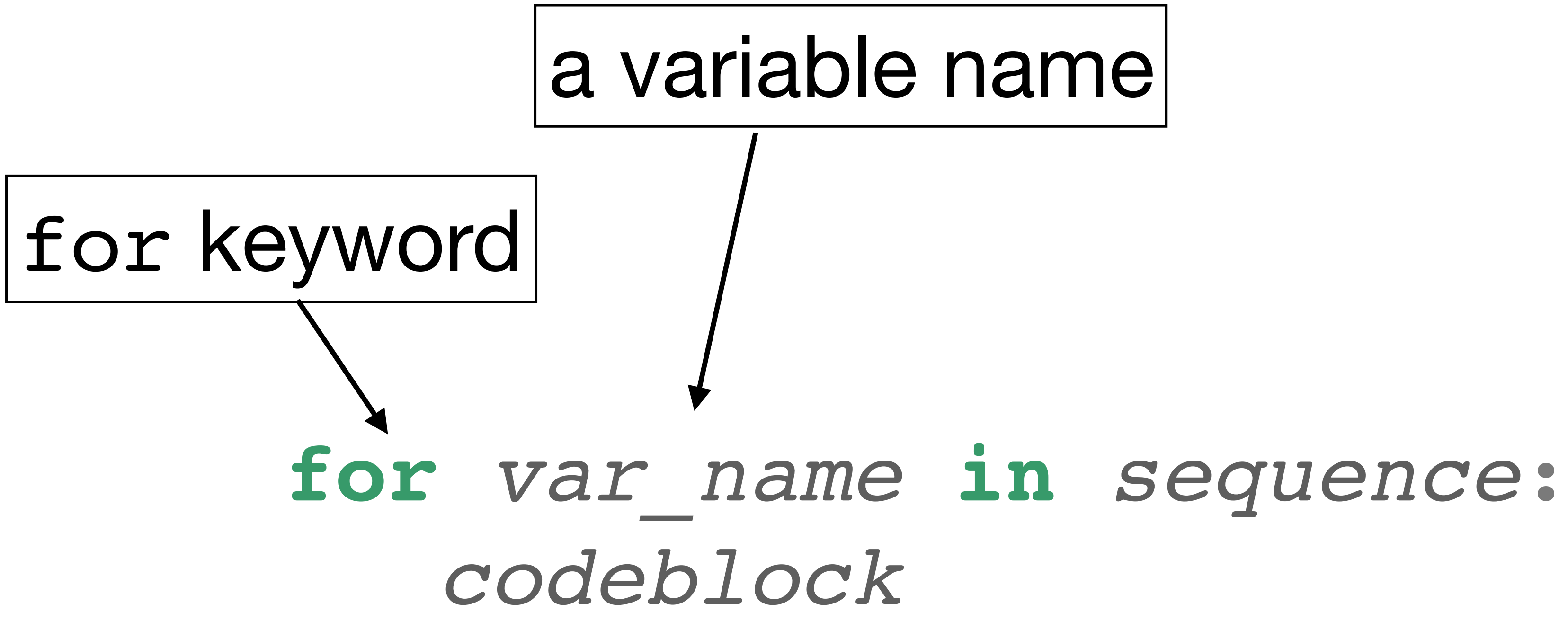

a variable name

for keyword

```
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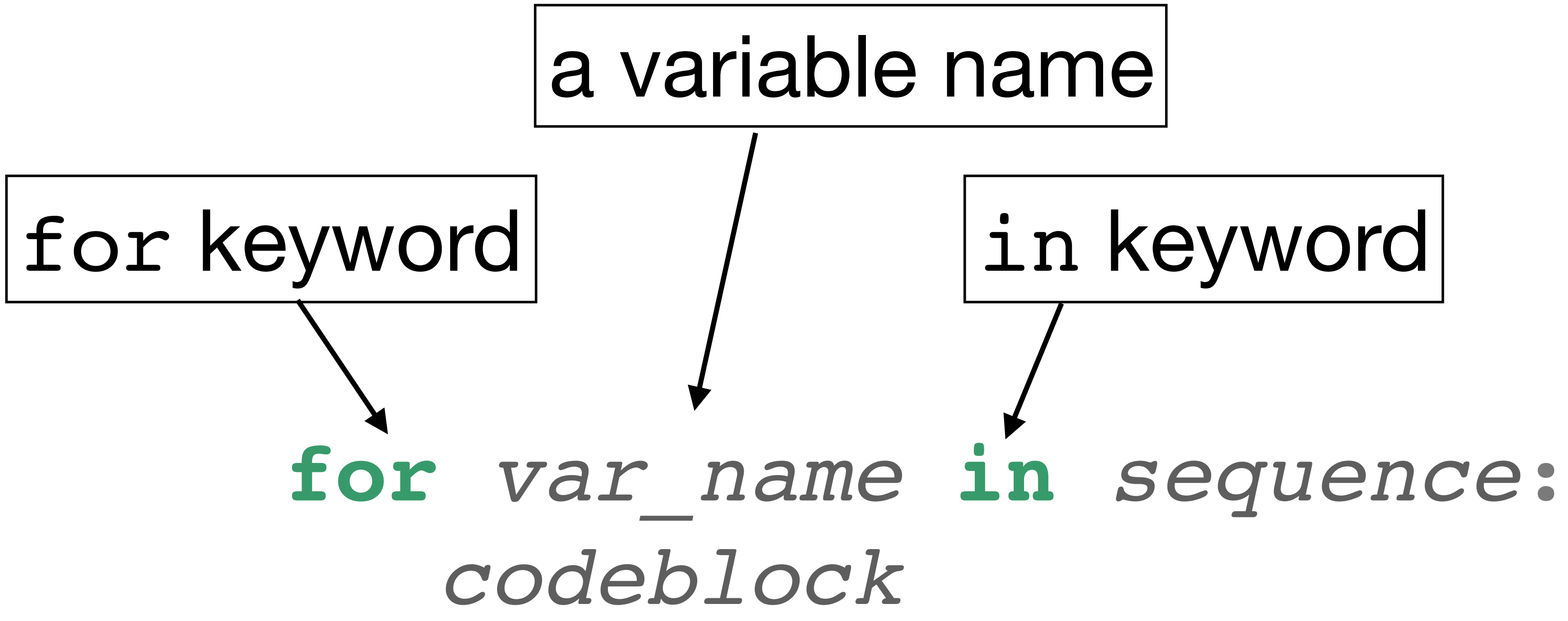
```

The for statement: syntax



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for keyword

in keyword

```
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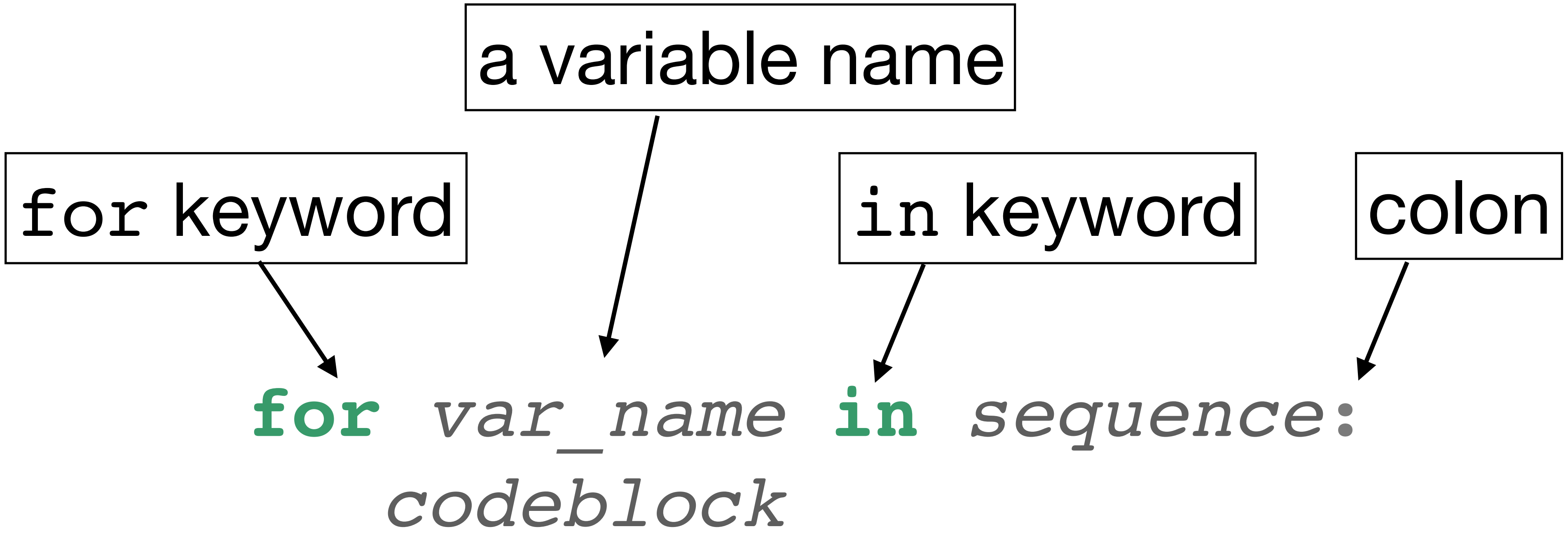
    codeblock
```

The for statement: syntax



a variable name

for keyword

in keyword

colon

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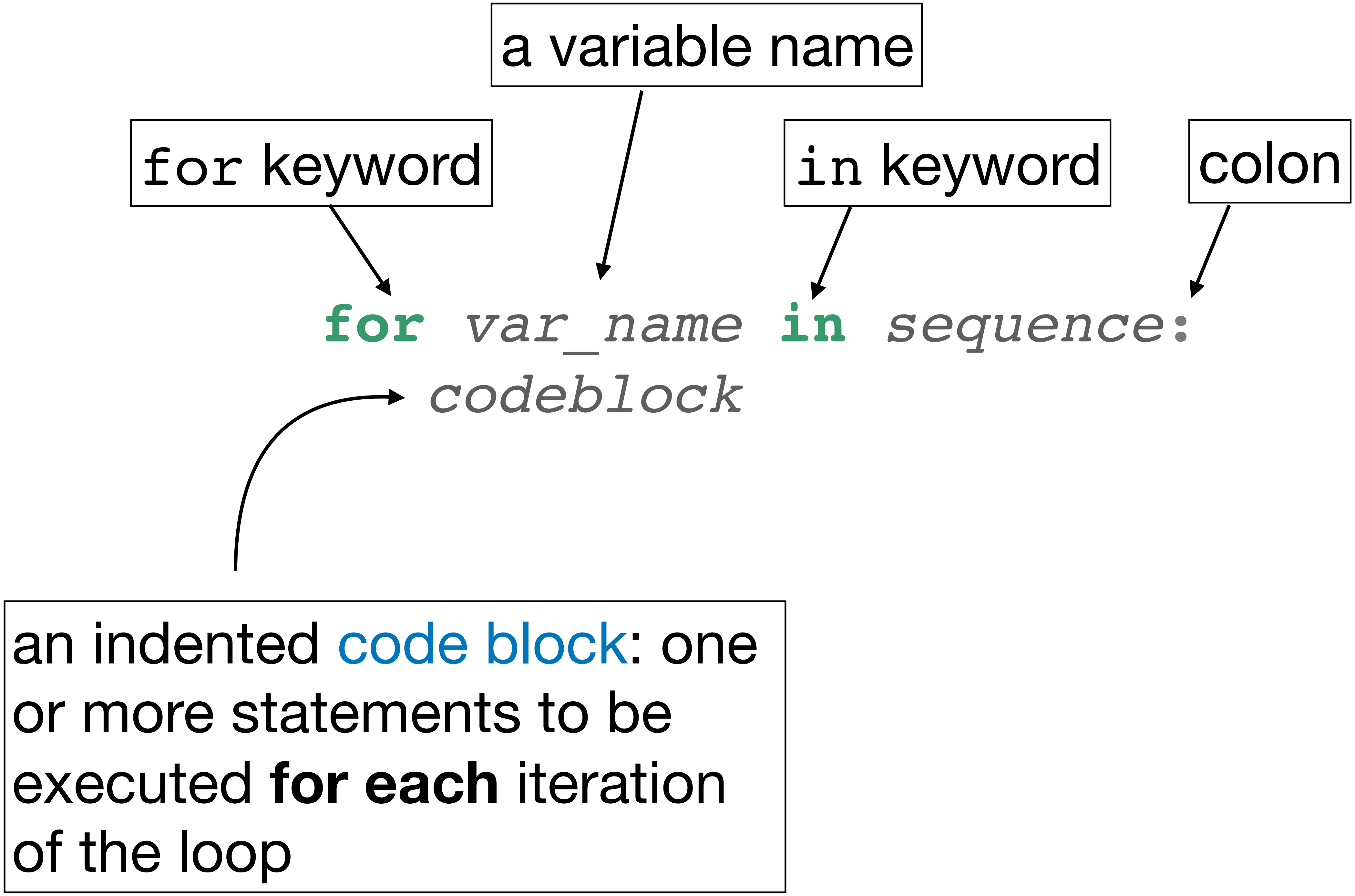
The `for` statement: syntax



a variable name

`for` keyword

`in` keyword

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for var_name in sequence:
    codeblock
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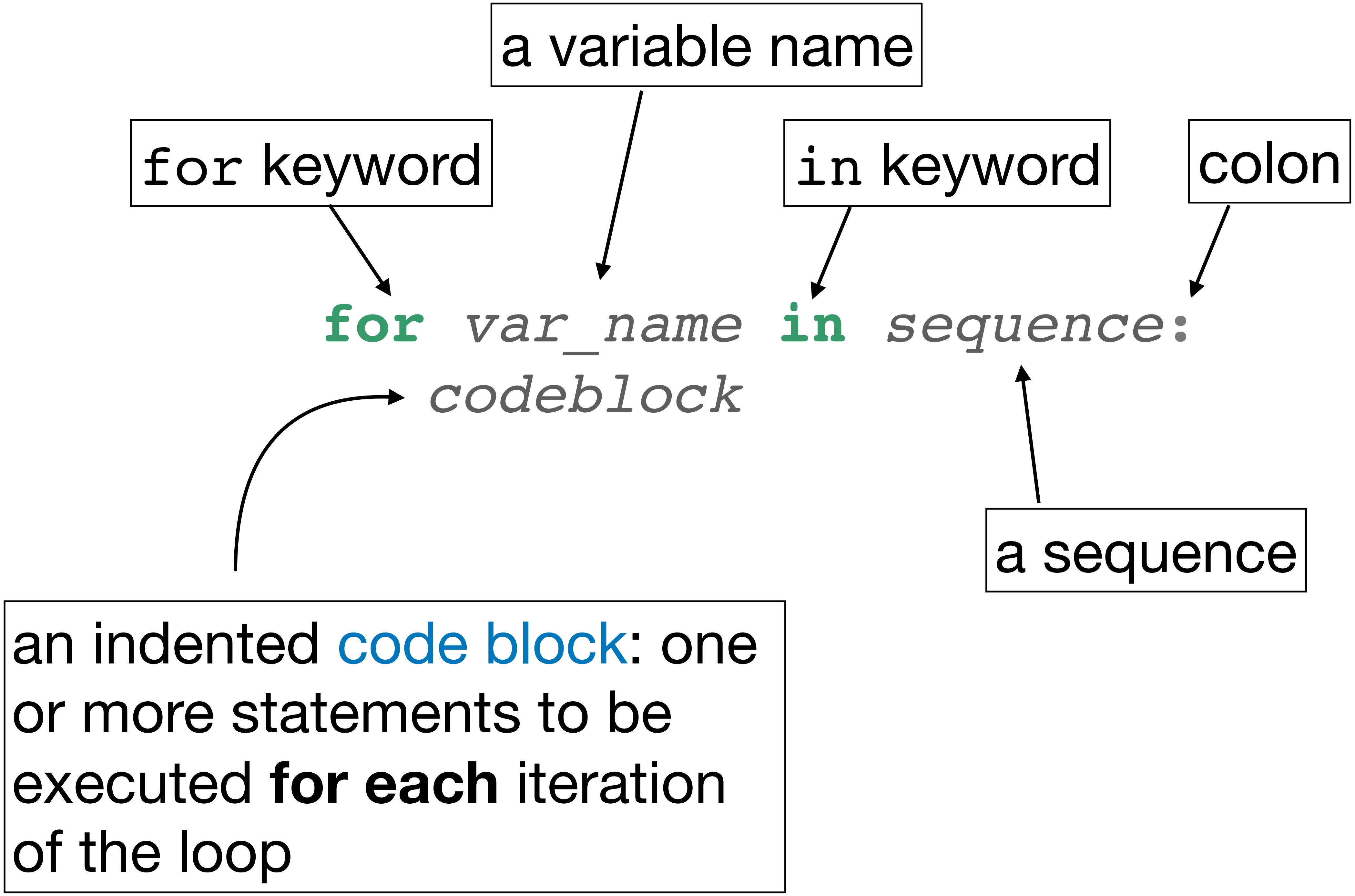
an indented code block: one or more statements to be executed **for each** iteration of the loop

The `for` statement: syntax



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colon

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a sequence

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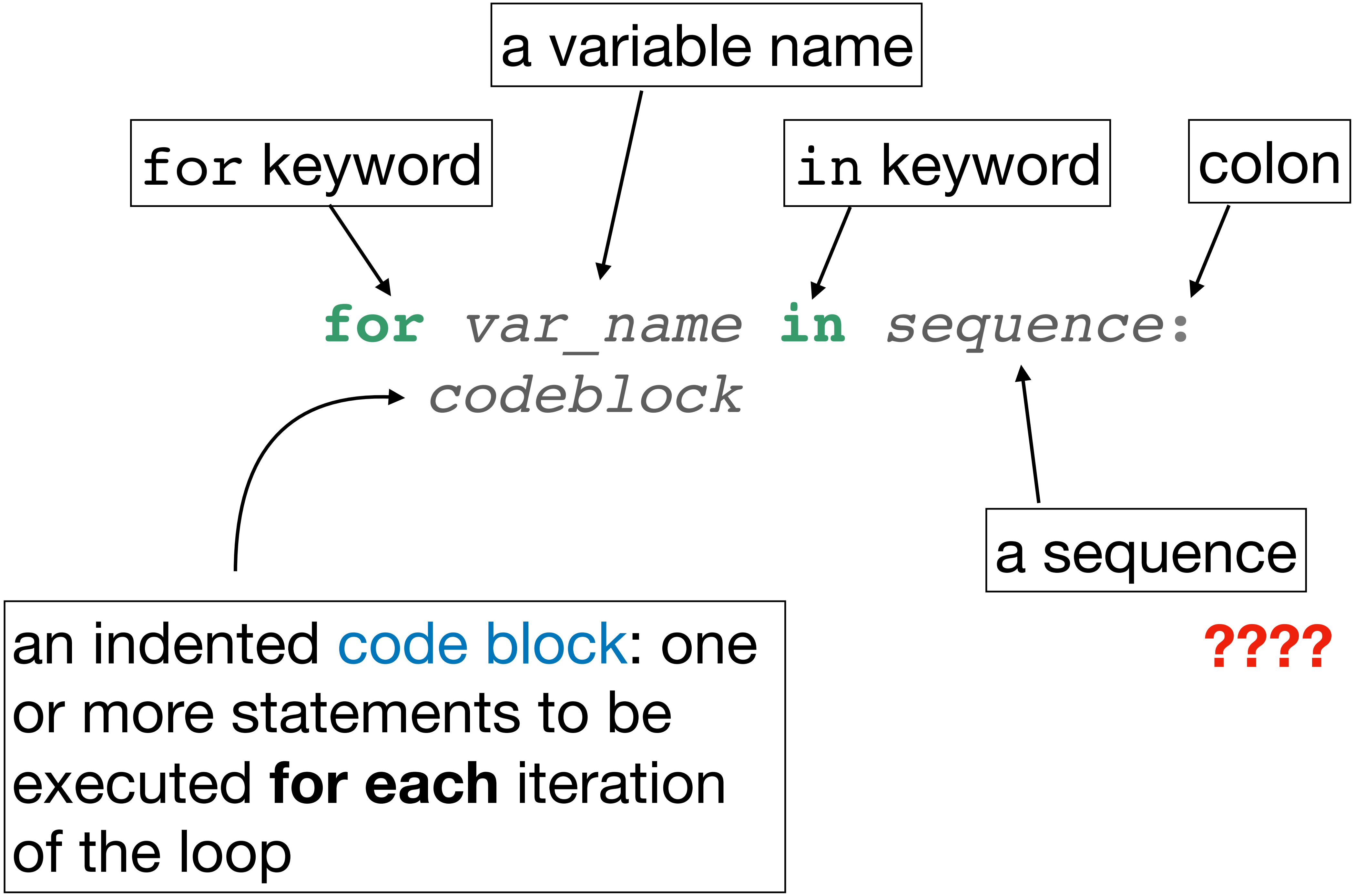

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a sequence

????

an indented code block: one or more statements to be executed **for each** iteration of the loop

Sequences in Python: Lists

```
for color in ["red", "green", "blue"]:
    print(color)
```

This code prints:

```
red
green
blue
```

Sequences in Python: Lists

```
for color in ["red", "green", "blue"]:
    print(color)
```

This is a `list`: an ordered collection of values.
Much more on these later.

This code prints:

```
red
green
blue
```

The `for` statement: behavior

```python
for color in ["red", "green", "blue"]:
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The `for` statement: behavior

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The loop body is executed once **for each** value in the sequence (list).

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In *each* iteration, the loop variable

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This code prints:

```
red
green
blue
```

In *each* iteration, the loop variable (`color`)

The `for` statement: behavior

```
for color in ["red", "green", "blue"]:
    print(color)
```

The loop body is executed once **for each** value in the sequence (list).

This code prints:

```
red
green
blue
```

In *each* iteration, the loop variable (`color`) takes on a *different* value from the sequence:

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for color in ["red", "green", "blue"]:
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```

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This code prints:

```
red
green
blue
```

In *each* iteration, the loop variable (`color`) takes on a *different* value from the sequence:

(`"red"`, then `"green"`, then `"blue"`)

The `for` statement: behavior

```
for color in ["red", "green", "blue"]:
    print(color)
```

The loop body is executed once **for each** value in the sequence (list).

This code prints:

```
red
green
blue
```

In *each* iteration, the loop variable (`color`) takes on a *different* value from the sequence:

(`"red"`, then `"green"`, then `"blue"`)

Notice: the loop variable gets updated **automatically** after each iteration!

Sequences in Python: Ranges

Lists are great if you have a list of things, but what about:

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Sequences in Python: Ranges

Lists are great if you have a list of things, but what about:

“Do `some_thing()` 10 times”? ugh.

```
for i in [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]:
    some_thing()
```

Sequences in Python: Ranges

Lists are great if you have a list of things, but what about:

“Do `some_thing()` 10 times”? ugh.

```
for i in [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]:
    some_thing()
```

New function to the rescue: `range` makes it easy to generate lists like this.

Sequences in Python: Ranges

```
for i in range(5):
    print(i)
```

This code prints:

```
0
1
2
3
4
```

Sequences in Python: Ranges

```
for i in range(5):
    print(i)
```

The range function returns a sequence of integers.

This code prints:

```
0
1
2
3
4
```

Sequences in Python: Ranges

```
for i in range(5):
    print(i)
```

The `range` function returns a sequence of integers.

Not technically a list, but acts like one: more on this later

This code prints:

```
0
1
2
3
4
```

Sequences in Python: the `range` function

Sequences in Python: the range function

```
for i in range(5):
    print(i, end=“ “)
```

prints: `0  1  2  3  4`

Sequences in Python: the `range` function

`range(`**`a`**`)`: from **0** *up to* but *not including* **`a`**

```
for i in range(5):
    print(i, end=“ “)
```

prints: `0  1  2  3  4`

Sequences in Python: the `range` function

`range(a)`: from **0** *up to* but *not including* **a**

```
for i in range(5):
    print(i, end=“ “)
```

prints: 0 1 2 3 4

```
for i in range(2, 5):
    print(i, end=“ “)
```

prints: 2 3 4

Sequences in Python: the `range` function

`range(`**`a`**`)`: from **0** *up to* but *not including* **`a`**

```
for i in range(5):
    print(i, end=“ “)
```

prints: 0 1 2 3 4

`range(`**`a, b`**`)`: from **a** *up to* but *not including* **`b`**

```
for i in range(2, 5):
    print(i, end=“ “)
```

prints: 2 3 4

Sequences in Python: the `range` function

`range(a)`: from **0** *up to* but *not including* **a**

```
for i in range(5):
    print(i, end=“ “)
```

prints: 0 1 2 3 4

`range(a, b)`: from **a** *up to* but *not including* **b**

```
for i in range(2, 5):
    print(i, end=“ “)
```

prints: 2 3 4

```
for i in range(1, 8, 3):
    print(i, end=“ “)
```

prints: 1, 4, 7

Sequences in Python: the `range` function

`range(`**`a`**`)`: from **0** *up to* but *not including* **`a`**

```
for i in range(5):
    print(i, end=" ")
```

prints: `0 1 2 3 4`

`range(`**`a, b`**`)`: from **a** *up to* but *not including* **`b`**

```
for i in range(2, 5):
    print(i, end=" ")
```

prints: `2 3 4`

`range(`**`a, b, c`**`)`: sequence from **a** *up to* but *not including* **`b`** counting in *increments* of **`c`**

```
for i in range(1, 8, 3):
    print(i, end=" ")
```

prints: `1, 4, 7`

Converting ranges to lists

The `range` function returns a **sequence** of integers.

It’s not technically a **list**: print(range(4)) does not print

```
[1, 2, 3]
```

To turn the range into a list (e.g., to print it), we can use the list function:

```
list(range(2, 5)) => [2, 3, 4]
```

Range function: Demo

- demo in shell
  - one, two, and three argument versions
- ranges.py

Range function: Demo

Range function: Demo

for posterity: see ranges.py

QOTD

```
for x in range(1,4):
   print (x + x * x, end=str(x))
```

Size of a `range`

```
for i in range(5):
    print(i, end=“ “)
```

prints: `0 1 2 3 4`

```
for i in range(2, 5):
    print(i, end=“ “)
```

prints: `2 3 4`

```
for i in range(1, 8, 3):
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```

prints: `1, 4, 7`

Exercise: How many elements are in `range(n)` ?

A. 0
B. n-1
C. n
D. 10

Size of a `range`

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prints: `0 1 2 3 4`

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prints: `1, 4, 7`

Exercise: How many elements are in `range(a, b)`?

A. a-b
B. b-a-1
C. b-a+1
D. b-a

QOTD

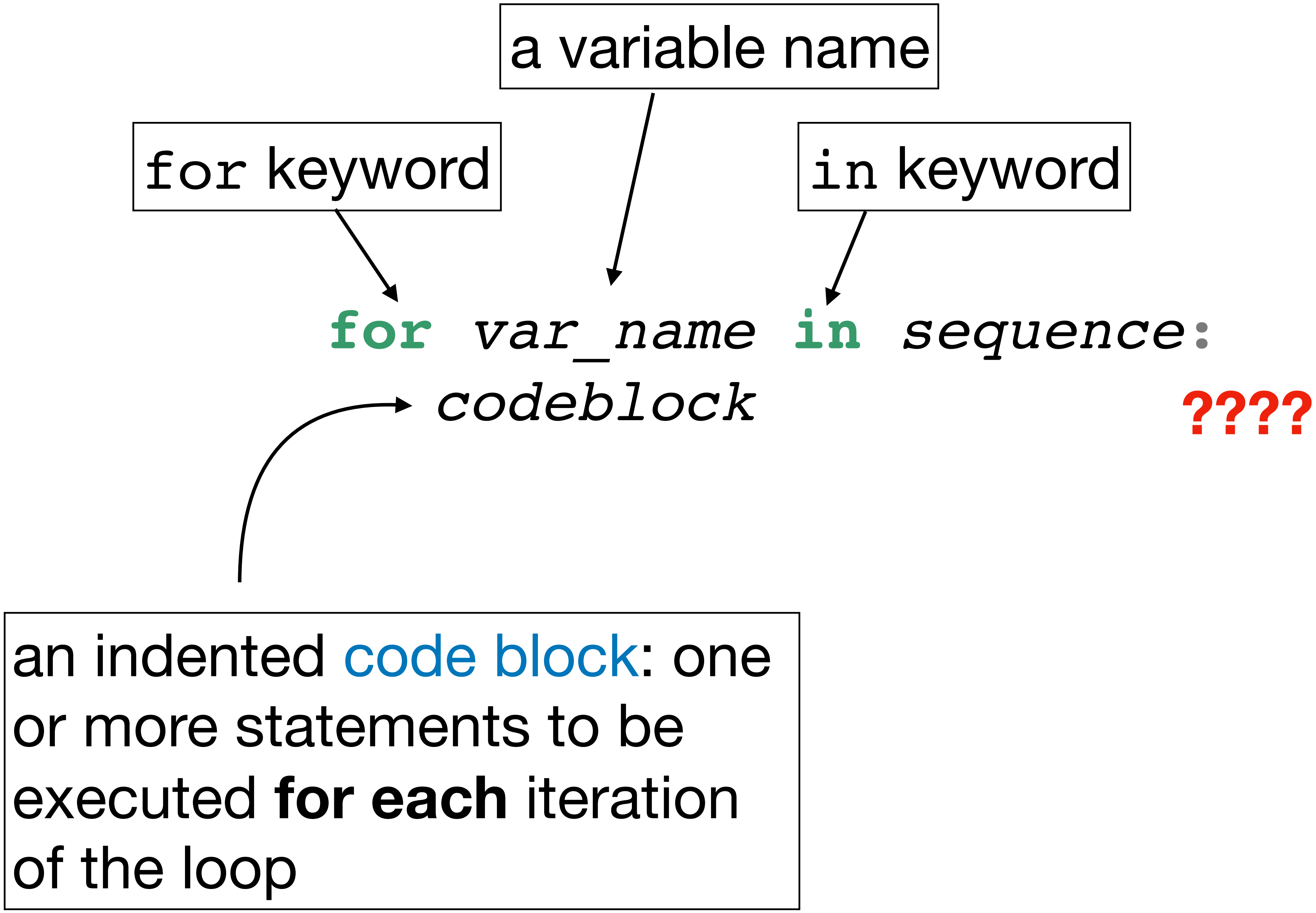
When running the code below, what pairs of values could be assigned to the variables x and y so that the program prints WWU 43 times? Select all correct choices.

```
x =
y =
for z in range(x, y):
  print("WWU")
```

Equivalent question:
for which of these is `y - x == 43`?

```
x: 0      y: 44
x: -21    y: 22
x: -21    y:21
x: -789   y: -746
x: -789   y: 746
x: 1      y: 44
```

Back to `for` loops...



a variable name

`for` keyword

`in` keyword

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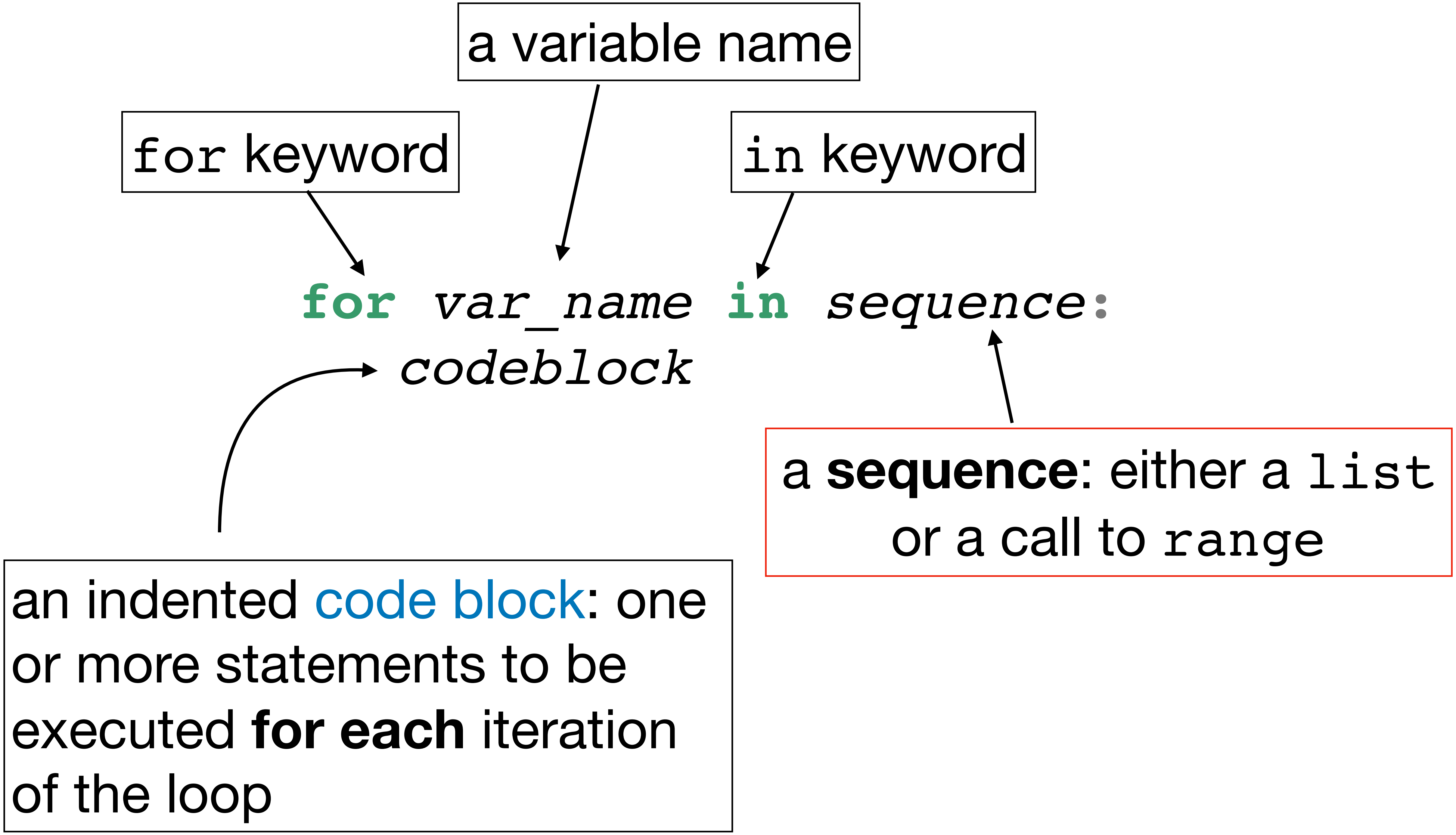
    codeblock
```

????

an indented code block: one or more statements to be executed **for each** iteration of the loop

Back to `for` loops...



a variable name

`for` keyword

`in` keyword

```
for var_name in sequence:
    codeblock
```

a **sequence**: either a `list` or a call to `range`

an indented code block: one or more statements to be executed **for each** iteration of the loop

`while` loops are annoying.

- Often, you want: “Do `some_thing()` 10 times”
- With a while loop you need to:

```
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I don’t even care about `i`,
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for i in range(10):
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```

We can!

Revisiting Repetition

```
for var_name in sequence:
    codeblock
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Revisiting Repetition

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```

- balance3.py - rewrite yearly bank account balance with a for loop

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- Average of 100 random numbers

Revisiting Repetition

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- balance3.py - rewrite yearly bank account balance with a for loop
- Average of 100 random numbers
- New problem: print all possible outcomes of two 6-sided dice.

Nesting loops?

Task: Print out all possible rolls of two six-sided dice.

Program output:

```
1 1
1 2
1 3
1 4
1 5
1 6
2 1
2 2
2 3
2 4
 …
6 4
6 5
6 6
```

(and so on)

Nesting loops!

Task: Print out all possible rolls of two six-sided dice.

Program output:

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            1 1
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(and so on)  …
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(and so on)

Break down the problem:

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(and so on)

Break down the problem:

- print 1 followed by each of 1 to 6

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…
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```

(and so on)

Break down the problem:

- print 1 followed by each of 1 to 6
- print 2 followed by each of 1 to 6

Nesting loops!

Task: Print out all possible rolls of two six-sided dice.

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```
1 1
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1 3
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6 6
```

(and so on)

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(and so on)   …
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             6 5
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Break down the problem:

- print 1 followed by each of 1 to 6
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Repetitive task

Nesting loops!

Task: Print out all possible rolls of two six-sided dice.

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(and so on)  …
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```

Break down the problem:

- print 1 followed by each of 1 to 6
- print 2 followed by each of 1 to 6
- and so on

Repetitive task

Repetitive task

Nesting loops! Demo

- dice.py - nested for loops to print all ordered pairs of numbers from 1 to 6 (inclusive)

Last time: Modules

The Python Standard Library is a collection of modules containing many more functions.

To use functions in a module, you need to import the module using an `import` statement:

```
import module
```

By convention, we put all import statements at the **top** of programs.

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(replace the in *`this font`* with the specific module name)

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`turtle` module

Python has Turtles!

turtle module

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```
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Python has Turtles!

```
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scott = turtle.Turtle()
```

What does this do?
Let's play with it.

Demo: basic turtle usage

Demo: basic turtle usage

- forward, backward
- left, right
- pendown/down
- penup/up

Creating and Using Objects

```
import turtle
scott = turtle.Turtle()
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The `Turtle()` function starts with a capital letter.
By convention this indicates that it is a special kind of function called a constructor that creates (and returns) new objects of type `Turtle`.

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The Turtle() function returns a Turtle object, and the variable `scott` now refers to it.

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The Turtle() function returns a Turtle object, and the variable `scott` now refers to it.

Objects can have functions associated with them, accessed via the dot notation, e.g.:

```
turtle.forward(10) # moves the turtle forward 10 units
turtle.left(90) # turns the turtle left 90 degrees
```

Creating and Using Objects

```
import turtle
scott = turtle.Turtle()
```

The `Turtle()` function starts with a capital letter.
By convention this indicates that it is a special kind of function called a constructor that creates (and returns) new objects of type `Turtle`.

The Turtle() function returns a Turtle object, and the variable `scott` now refers to it.

functions that belong to an object are called its ***methods***

Objects can have functions associated with them, accessed via the dot notation, e.g.:

```
turtle.forward(10) # moves the turtle forward 10 units
turtle.left(90) # turns the turtle left 90 degrees
```

Creating and Using Objects

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What methods do Turtles have? Lots!
Check the docs: https://docs.python.org/3.3/library/turtle.html?highlight=turtle

`turtle` module

Python has Turtles!

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Python has Turtles!

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Basic turtle methods

- forward: moves the turtle forward
- left/right: turns the turtle
- penup/pendown: turns drawing on and off

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Task: Write pseudocode for an algorithm to draw a square with side length 100:

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1. Move forward 100

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Task: Write pseudocode for an algorithm to draw a square with side length 100:

1. Move forward 100
2. Turn left 90 degrees

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
```

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Task: Write pseudocode for an algorithm to draw a square with side length 100:

1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
7. Move forward 100
```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
7. Move forward 100
8. (Turn left 90 degrees)
```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
7. Move forward 100
8. (Turn left 90 degrees)
```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
7. Move forward 100
8. (Turn left 90 degrees)
```

Can we do better?

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
Repeat 4 times:
    1. move forward 100
    2. turn left 90
```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

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Repeat 4 times:
    1. move forward 100
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```

Demo

Demo

- turtle_square.py: Write a loop-based program that makes a turtle and draws a square with it.

`while` **vs** `for`

Are for loops **always** better?

`while` vs `for`

Task: Generate and print random integers between 1 and 10 (inclusive) until one of the random numbers exceeds 8.

Would you use a `for` loop or a `while` loop?

`while` vs `for`

Task: Ask the user for a number (**n**), then print 100 random numbers between 0 and **n**.

Would you use a `for` loop or a `while` loop?

`while` vs `for`

Task: Sum the numbers from 1 to 340, leaving out those divisible by 5.

Would you use a `for` loop or a `while` loop?

Generalized Squares
AKA Equilateral Polygons

Task: Write code that makes the Turtle object `scott` draw an **n**-sided polygon, where **n** and the length of each side are given by the user.

Hint: the total amount the turtle needs to turn is 360 degrees.
Code from turtle_square:

```
import turtle

scott = turtle.Turtle()
for i in range(4):
    scott.forward(100)
    scott.left(90)
```

Additional Suggested Practice Problems

1. Make a Turtle do a random walk: write a program that repeats the following 100 times:

    - Move the turtle a random distance forward.
    - Turn the turtle a random number of degrees.

2. Re-write the dice exercise from last time using `for` loops (it's simpler this way!)