CSCI 141

Lecture 9:
Repetition: Repetition, the `while` statement,
Repetition, Repetition, Modules

Announcements

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- Midterm exam is a week from Friday!
  - Notes on how to study coming up next lecture.

Goals

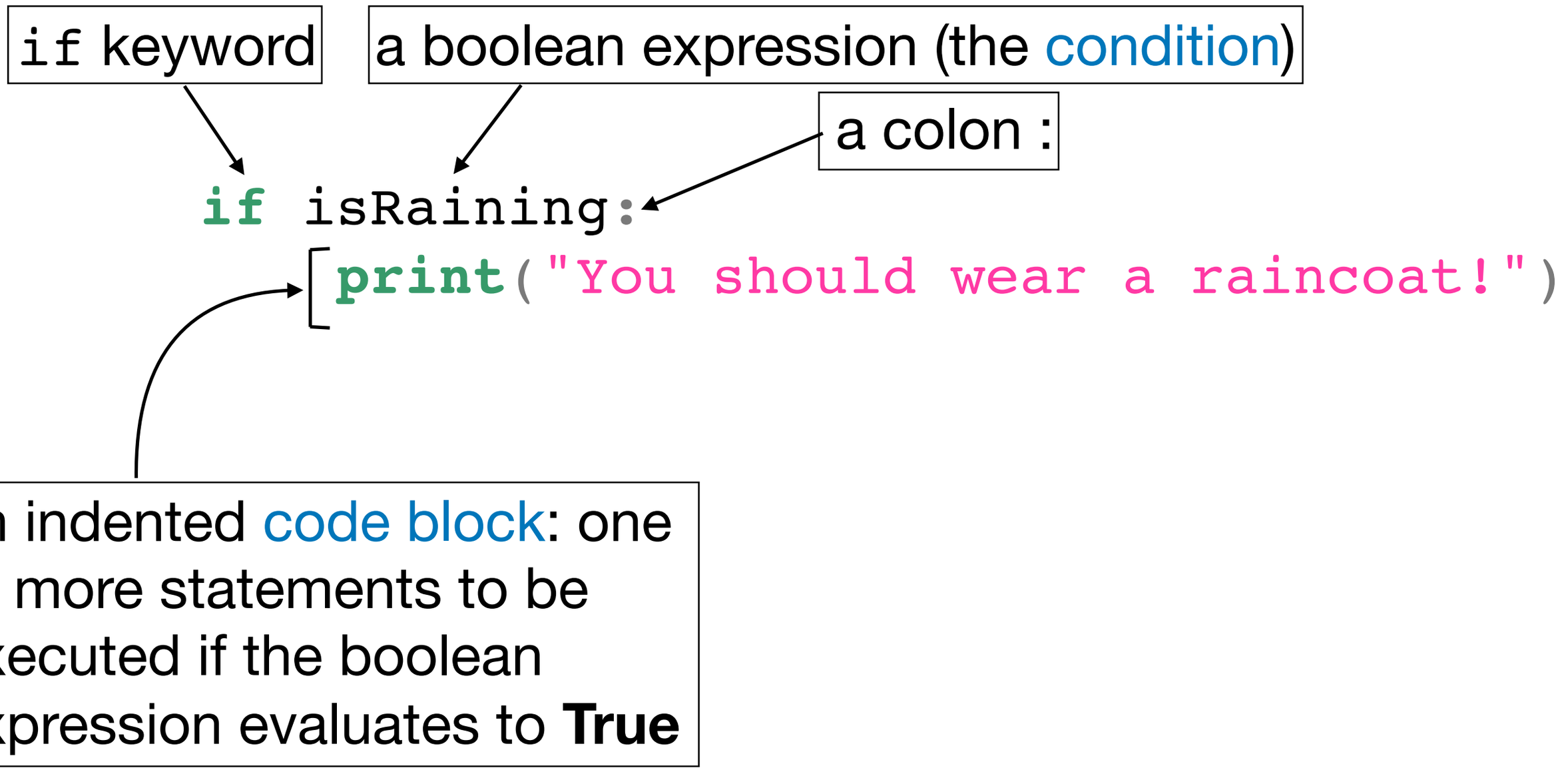
- Understand the syntax and behavior of the `while` statement (also known as `while` loop).

- Know how to use in-place operators: `+=`, `-=`, etc.

- Know how to import a module and call its functions

  - Know how to generate random numbers using the `random` module's `randrange` function.

Last time: `if` statements



Last Time:
Chained Conditionals

`elif` keyword

```
if isRaining and not isWindy:
    print("Bring an umbrella!")
elif isRaining and isWindy:
    print("Wear a raincoat!")
else:
    print("No rain gear needed!)
```

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an indented
code block
to be executed if:

- **none** of the above conditions was True
- ***and*** this `elif`'s condition is True

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(this behaves exactly like nesting an if inside each else)

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- ***and*** this `elif`'s condition is True

(this behaves exactly like nesting an if inside each else)

an indented code block to be executed if the **none** of the above conditions was true

(the else clause is optional)

QOTD

Program 1:

```
if (num_tacos == 32):
    print("32 tacos")
elif (num_tacos < 32):
    print("Too few tacos")
elif (num_tacos == 32):
    print("32 tacos")
elif (num_tacos % 5 == 0):
    print("Oh yes, tacos!")
else:
    print("Too many tacos")
```

Give the **smallest positive integer** value for the variable num_tacos such that the three programs print **exactly** the same thing when they are executed.

QOTD

Program 2:

```
if (num_tacos == 32):
     print("32 tacos")
if (num_tacos < 32):
     print("Too few tacos")
if (num_tacos == 33):
     print("33 tacos")
if (num_tacos % 5 == 0):
     print("Oh yes, tacos!")
else:
     print ("Too many tacos")
```

Give the **smallest positive integer** value for the variable num_tacos such that the three programs print **exactly** the same thing when they are executed.

QOTD

Program 3:

```
if (num_tacos == 32):
    print("32 tacos")
else:
    if (num_tacos < 32):
        print("Too few tacos")
    else:
        if (num_tacos == 34):
            print("34 tacos")
        else:
            if (num_tacos % 5 == 0):
                print("Oh yes, tacos!")
            else:
                print ("Too many tacos")
```

Give the **smallest positive integer** value for the variable num_tacos such that the three programs print **exactly** the same thing when they are executed.

Today: Repetition

- So far, we've seen how to:
  - Print things to the screen and replace your calculator
  - Represent complicated boolean expressions and execute different code based on their truth values.
- So far we *haven't* seen how to:
  - Do anything that you couldn't do yourself, given pencil and paper and a few minutes to step through the code.

Motivation

Anyone really good at tongue twisters?

Pad kid poured curd pulled cod.
Pad kid poured curd pulled cod.
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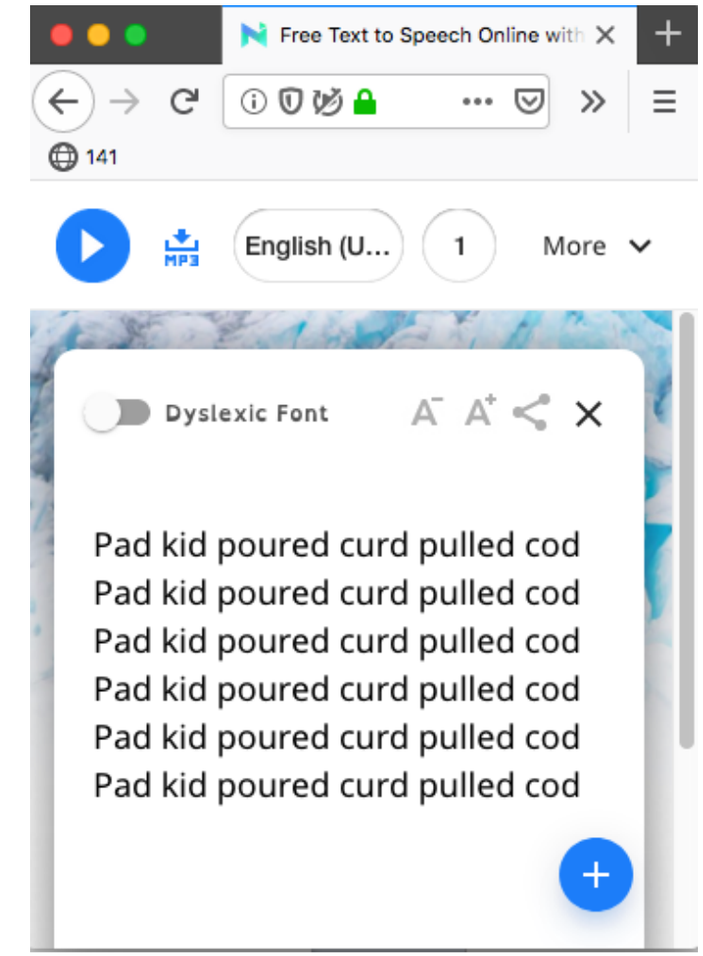
This is (according to MIT psychologists*) the hardest known tongue twister.

Fact: humans are **bad** (or at least slow) at performing repetitive tasks.

*Stefanie Shattuck-Hufnagel et al., 2013

Motivation

Fact: humans are **bad** (or at least slow) at performing repetitive tasks.



https://www.naturalreaders.com/online/

Fact: computers are are good (or at least fast) at performing repetitive tasks.

Motivation

Suppose you have a starting bank account balance of $100.00, and your account earns 2% interest each year.

What is your balance after five years?

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Suppose you have a starting bank account balance of $100.00, and your account earns 2% interest each year.

What is your balance each year for five years?

```
balance = 100.00
```

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```
balance = 100.00
balance = balance + (0.02 * balance)
print(balance) # year 1
```

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What is your balance each year for five years?

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balance = 100.00
balance = balance + (0.02 * balance)
print(balance) # year 1
balance = balance + (0.02 * balance)
print(balance) # year 2
```

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balance = balance + (0.02 * balance)
print(balance) # year 2
balance = balance + (0.02 * balance)
print(balance) # year 3
```

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print(balance) # year 4
```

uh oh…
my font is
getting small

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print(balance) # year 4
balance = balance + (0.02 * balance)
print(balance) # year 5
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```

argh, ok, done.

Motivation

Suppose you have a starting bank account balance of $100.00, and your account earns 2% interest each year.

What is your balance each year for **500** years?

An extremely common task: do the same thing over and over again, or do the same processing on many pieces of data.

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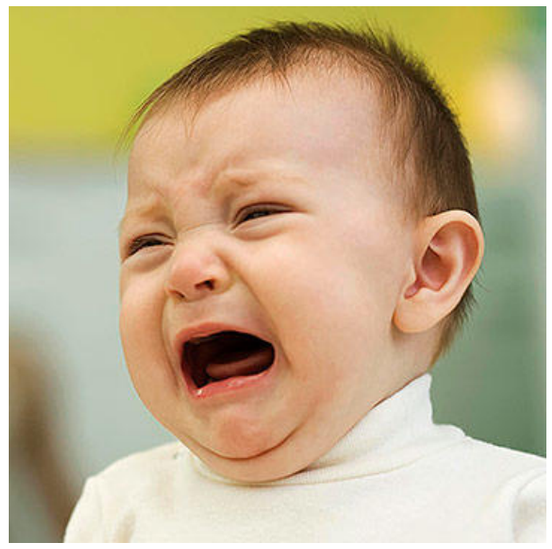
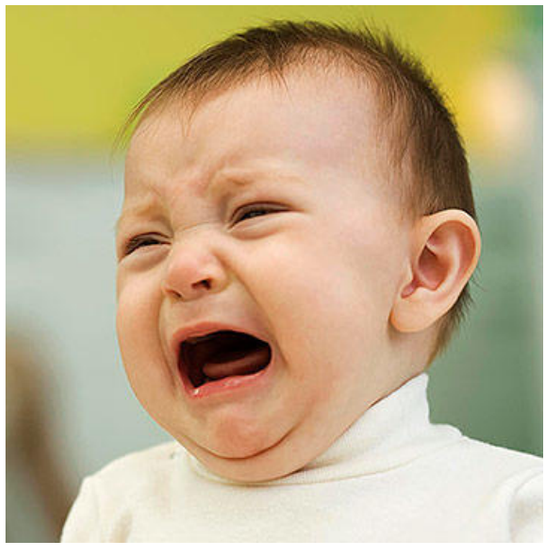
...



Motivation

Example: Convert this 100x100 pixel image to grayscale (“black-and-white”).



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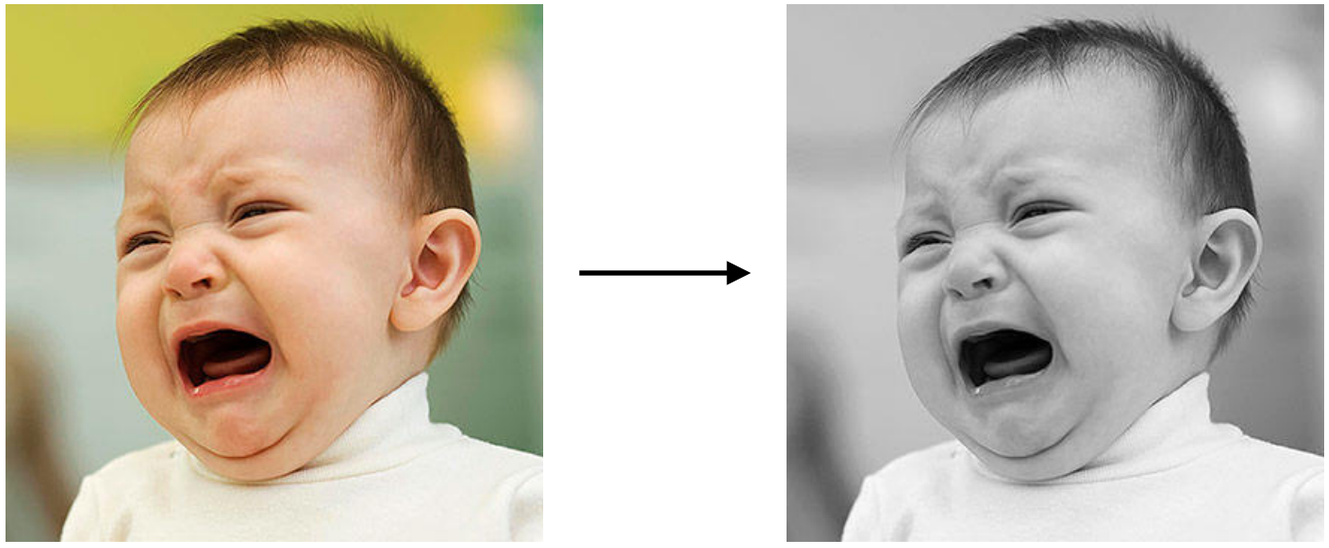

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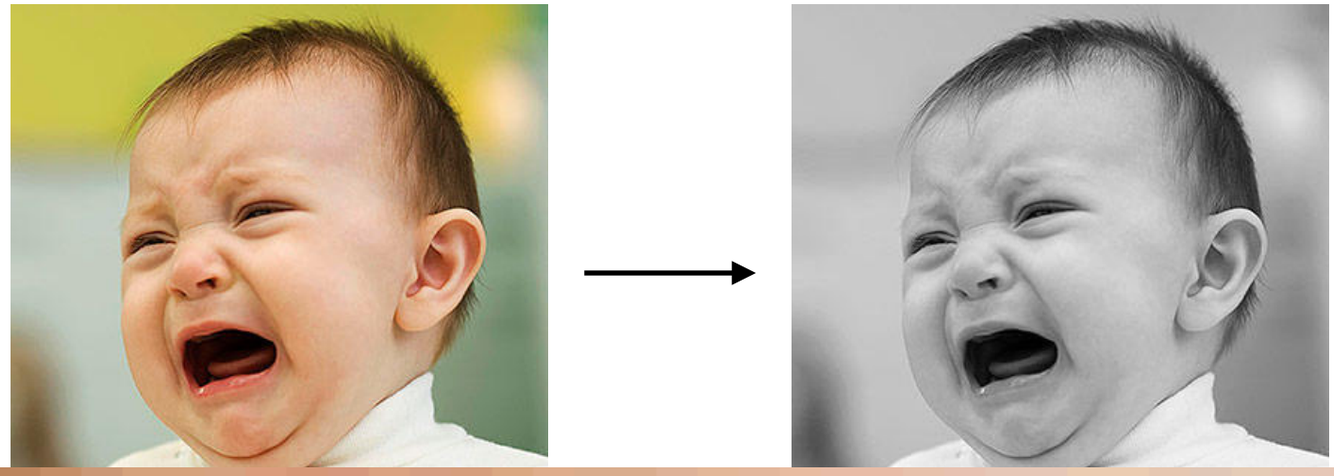

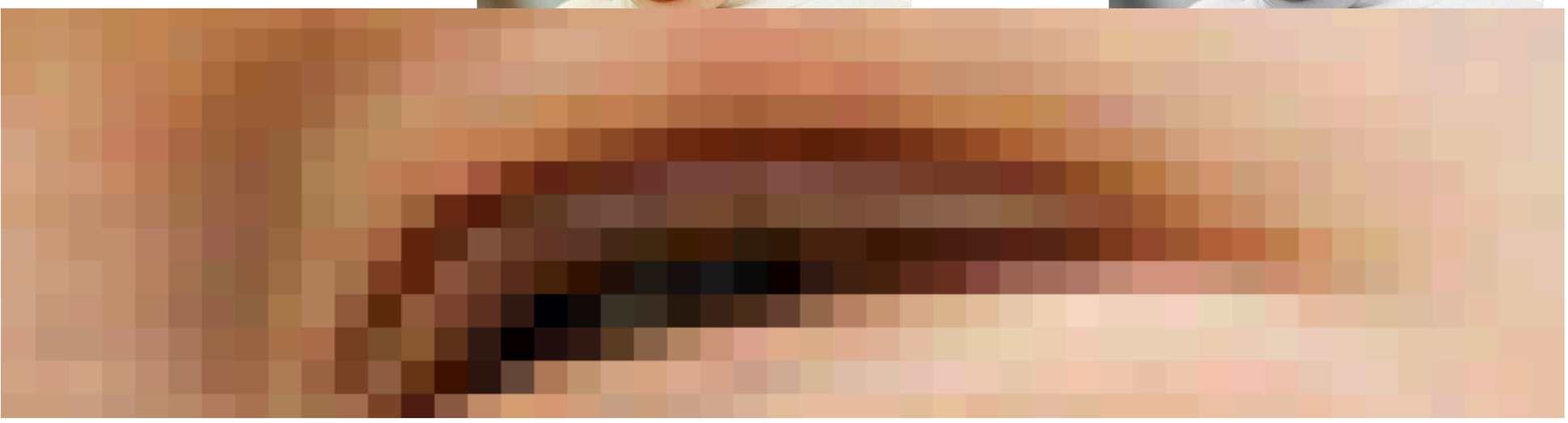

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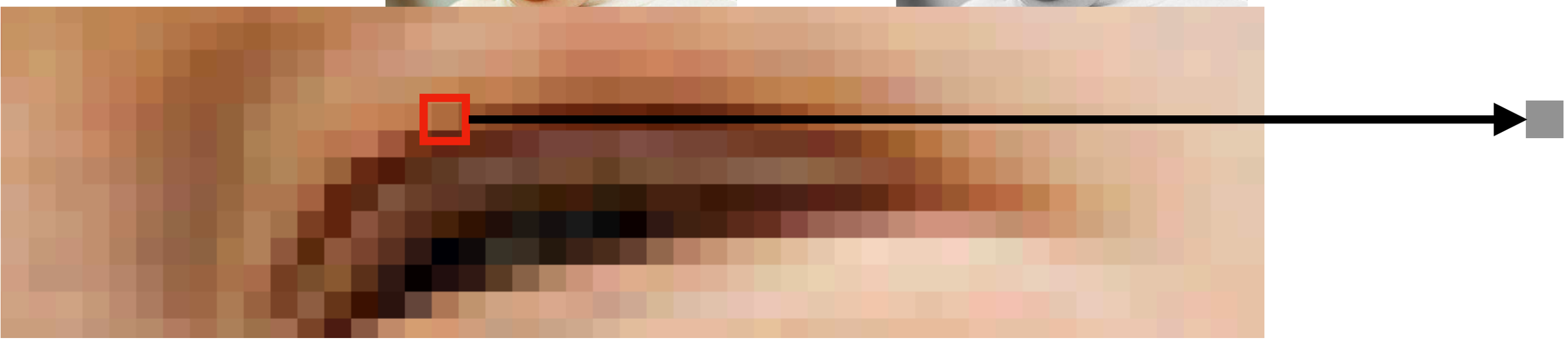

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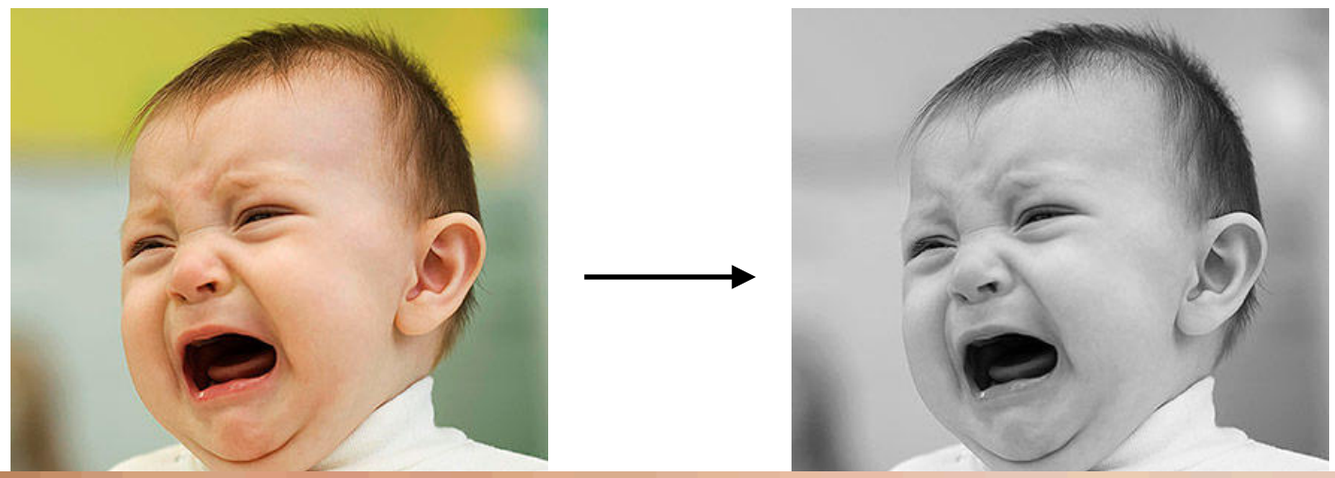
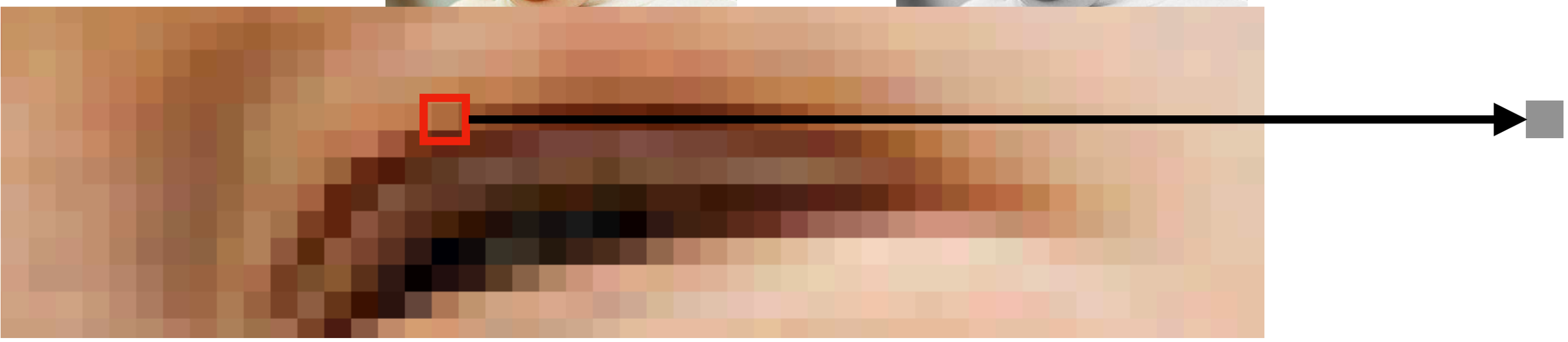


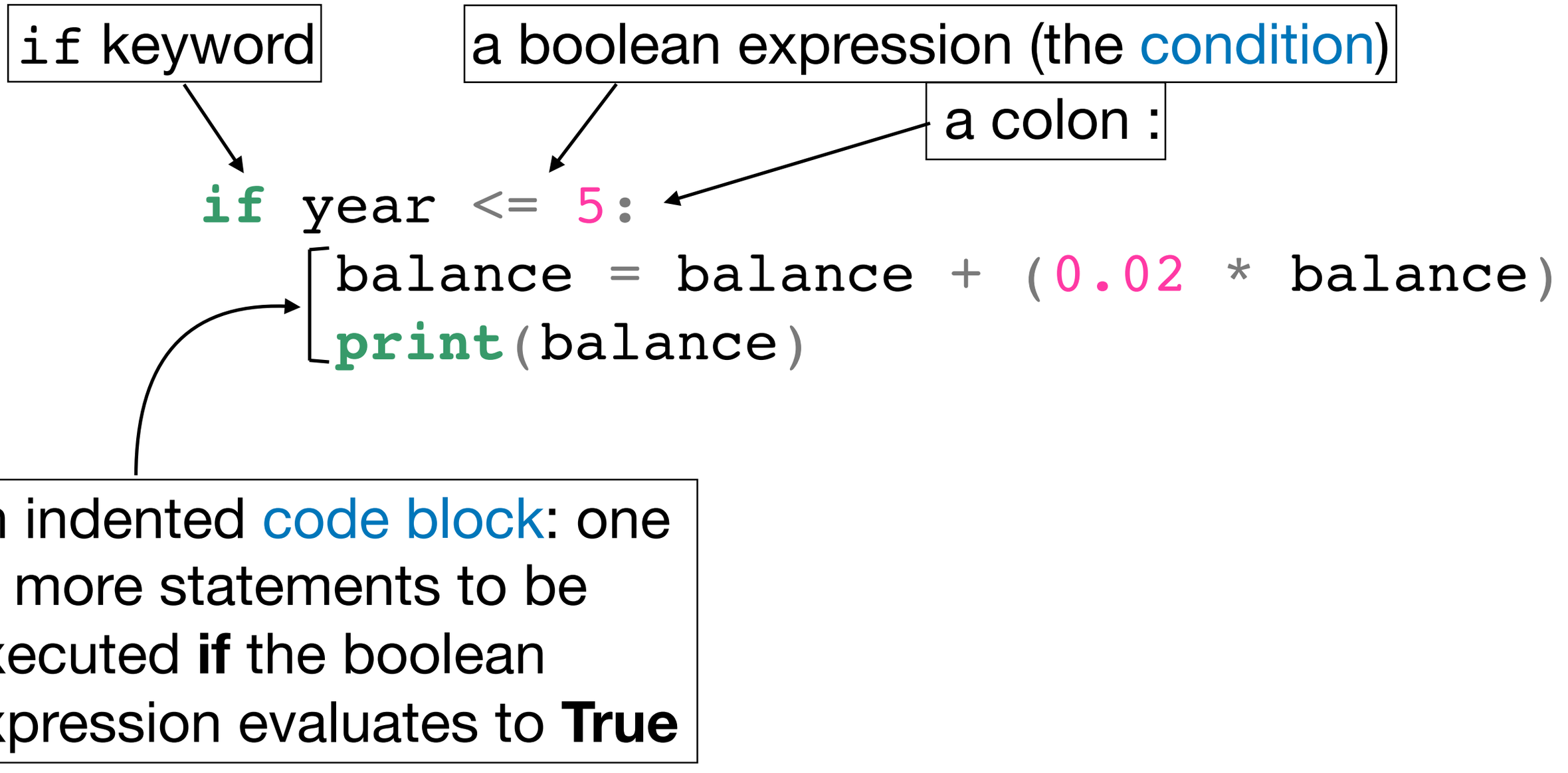


10,000 pixels, same calculation:

```
grey = 0.29 * red + 0.59 * green + 0.12 * blue
```

Python to the rescue: the `while` statement

Not so different from an `if` statement:



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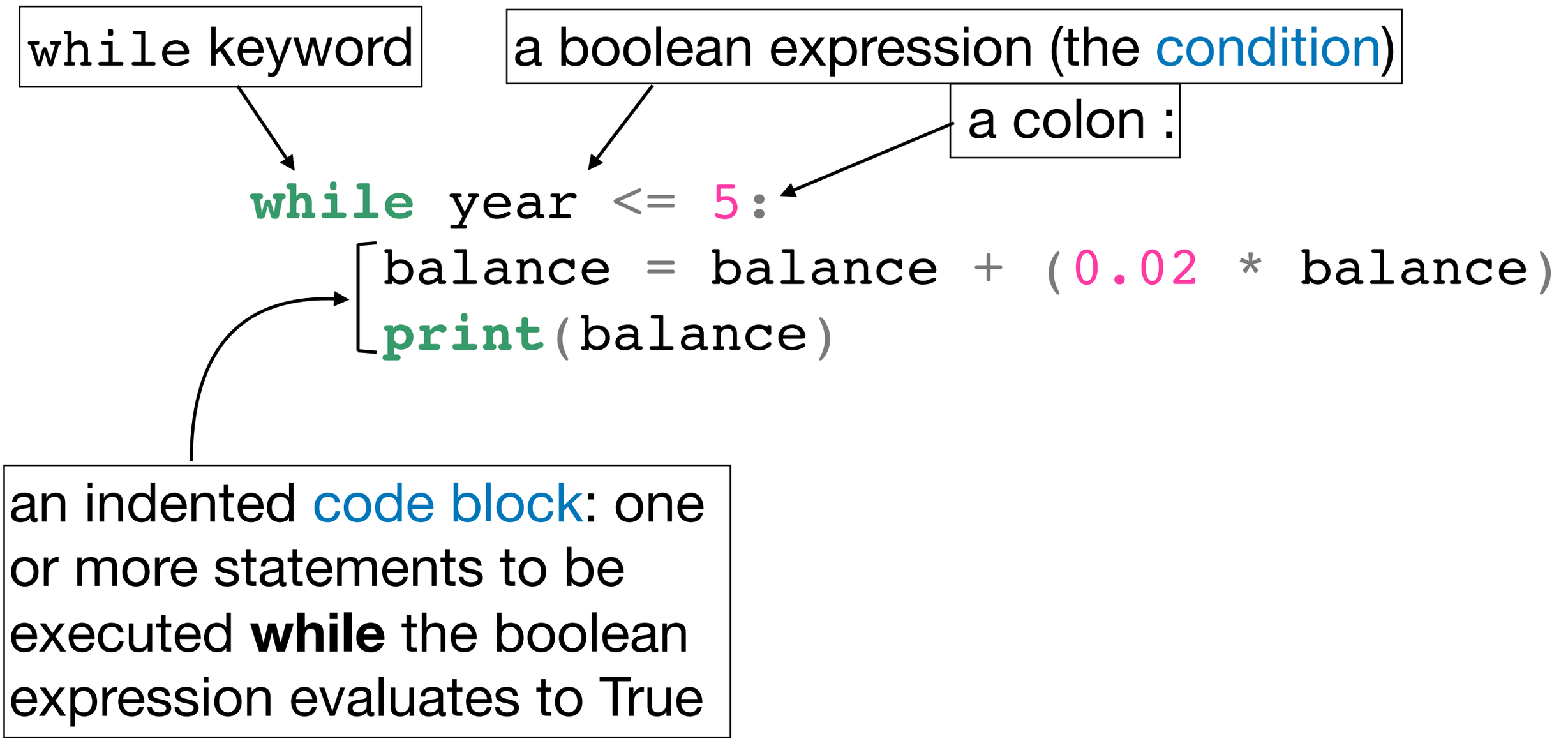

The `while` statement: A Working Example

```
# print account balance after each
# of five years:
balance = 100.0 # starting balance
year = 1
while year <= 5:
    balance = balance + (0.02 * balance)
    print(balance)
    year = year + 1
```

The `while` statement: A Working Example

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Terminology notes:

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Terminology notes:

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Terminology notes:

- the line with `while` and the condition is the loop header
- the code block is the loop body
- the entire construct (header and body) is a `while` statement
- usually people call them while loops instead

demo: interest

- balance1.py: the tedious way
- balance2.py: the loopy way

The `while` statement: Semantics (Behavior)

If statement:

1. Evaluate the condition
2. If true, execute body (code block), then continue on.

While statement:

1. Evaluate the condition
2. If true, execute body, otherwise skip step 3 and continue on.
3. Go back to step 1

Doubling to 100

Task: Find how how many times you have to double the number 1 to make it larger than 100.

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```
times = 0
n = 1
while [condition here]:
    n = n * 2
    times = times + 1
print(times, "times!")
```

Doubling to 100

Task: Find how how many times you have to double the number 1 to make it larger than 100.

```
times = 0
n = 1
while [condition here]:
    n = n * 2
    times = times + 1
print(times, "times!")
```

Which of the following conditions is correct?

A. `times < 100`

B. `times <= 100`

C. `n > 100`

D. `n <= 100`

Aside: In-Place Operators

When writing loops (and code in general), you'll find yourself doing things like this often:

```
count = count - 1
total = total + n
```

Python has a nice shorthand for this:

```
count -= 1
total += n
```

Many math operators have an in-place version:

```
+=      -=      /=      //=      %=
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```

[**No**, Python doesn't have increment and decrement operators ++ and --]

Demo

Demo

- double.py - change to in-place operators
- count.py:
  - Counting up, counting down by an interval
- never.py:
  - Condition never True
  - Condition never False
- input.py:
  - sum user-provided positive numbers until a negative number is entered

Other Peoples' Code

We've already used code other people wrote by calling built-in Python functions:

- `print`, `input`, `type`

Built-in functions are special because they're always available.

Many other functions exist in the Python Standard Library, which is a collection of modules containing many more functions.

Other Peoples' Code

An example: I want to generate a random integer between 0 and 10.

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```
import random
```

I could go look at the source code…

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```
197
198 ## -------------------- integer methods  --------------------
199
200     def randrange(self, start, stop=None, step=1, _int=int):
201         """Choose a random item from range(start, stop[, step]).
202
203         This fixes the problem with randint() which includes the
204         endpoint; in Python this is usually not what you want.
205
206         """
207
208         # This code is a bit messy to make it fast for the
209         # common case while still doing adequate error checking.
210         istart = _int(start)
211         if istart != start:
212             raise ValueError("non-integer arg 1 for randrange()")
213         if stop is None:
214             if istart > 0:
215                 return self._randbelow(istart)
216             raise ValueError("empty range for randrange()")
217
218         # stop argument supplied.
219         istop = _int(stop)
220         if istop != stop:
221             raise ValueError("non-integer stop for randrange()")
222         width = istop - istart
223         if step == 1 and width > 0:
224             return istart + self._randbelow(width)
225         if step == 1:
226             raise ValueError("empty range for randrange() (%d, %d, %d)" % (istart, istop, width))
227
228         # Non-unit step argument supplied.
229         istep = _int(step)
230         if istep != step:
231             raise ValueError("non-integer step for randrange()")
```

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An example: I want to generate a random integer between 0 and 10.

I don't know how to do this.

Someone who does has written some functions for me. They live in the `random` module:

```
import random
```

I could go look at the source code… but I'd rather just use their functions without knowing **how** they work.

```
num = random.randint(0,10)
```

Other Peoples' Code

```
import random
num = random.randint(0,10)
```

Two questions:

1. **What is this syntax about?**

2. How do I know what the function does?

Using Modules: Syntax

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.

Using Modules: Syntax

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
```

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

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

Using Modules: Syntax

Once you've imported a module:

```
import random
```

you can call functions in that module using the following syntax:

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random.randint(0,10)
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Function call (the usual syntax)

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Module name — Dot — Function call (the usual syntax)

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```
import random
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Two questions:

1. What is this syntax about?

2. **How do I know what the function does?**

Read about it in the Python documentation.
My approach, in practice:

1. Google "python 3 <whatever>"
2. Make sure the URL is from python.org and has version python 3.x

example

Demo

- use of randint in a very simple guessing game

`math` module

- The math module has useful stuff!
- You can read about it in the documentation.
- logarithms, trigonometry, …
- Modules can also contain values:

```
>>> import math
>>> math.pi
3.141592653589793
>>> math.e
2.718281828459045
>>>
```

More on import statements

- Import the entire module:

```
import random
num = random.randint(1, 10)
```

- Import a specific function:

```
from math import sin
sin0 = sin(0)
```

  - Don’t need module name dot notation
  - Other `math` functions are not accessible

You try it

Exercise: write a program that generates and prints random integers between 1 and 10 (inclusive) until one of the random numbers exceeds 8.

Documentation says:

`random.`**`randint`**(a, b)

Return a random integer N such that `a <= N <= b`