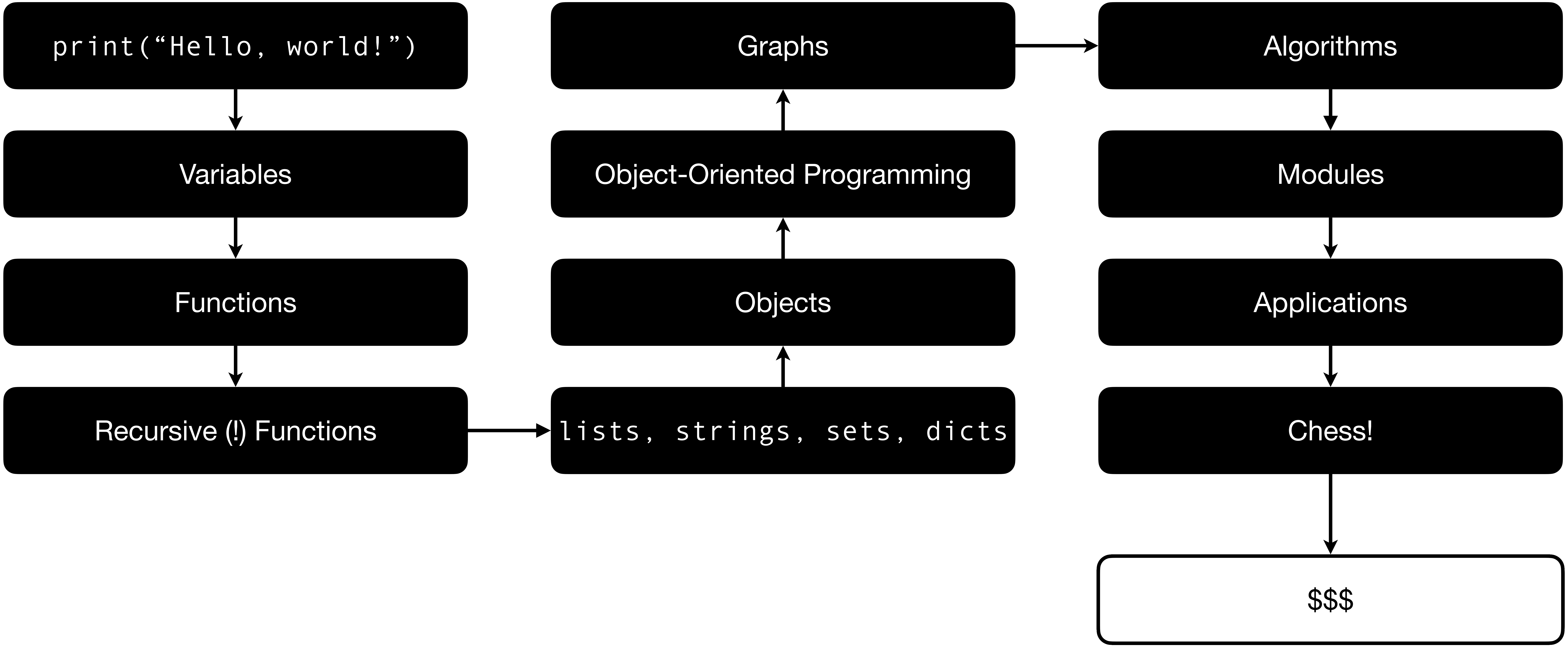
CMSC 14300

you’re in the right place

Byron Zhong

Your Journey in CS So Far



`print(“Hello, world!”)`

Variables

Functions

Recursive (!) Functions

`lists, strings, sets, dicts`

Objects

Object-Oriented Programming

Graphs

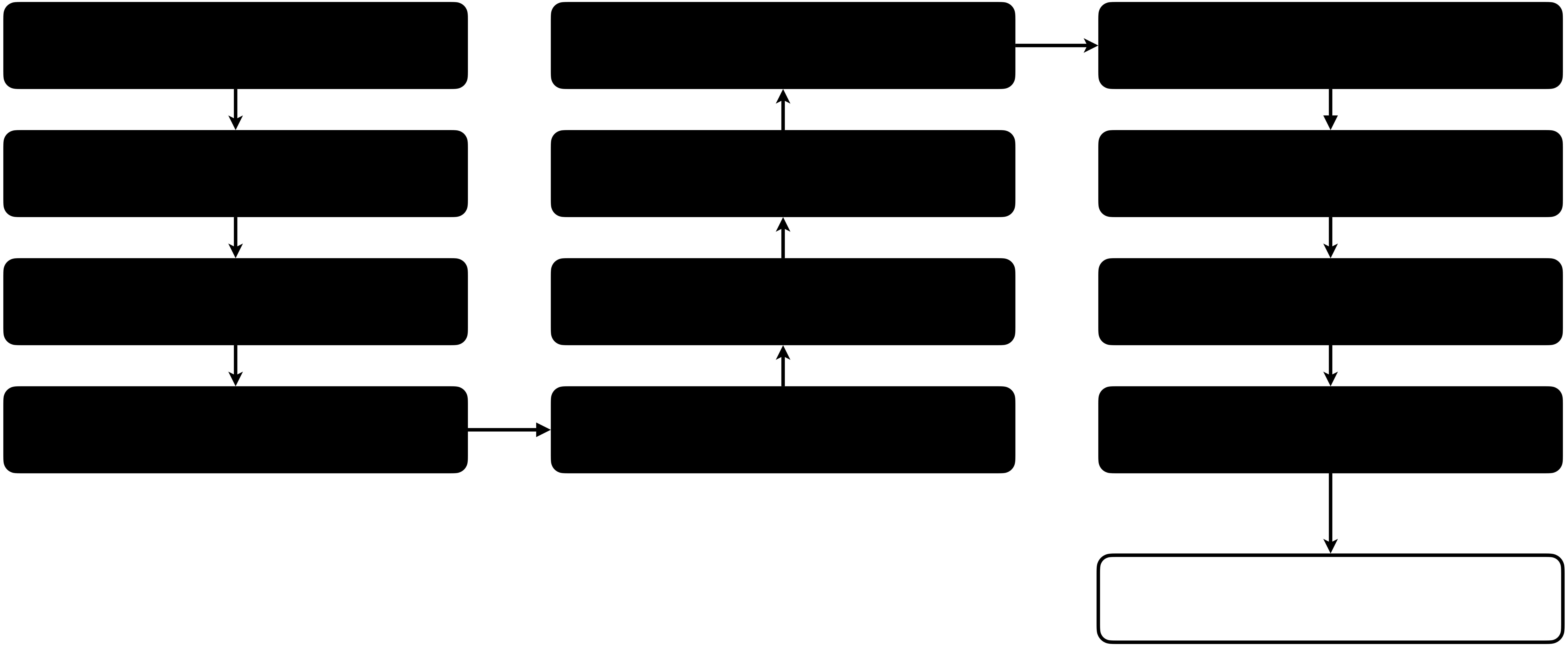
Algorithms

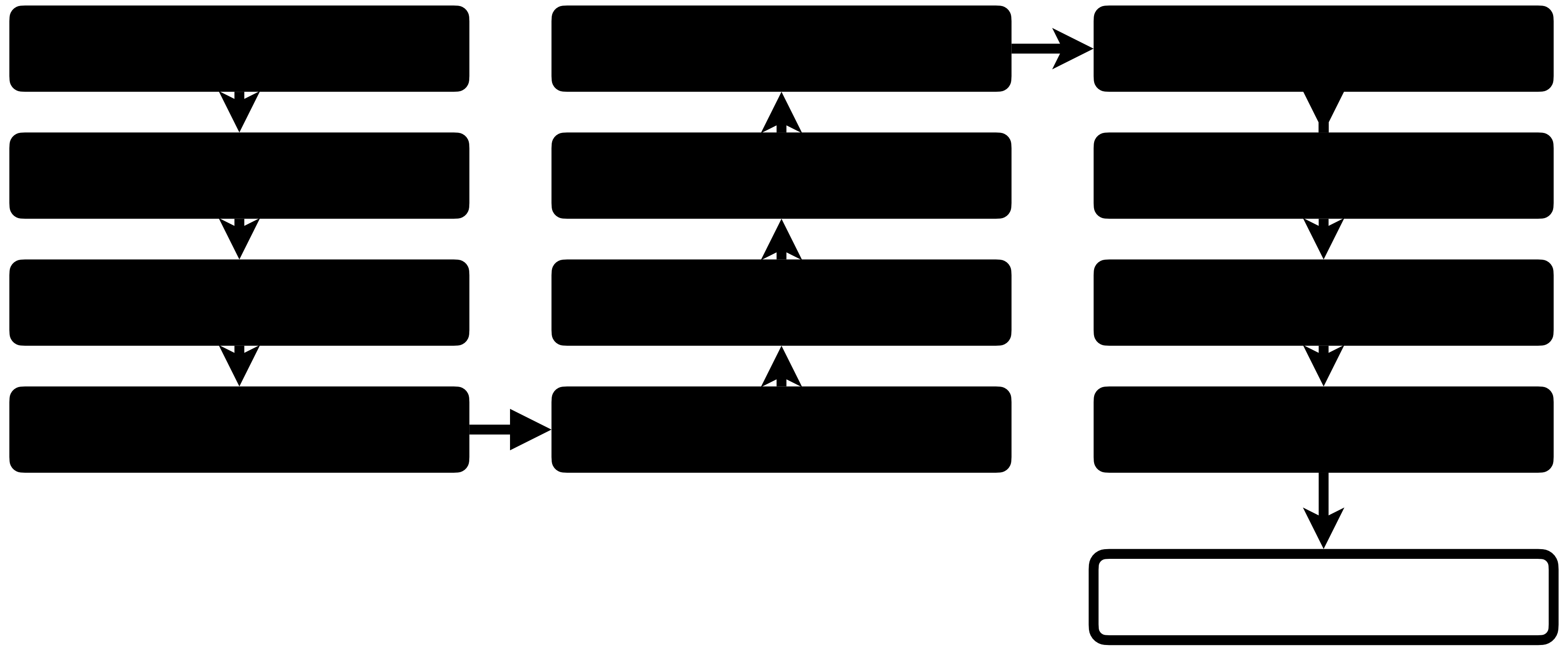
Modules

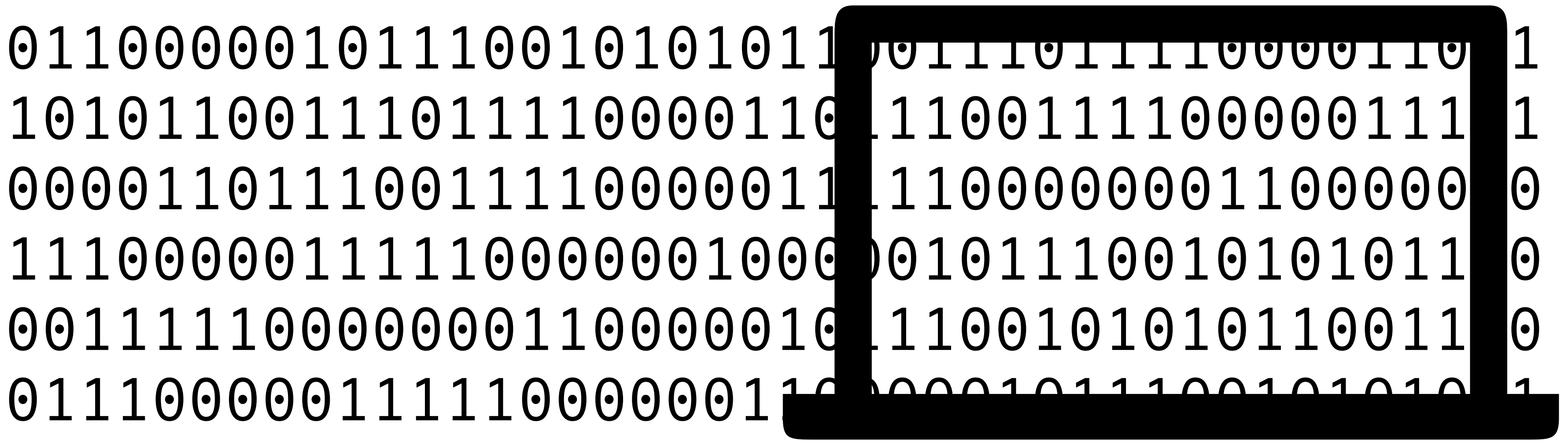
Applications

Chess!

$$$







But what really is a variable?

… what really is a function?

… what does CPU do exactly?

… how does anything work?

CMSC 14300
Systems Programming I

Introduction

Byron Zhong

Today's Plan

1. Administrivia
2. A whirlwind tour of C
3. Terminal and coding environment

Administrivia

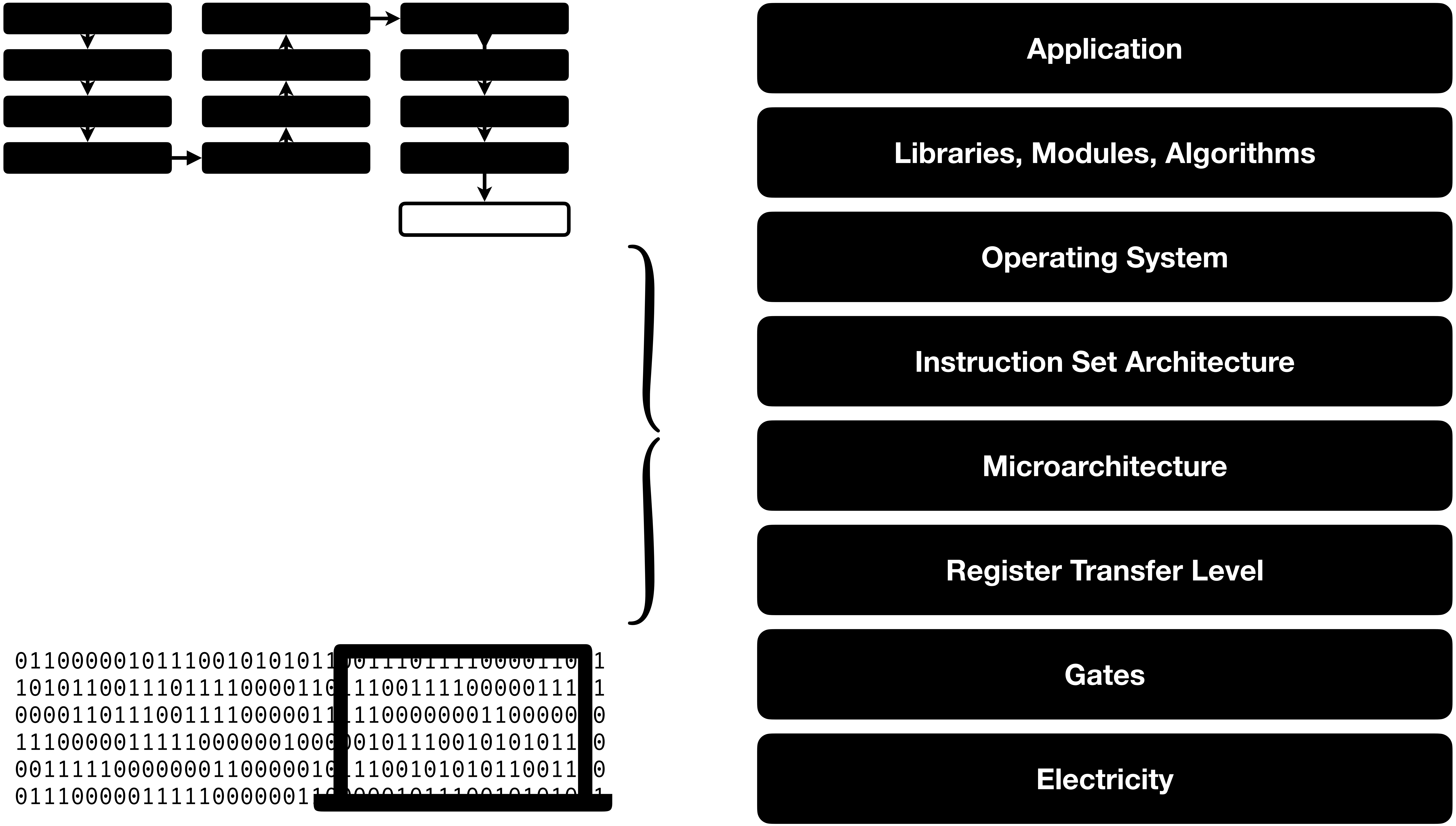
Staff

1. Me
2. Víctor (Course Coordinator)

Administrivia

143’s goals

1. Develop a deep understanding of how computers work
2. Transition from introductory programming to programming as a professional



Application

Libraries, Modules, Algorithms

Operating System

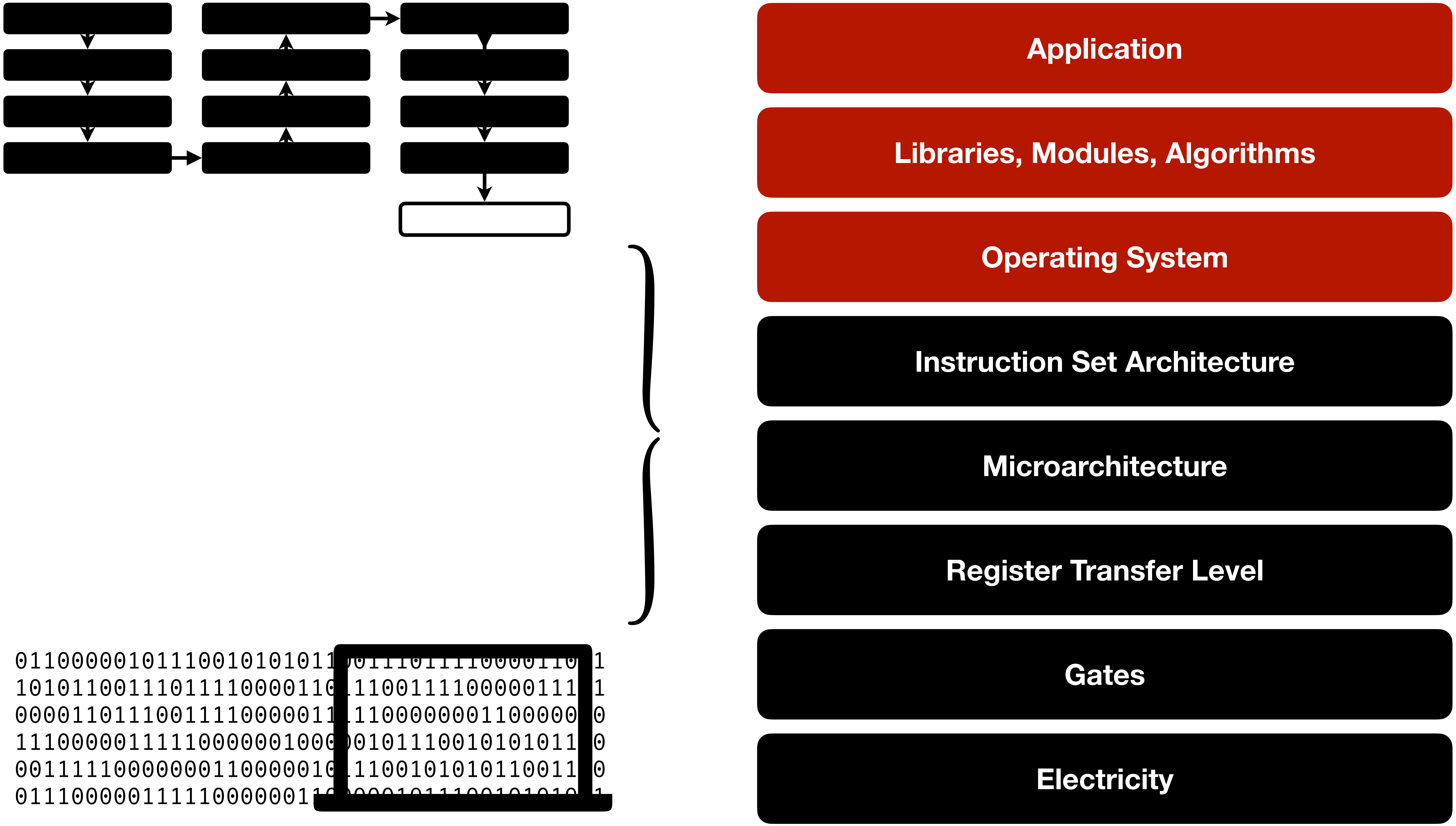
Instruction Set Architecture

Microarchitecture

Register Transfer Level

Gates

Electricity



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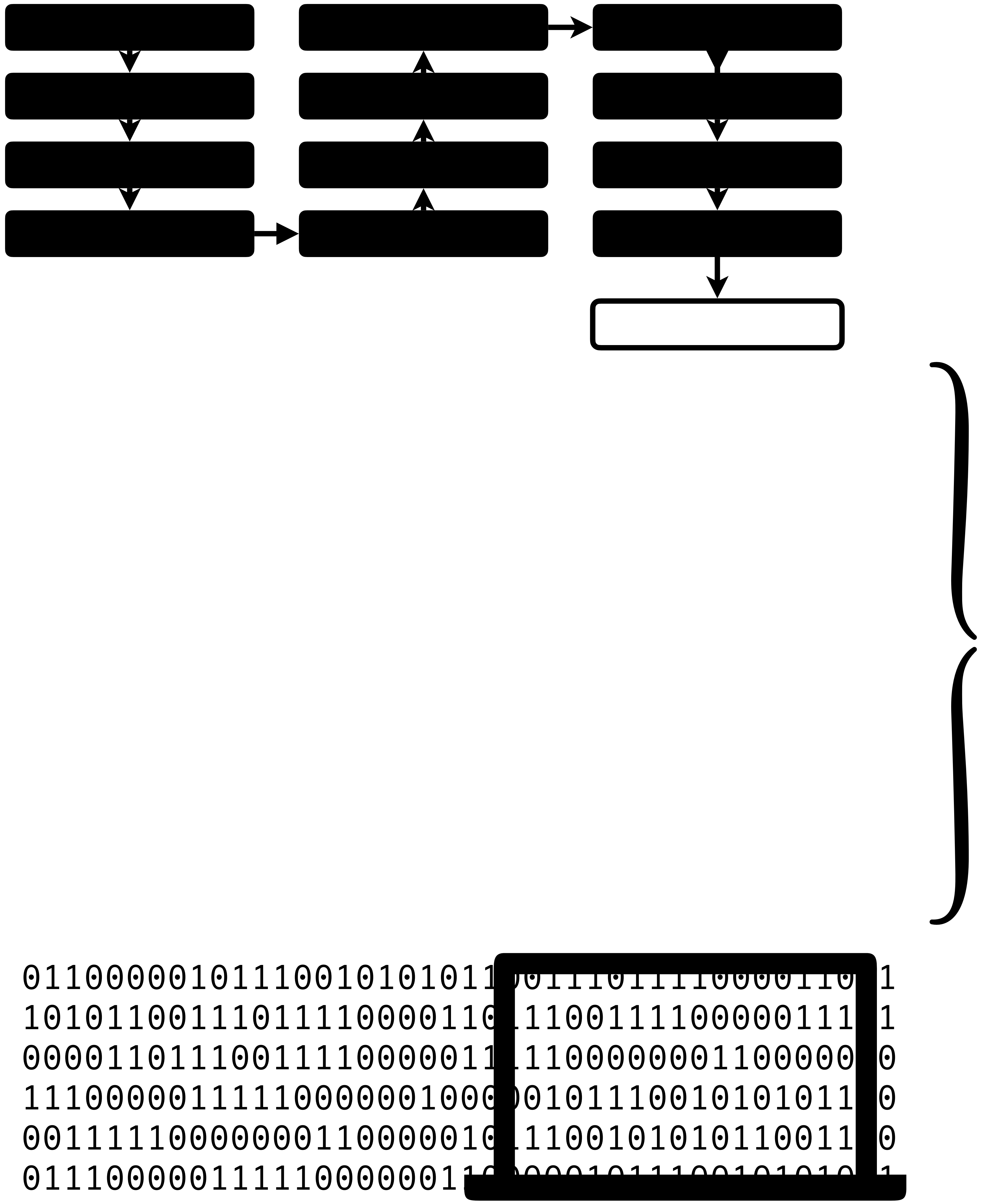

Application

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Operating System

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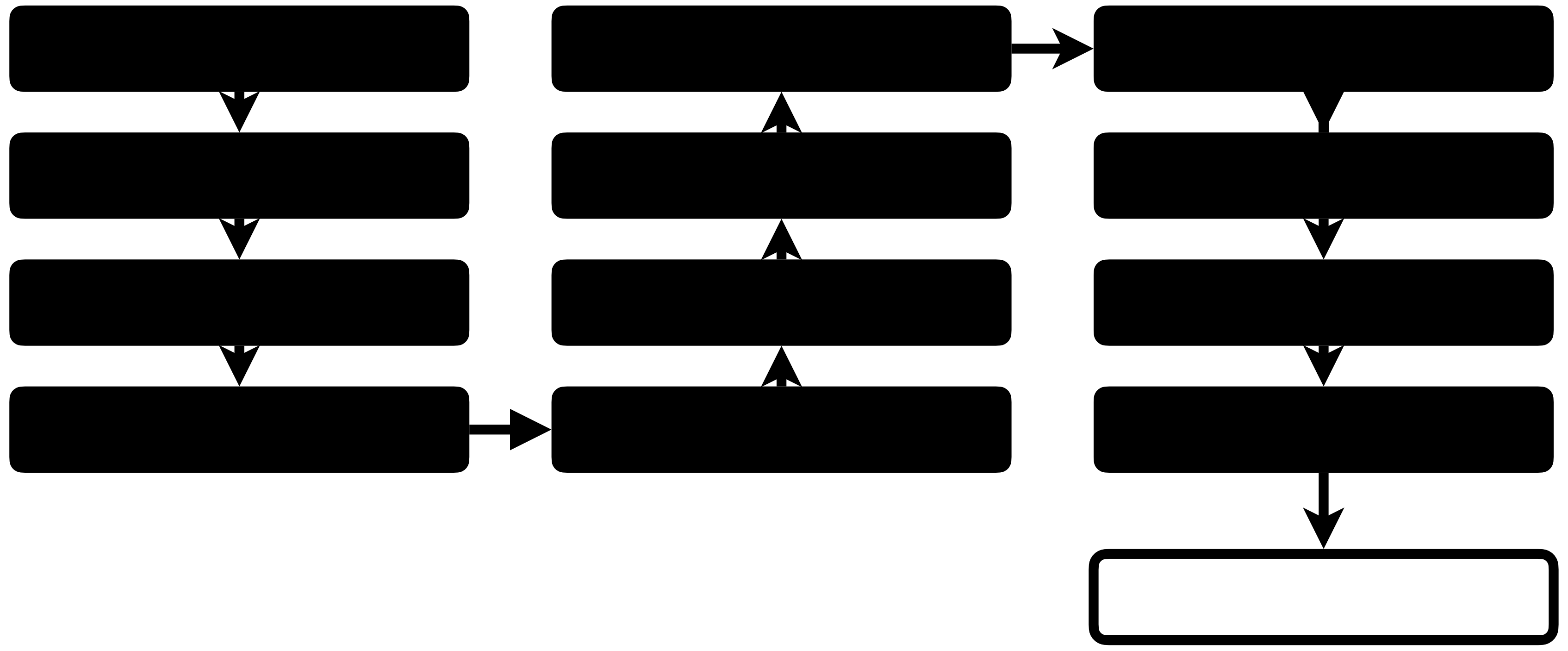

- Application
- Libraries, Modules, Algorithms
- Operating System
- Instruction Set Architecture
- Microarchitecture
- Register Transfer Level
- Gates
- Electricity

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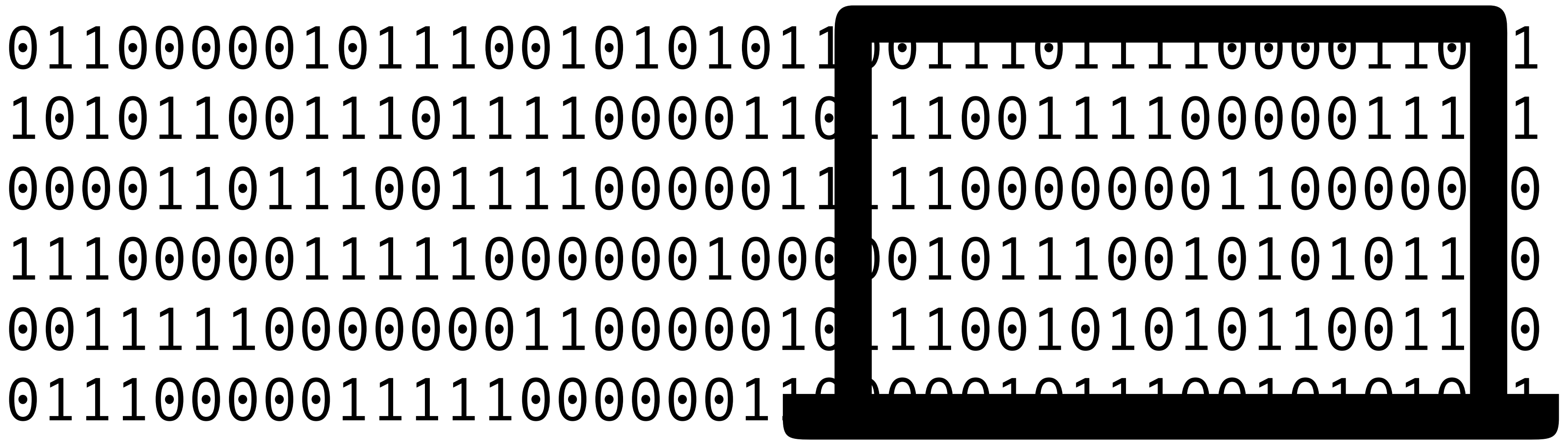
EE



Administrivia

Grading

Homework	60%
Quiz	15%
Final	25%

Administrivia

Homework

- Weekly assignments, starting today
- Due every **Monday 11:59:59pm** (generally)
- Late policy:
  - 4,320 minutes of late time
  - every minute past, 0.003% penalty
  - emergency, contact your advisor

Administrivia

Quiz and Exam

- Quiz: Monday, July 10, 6:00pm-7:20pm.
- Exam: Thursday, August 3, 6:00pm-7:20pm.

Administrivia

HELP!

- Resource page on course website
- Ed
  - Details: don’t just say “X doesn’t work”
  - No screenshots or giant code block
- Office hours:
  - TBD, do the survey
- Email me

Administrivia

Advice

- Practice, practice, practice…
- Start early
  - coding is fun but fighting for hours is not
- Write a little, test a little
  - you will make mistakes, make them easy to find
- Let me know your feedback; I’m still experimenting

Administrivia

Academic Dishonesty

- Do not copy code …it’s very obvious
- Do not show your solution
  - … online
  - … to others
  - use private Ed post if you’re unsure
- Discuss concept ok, code no
- Document your collaboration

Administrivia

Accessibility

- Contact SDS soon
- Víctor

A Whirlwind Tour of C

Why C?

- C is the *lingua franca* of computer programming
  - unix is written in C
  - many, many languages have C-like syntax
- C helps you understand how computers work
  - ~~to use C, you *have to* understand how computers work~~
- C is very fast, good for serious applications

The Anatomy of C

```c
#include <stdio.h>

void say_hello(void);

int main(void)
{
        say_hello();
        return 0;
}

void say_hello(void)
{
        printf("Hello, world!\n");
}
```

The Anatomy of C

```
#include <stdio.h>
```

<— Directives

```
void say_hello(void);
```

<— Declarations

```
int main(void)
{
        say_hello();
        return 0;
}
```

<— Declarations

```
void say_hello(void)
{
        printf("Hello, world!\n");
}
```

<— Declarations

The Anatomy of C

- A C program is a list of *declarations* and *directives*.
- Declarations tell us how to interpret *names*.
  - `say_hello` and `main` are functions.
- Directives (beginning with `#`) tell compiler to do stuff.
  - `#include <stdio.h>` tells compiler to import the standard I/O library.*

The Anatomy of C

```c
#include <stdio.h>

void say_hello(void);

int main(void)
{
        say_hello();
        return 0;
}

void say_hello(void)
{
        printf("Hello, world!\n");
}
```

- A special declaration is called `main`
- No top-level code — all code is in some functions, which are called by `main`, directly or indirectly
- Functions can call everything declared *above*, including itself

The Anatomy of C

```c
#include <stdio.h>

void say_hello(void);

int main(void)
{
        say_hello();
        return 0;
}

void say_hello(void)
{
        printf("Hello, world!\n");
}
```

- A function *signature* specifies its argument types and return types — write `void` if none
- A function is *declared* if the signature is followed by `;`
- A function is *defined* if it is followed by a block `{ .. }`

The Anatomy of C

```
#include <stdio.h>

int factorial(int x);  <— Argument type: int
^^^——— Return type: int
int main(void)
{
        int a;
        a = 20;
        int fact_a = factorial(a);
        printf("factorial(%d) = %d\n", a, fact_a);

        return 0;
}

int factorial(int x)
{
        if (x == 0) {
                return 1;
        }

        return x * factorial(x - 1);
}
```

The Anatomy of C

```
int main(void)
{
        int a;                             <-- tell compiler variable a of type int exists
        a = 20;
        int fact_a = factorial(a);
        printf("factorial(%d) = %d\n", a, fact_a);

        return 0;
}
```

- A *block* `{  ..  }` consists of a list of *statements.* Each statement ends with `;`
- A statement can *declare* a variable

The Anatomy of C

```
int main(void)
{
        int a;
        a = 20;                         <-- write 20 to a
        int fact_a = factorial(a);
        printf("factorial(%d) = %d\n", a, fact_a);

        return 0;
}
```

- A *block* `{ .. }` consists of a list of *statements.* Each statement ends with `;`
- A statement can *declare* a variable
- *assign* a variable

The Anatomy of C

```
int main(void)
{
    int a;
    a = 20;
    int fact_a = factorial(a);     <-- fact_a exists, call function, write result
    printf("factorial(%d) = %d\n", a, fact_a);

    return 0;
}
```

- A *block* `{ .. }` consists of a list of *statements.* Each statement ends with `;`
- A statement can *declare* a variable
- *assign* a variable

The Anatomy of C

```
int main(void)
{
        int a;
        a = 20;
        int fact_a = factorial(a);
        printf("factorial(%d) = %d\n", a, fact_a);
                                            ^-- call a function to print
        return 0;
}
```

- A *block* `{ .. }` consists of a list of *statements.* Each statement ends with `;`
- A statement can *declare* a variable
- *assign* a variable
- *call* a function

The Anatomy of C

```
int main(void)
{
        int a;
        a = 20;
        int fact_a = factorial(a);
        printf("factorial(%d) = %d\n", a, fact_a);

        return 0;                                    <-- exit main
}
```

- A *block* `{ .. }` consists of a list of *statements.* Each statement ends with `;`
- A statement can *declare* a variable
- *assign* a variable
- *call* a function
- …

Control-flow Compared

If

```c
if (x == 0) {
        do_stuff();
} else if (x == 1) {
        do_stuff()
} else {
        do_something_else();
}
```

C

```python
if x == 0:
    do_stuff()
elif x == 1:
    do_stuff()
else:
    do_something_else()
```

Python

Control-flow Compared

While

```
while (x != 0) {
        do_stuff();
}
```

C

```
while x == 0:
    do_stuff()
```

Python

Control-flow Compared

For

```
for (int i = 0; i < 200; i += 1) {
        do_stuff(i);
}
```

↕ Equivalent

```
int i = 0;
while (i < 200) {
        do_stuff(i);
        i += 1;
}
```

C

```
for x in iterator:
    do_stuff(x)
```

↕ Equivalent

```
x = the first element
while x.has_more():
    do_stuff(x)
    x = next(x)
```

Python

Control-flow Compared

Return, Continue, Break

```
while (x != 0) {
        return x;
        continue;
        break;
}
```

```
while x != 0:
    return x
    continue
    break
```

Boolean Compared

- C doesn't have Boolean (!)
  - any non-zero value is considered `true`, and zero is `false`
  - e.g. `if (42) { .. } –> if (true) { .. }`

C	Python
`x && y`	`x and y`
`x || y`	`x or y`
`!x`	`not x`

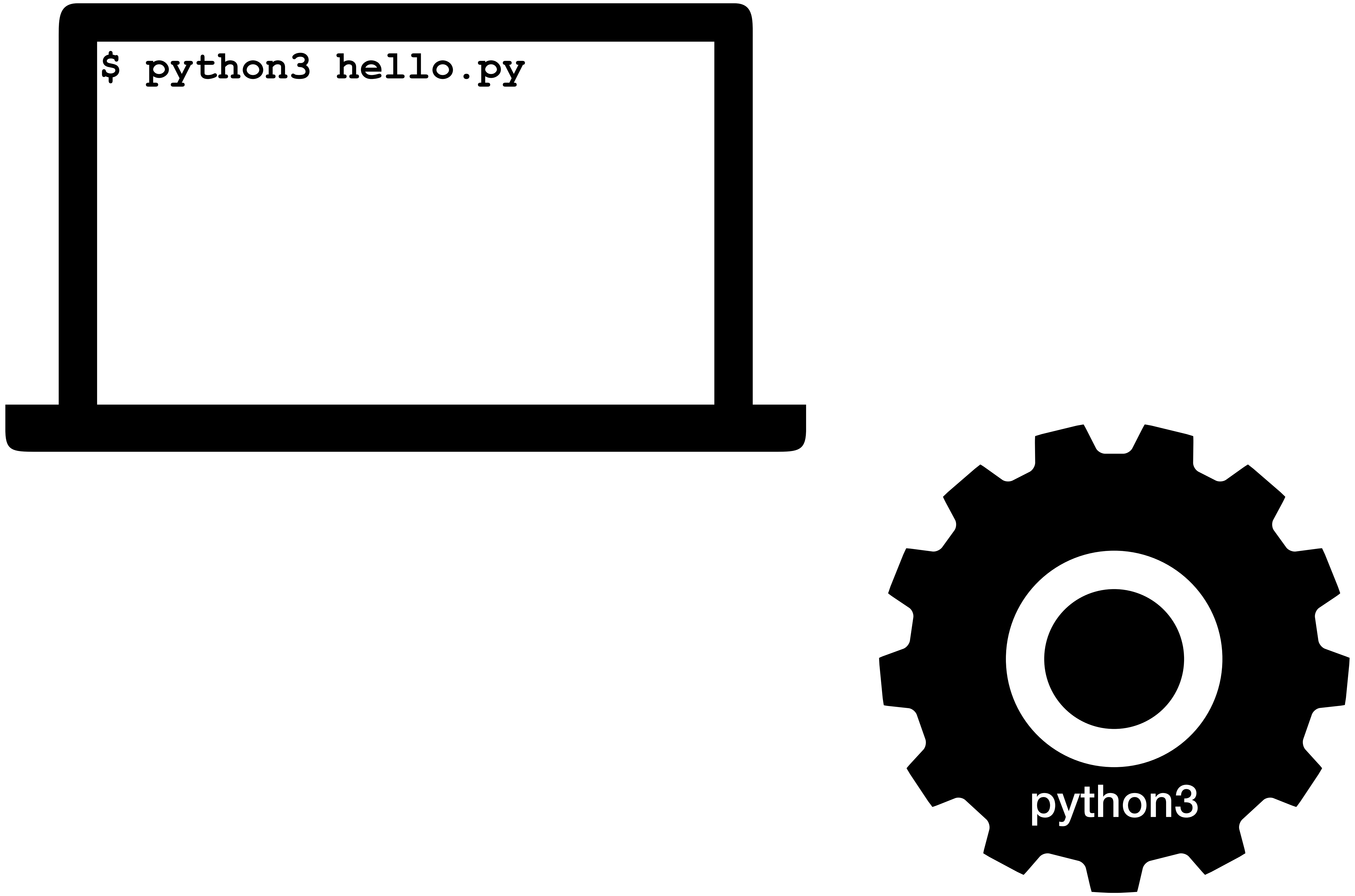
How to Run C

Review: how does Python work?

```
$ python3 hello.py
```

How to Run C

Review: how does Python work?



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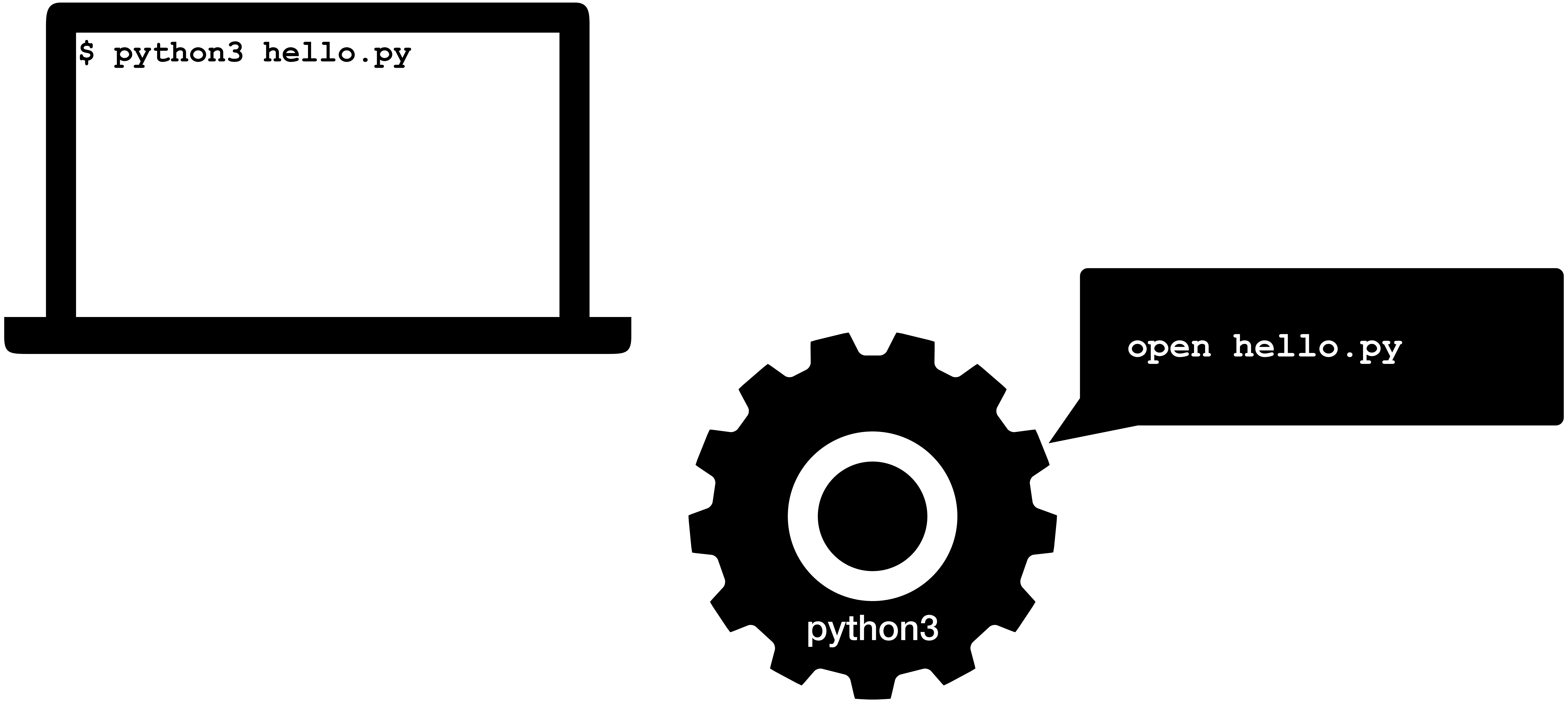

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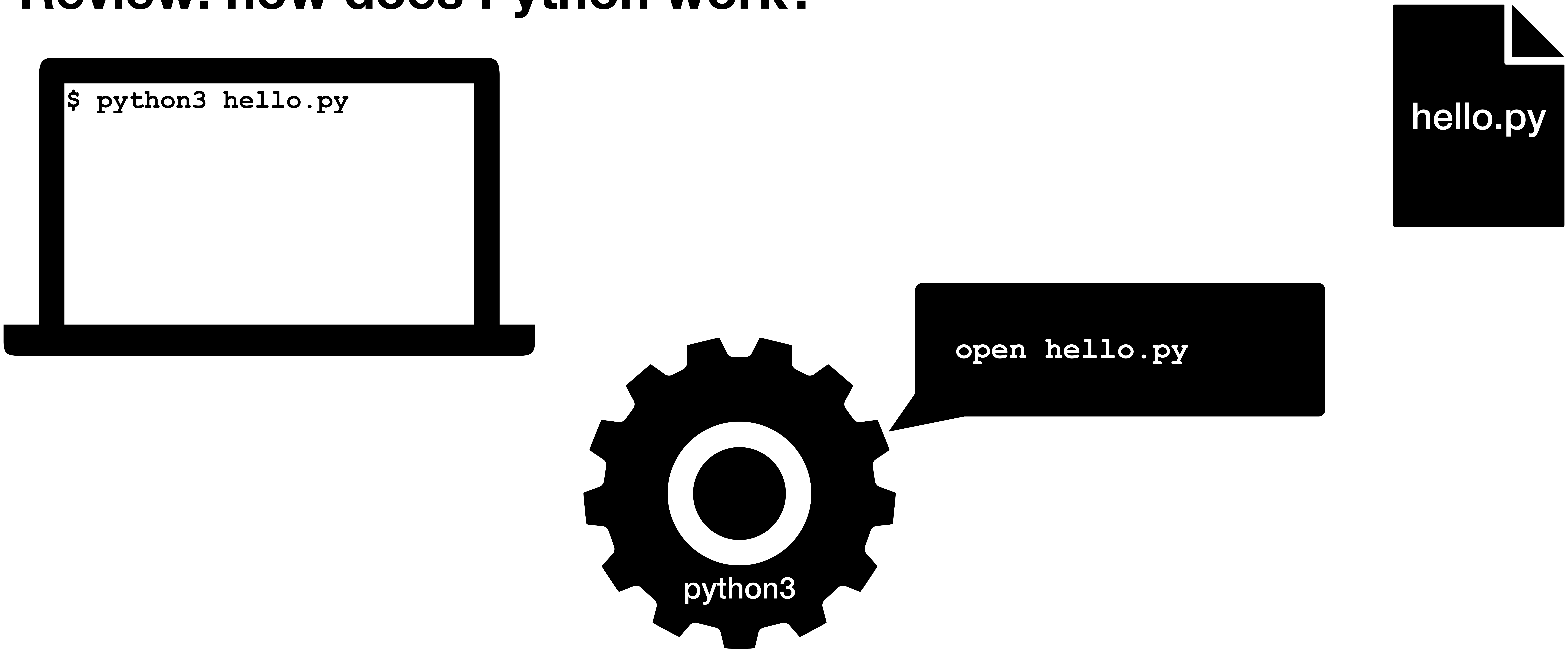

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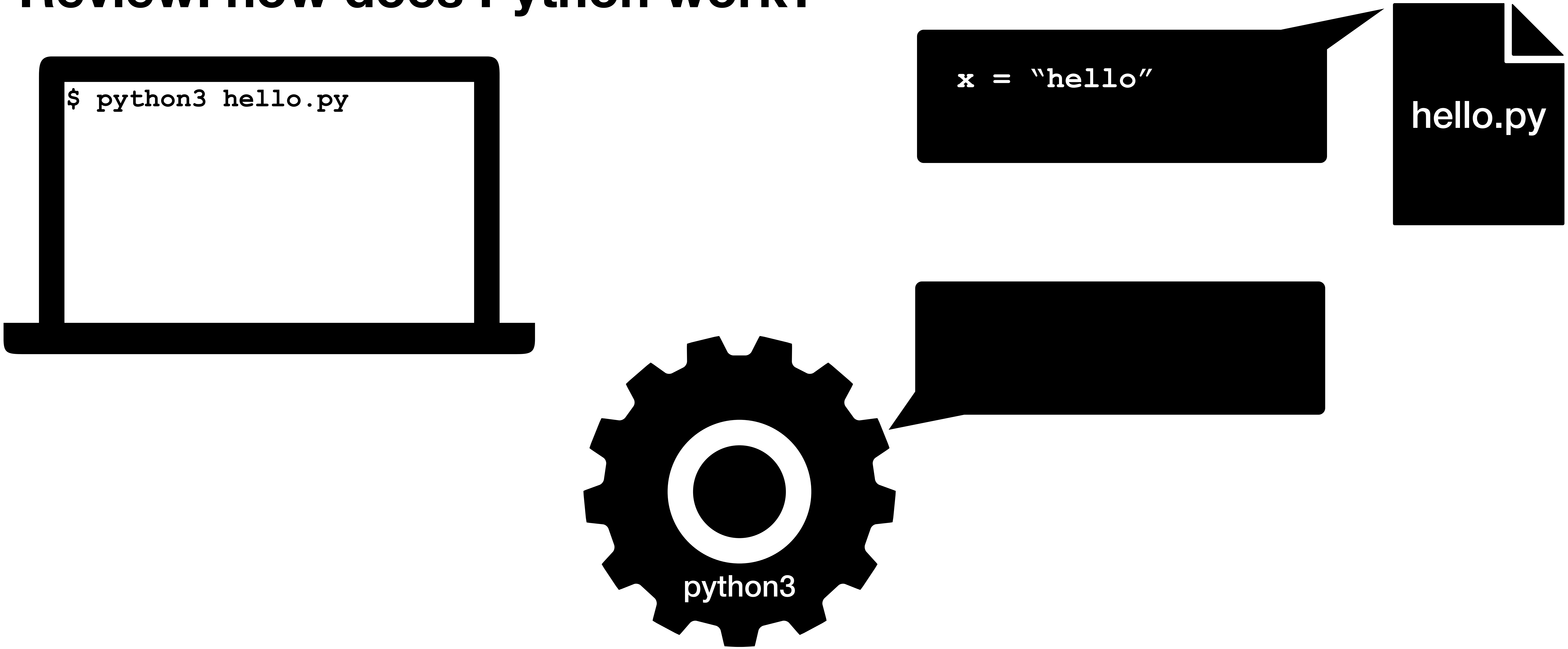

```
$ python3 hello.py
```

```
x = “hello”
```

How to Run C

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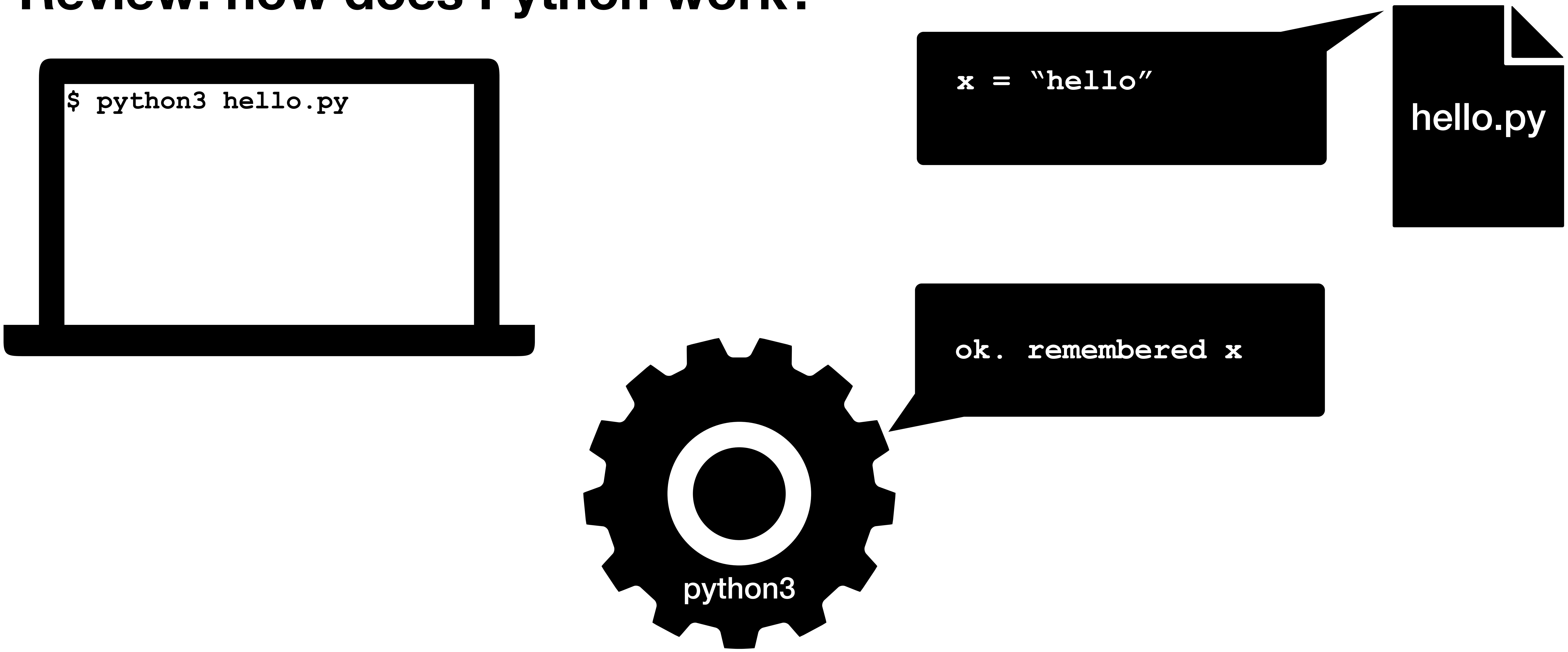


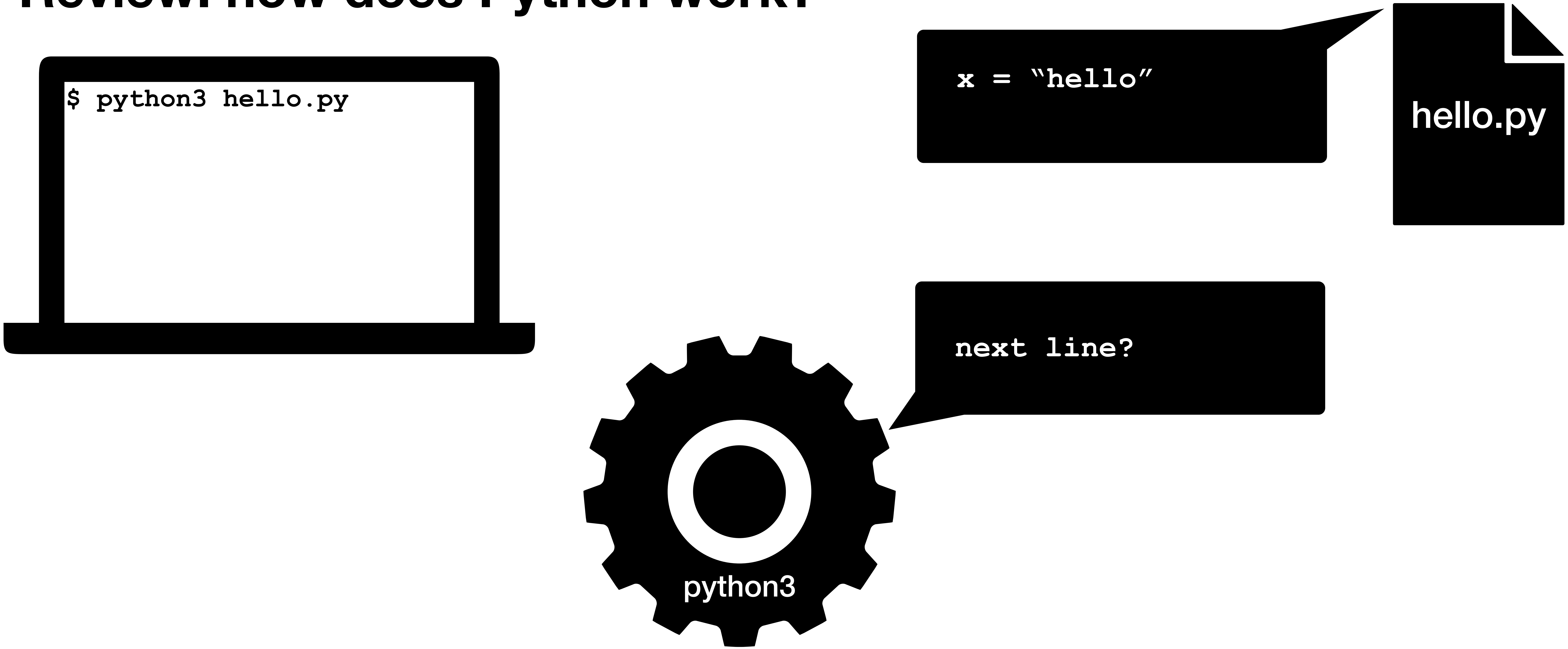
```
$ python3 hello.py
```

```
x = “hello”
```

```
ok. remembered x
```

How to Run C

Review: how does Python work?



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```

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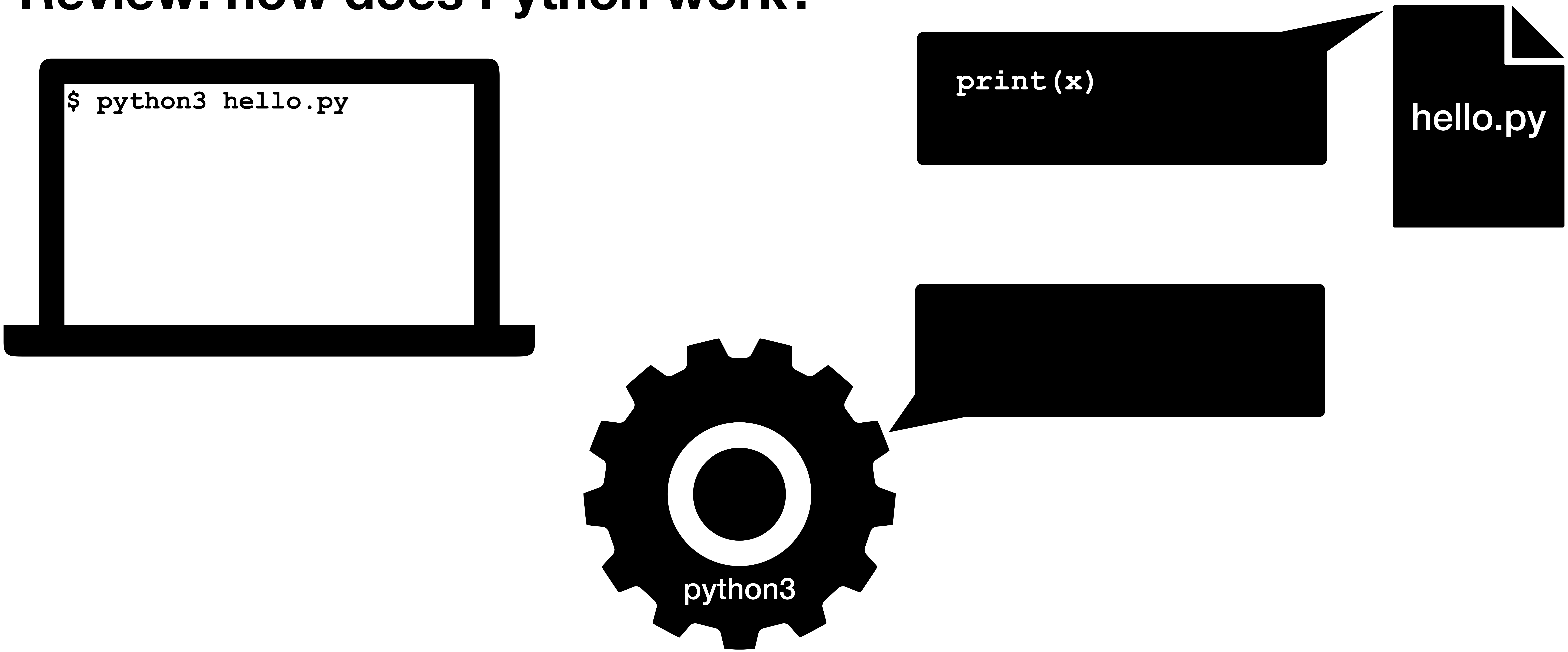
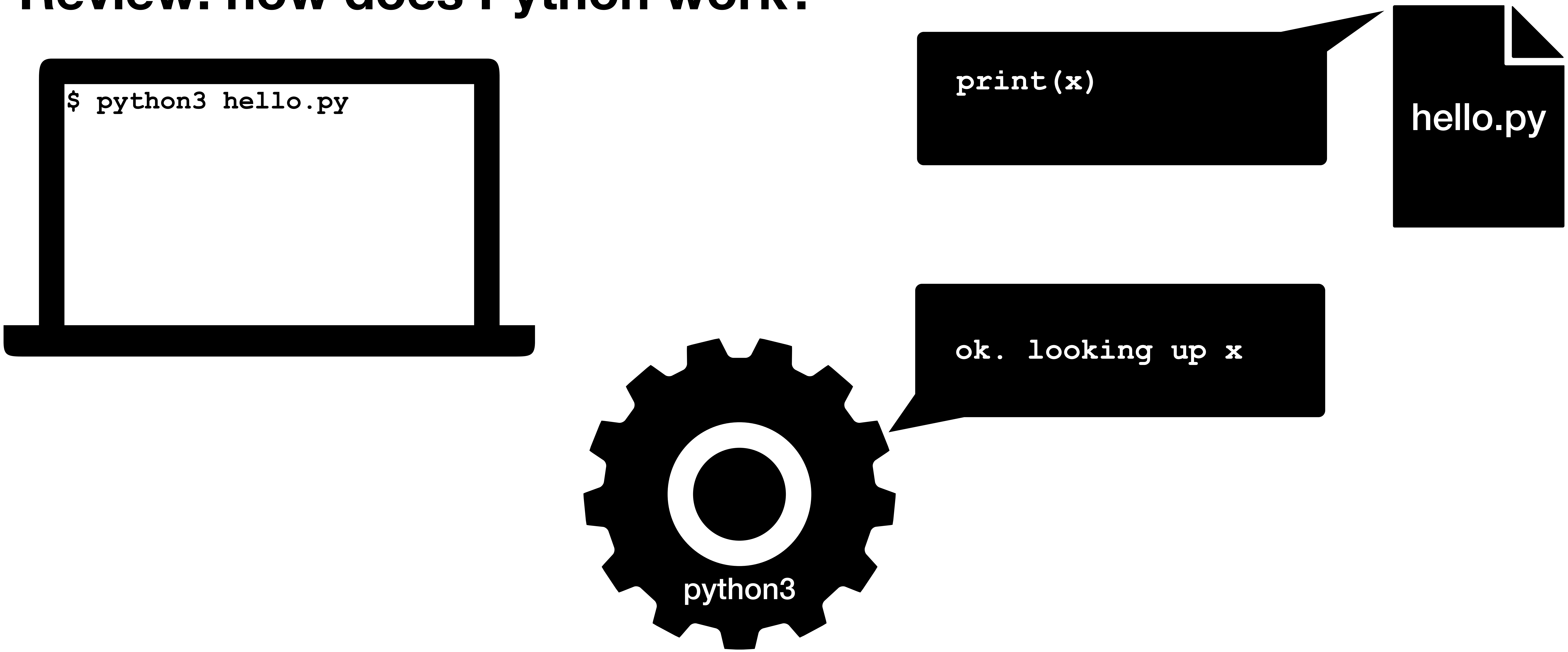


```
$ python3 hello.py
```

```
print(x)
```

How to Run C

Review: how does Python work?



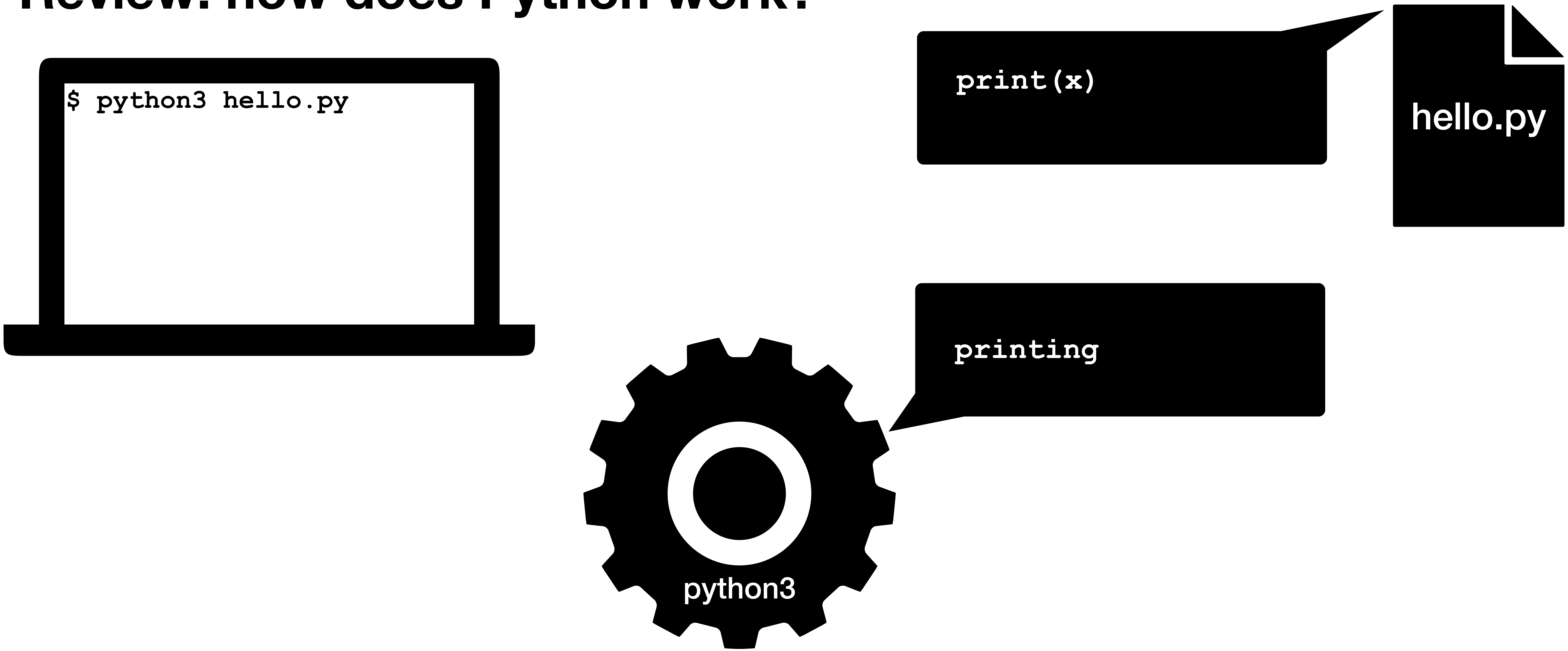
```
$ python3 hello.py
```

```
print(x)
```

```
ok. looking up x
```

How to Run C

Review: how does Python work?



```
$ python3 hello.py
```

```
print(x)
```

How to Run C

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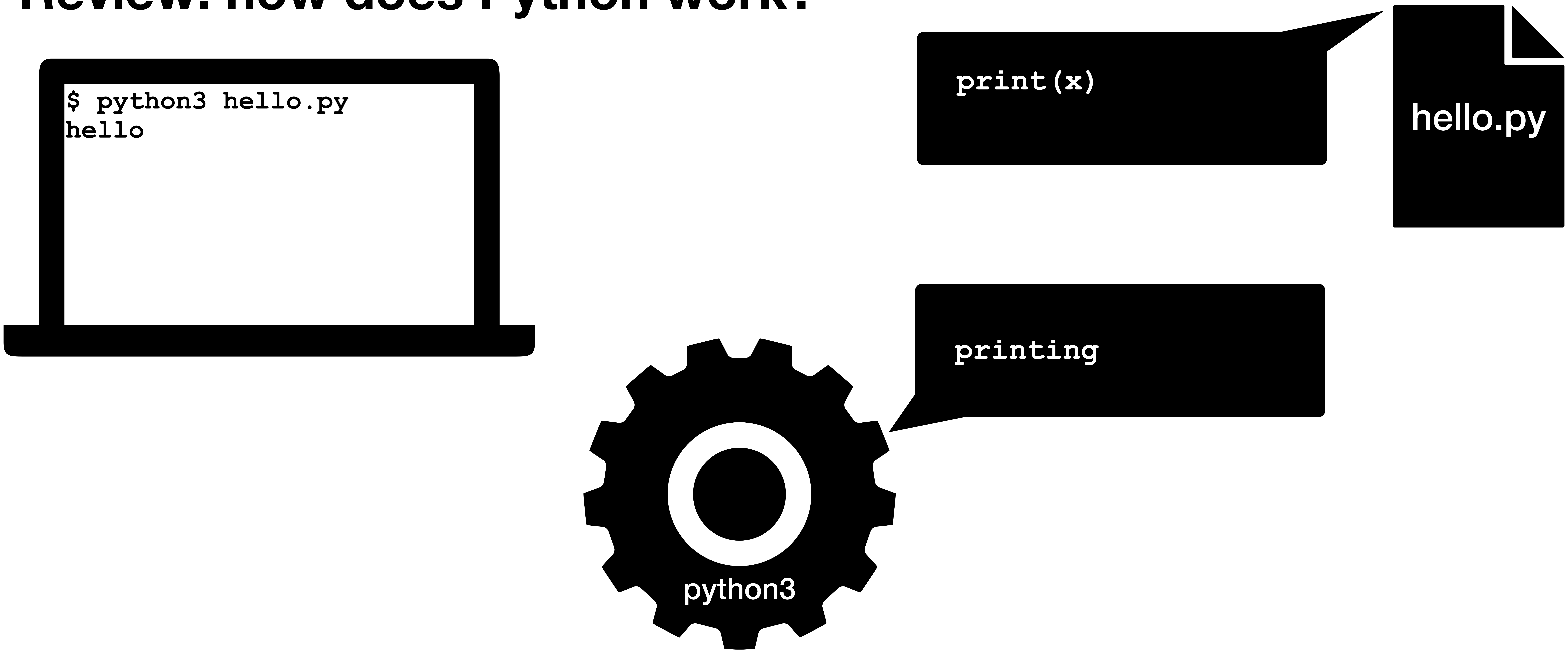

```
$ python3 hello.py
hello
```

How to Run C

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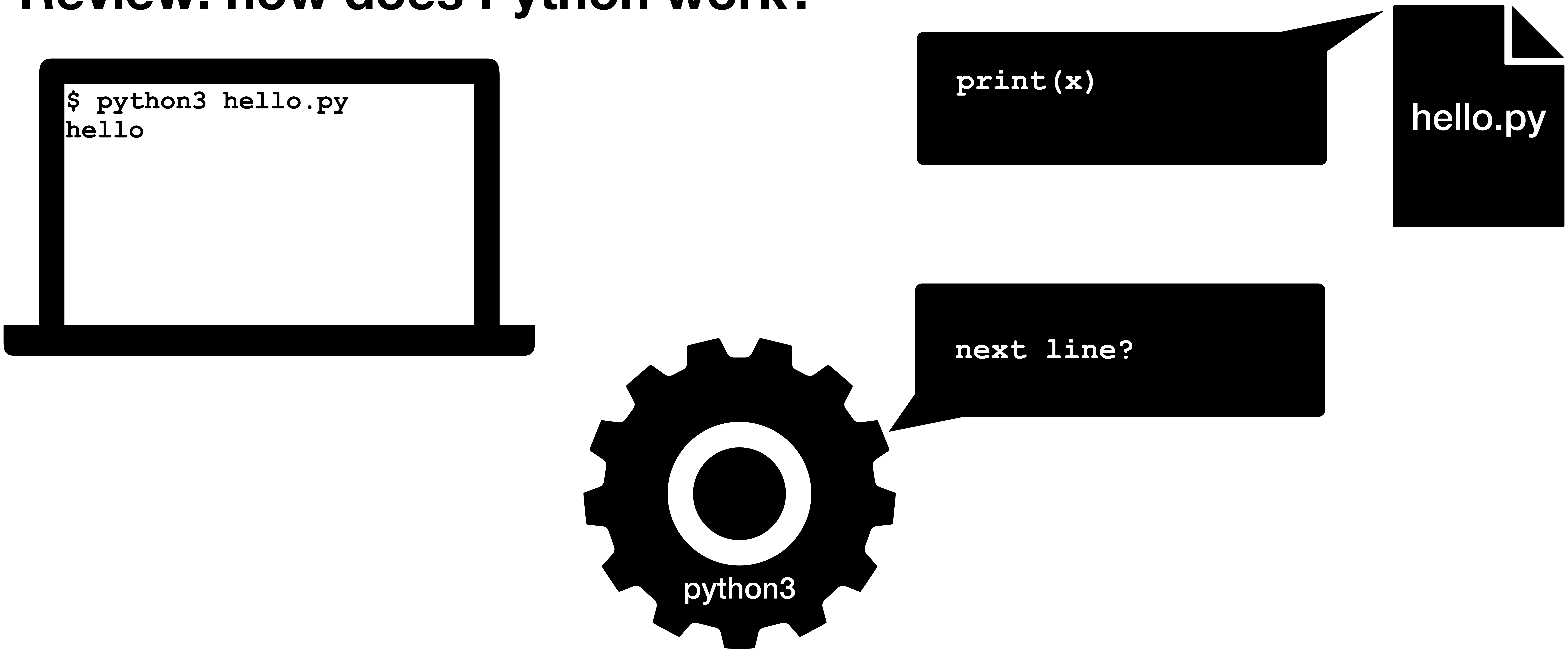

```
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hello
```

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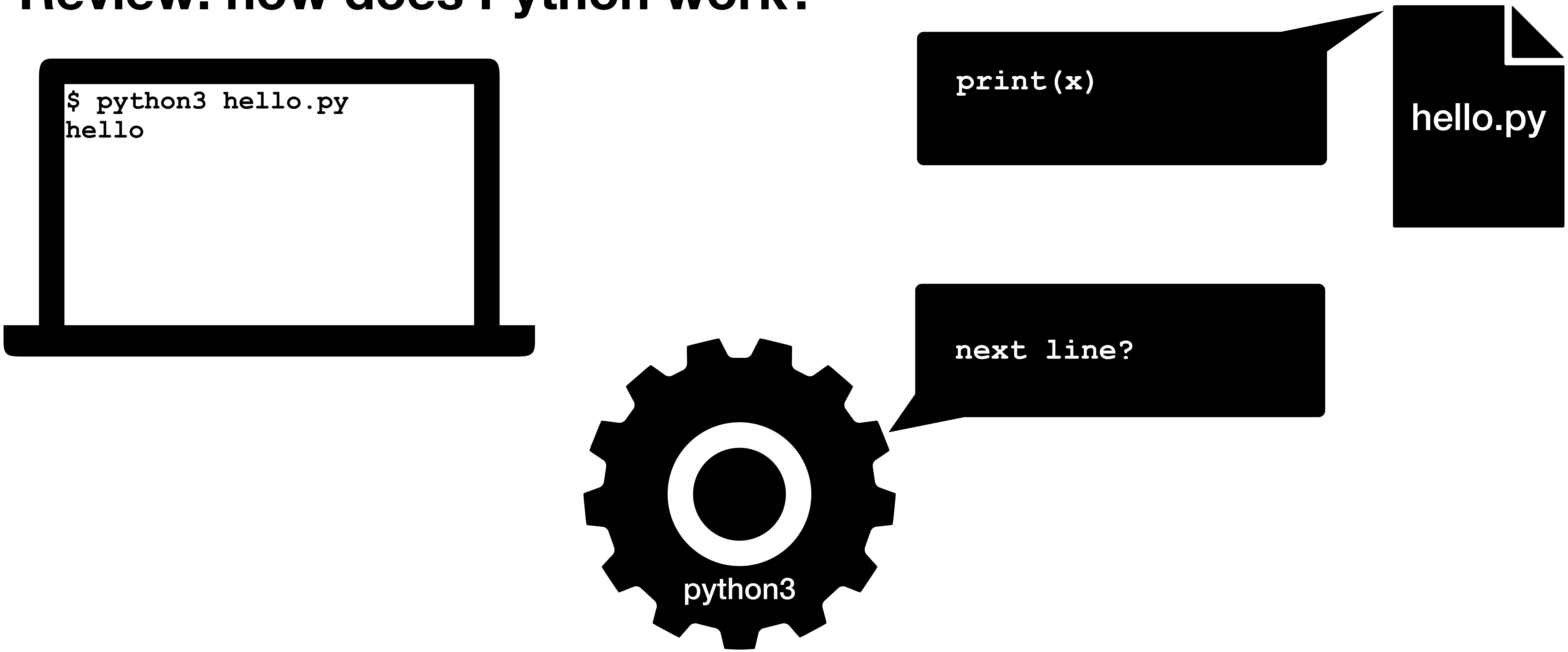

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hello
```

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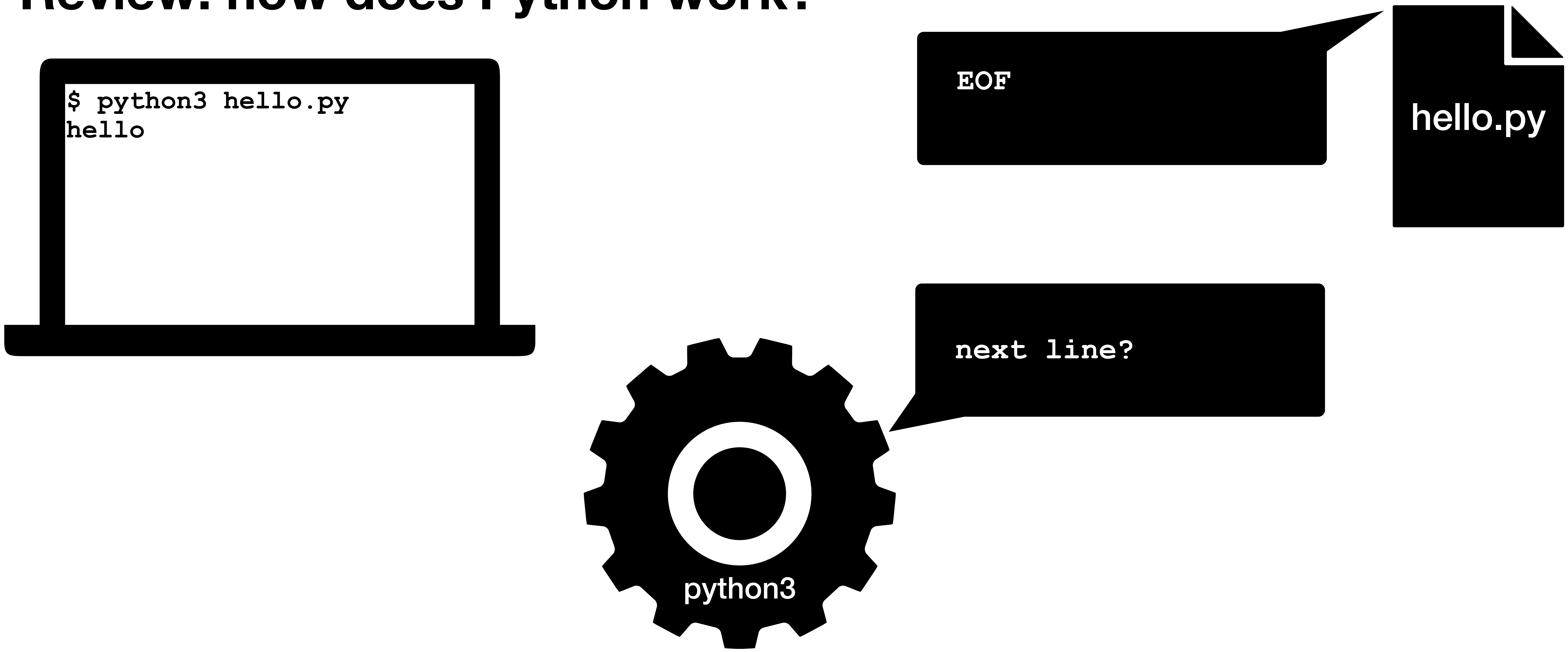

```
$ python3 hello.py
hello
```

How to Run C

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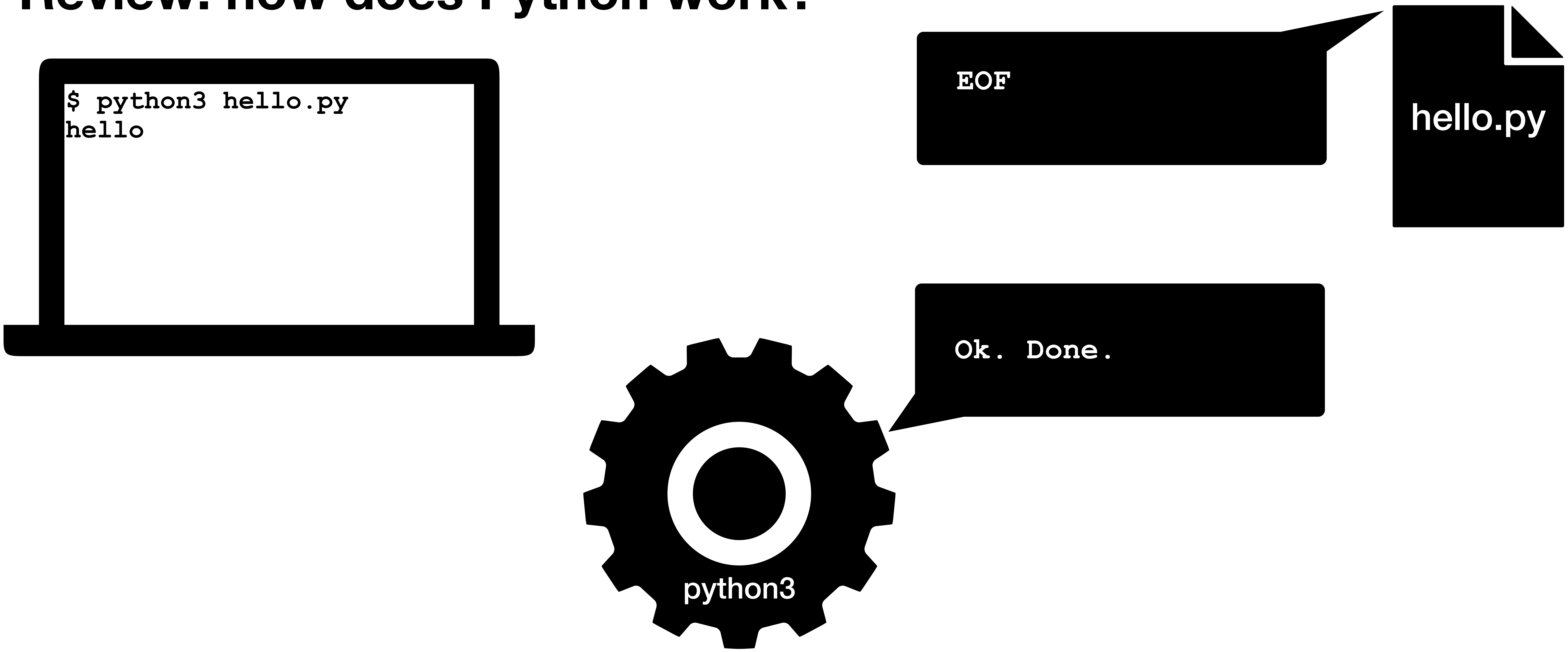


```
$ python3 hello.py
hello
```

How to Run C

Review: how does Python work?

```
$ python3 hello.py
hello
$
```

How to Run C

Review: how does Python work?

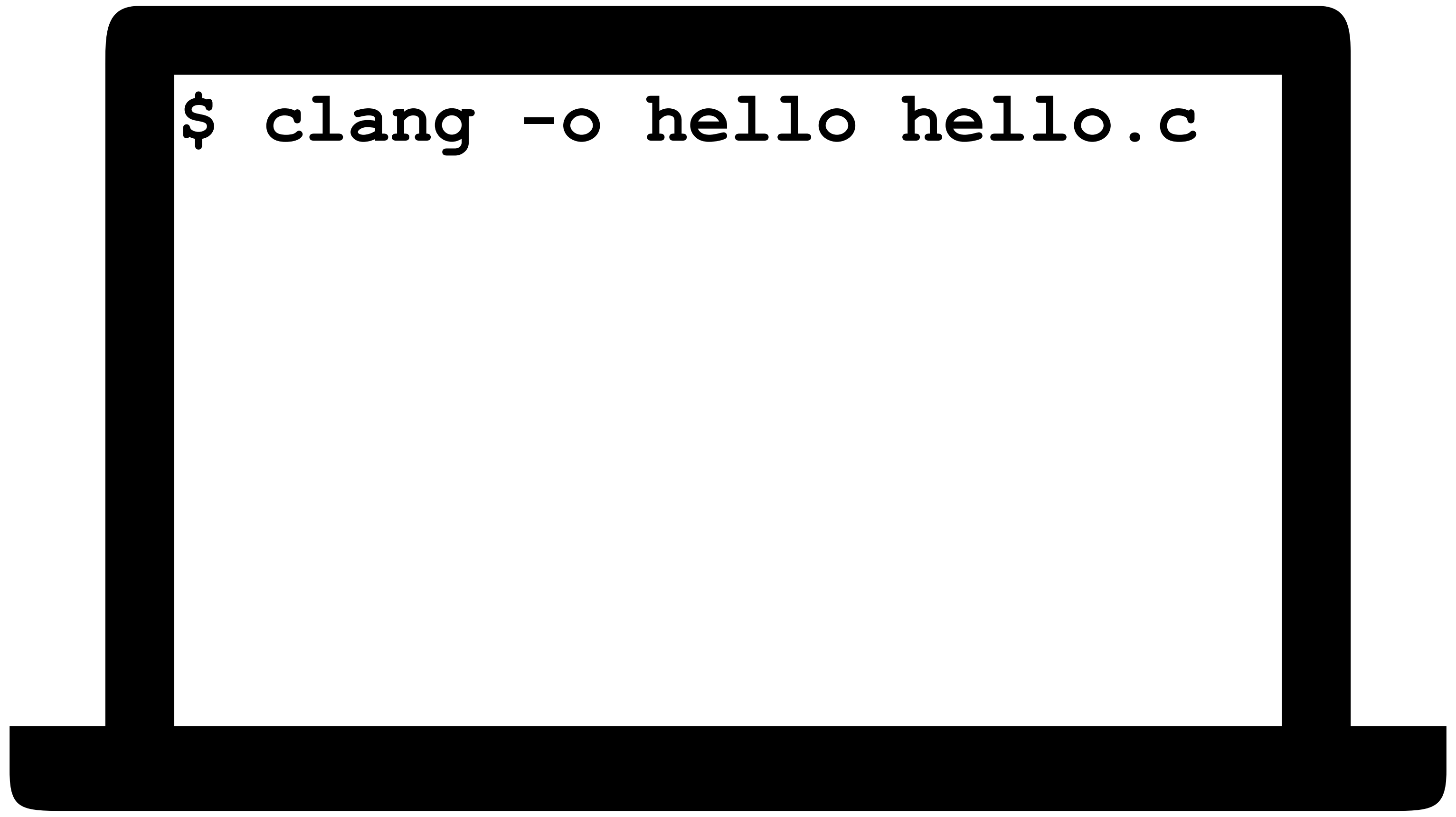
- There is a program that reads your Python script, and executes line by line
- This program is called Python interpreter

How to Run C

How about C?

How to Run C

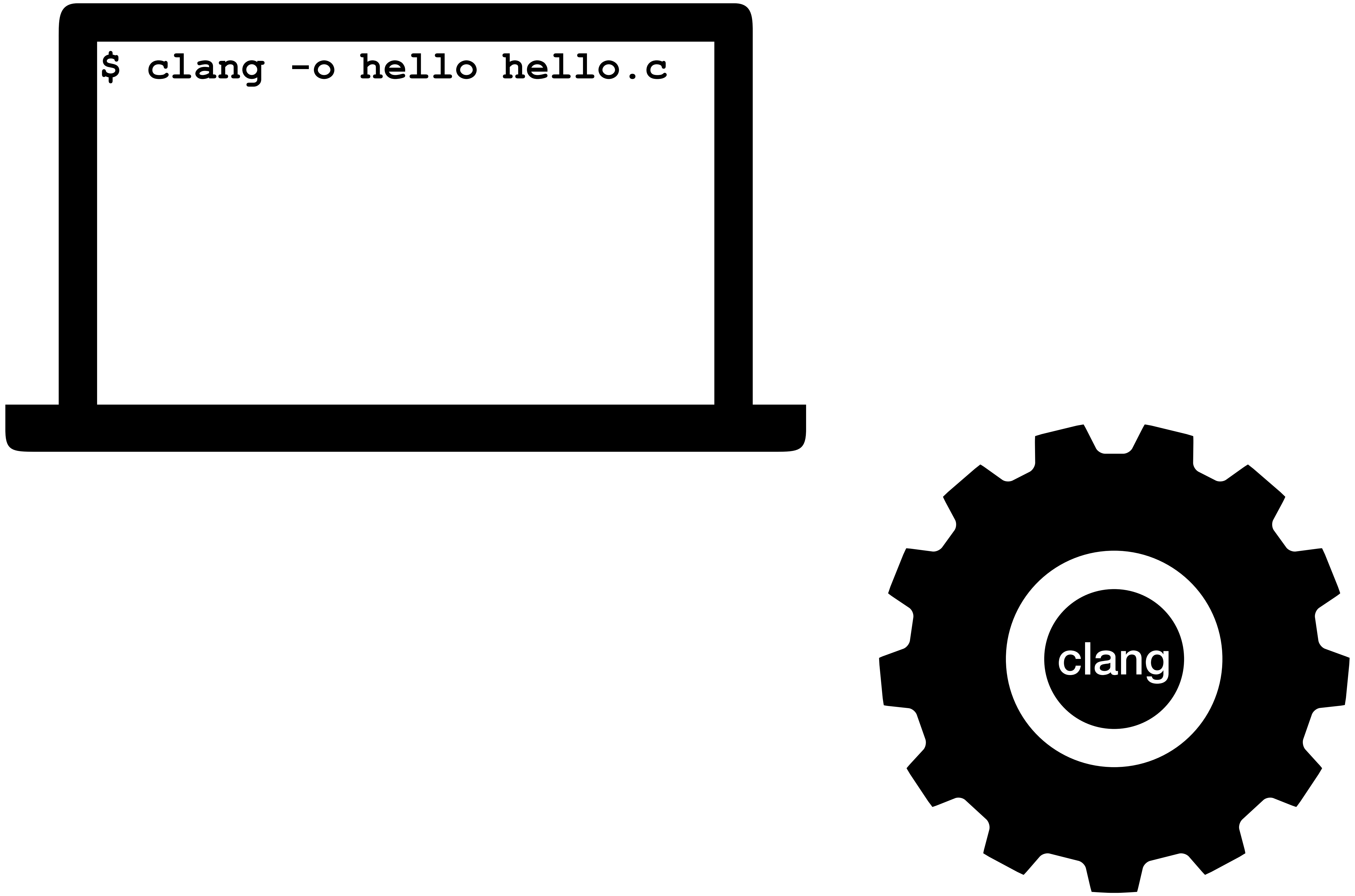
How about C?



```
$ clang -o hello hello.c
```

How to Run C

How about C?



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How to Run C

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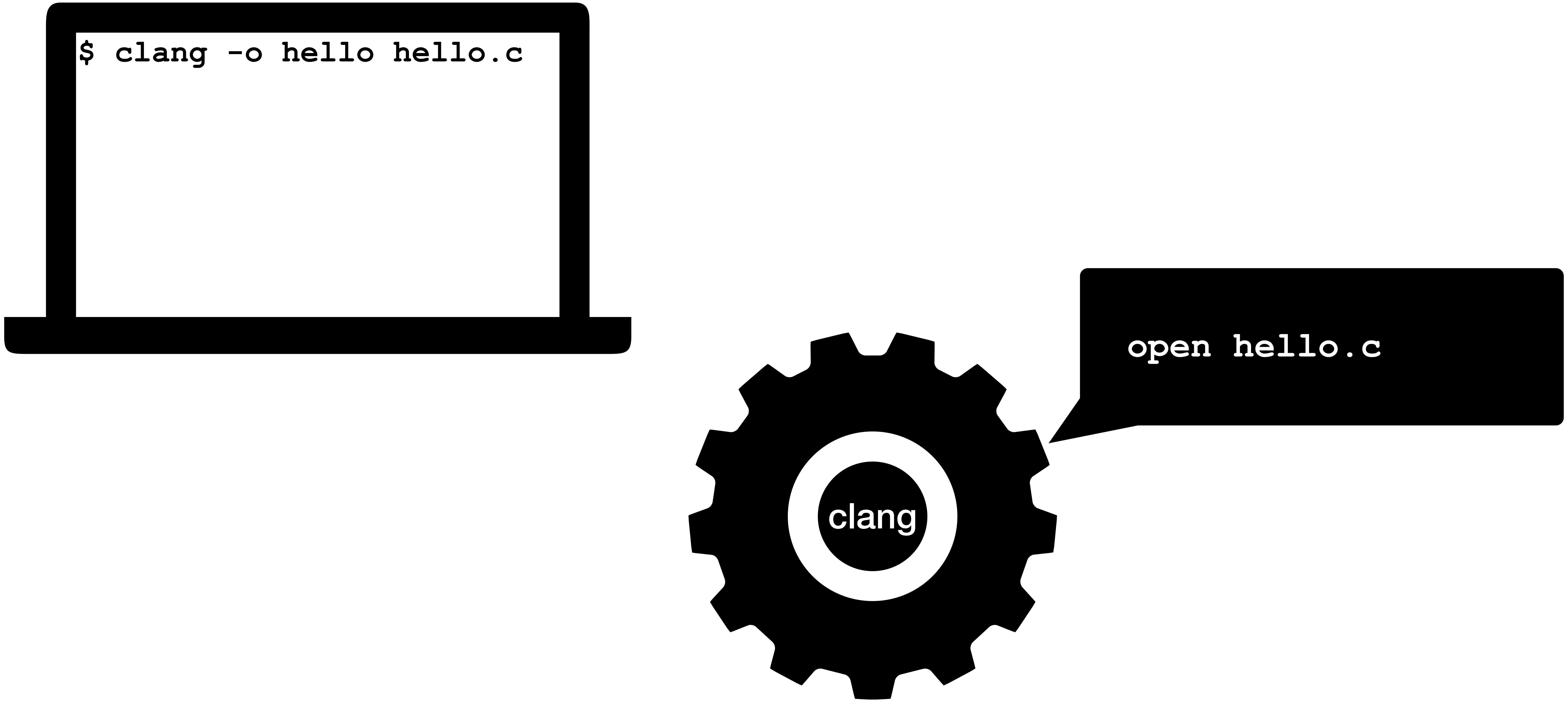

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How to Run C

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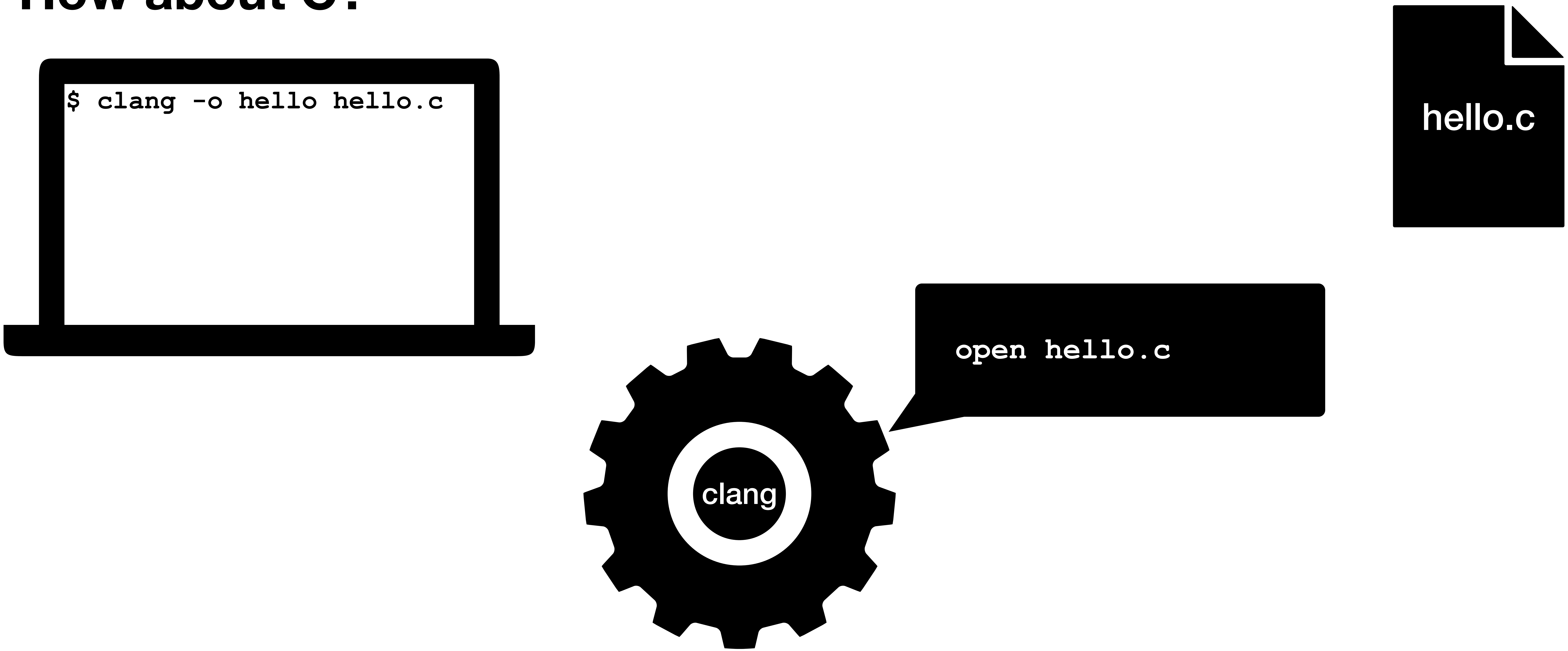

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How to Run C

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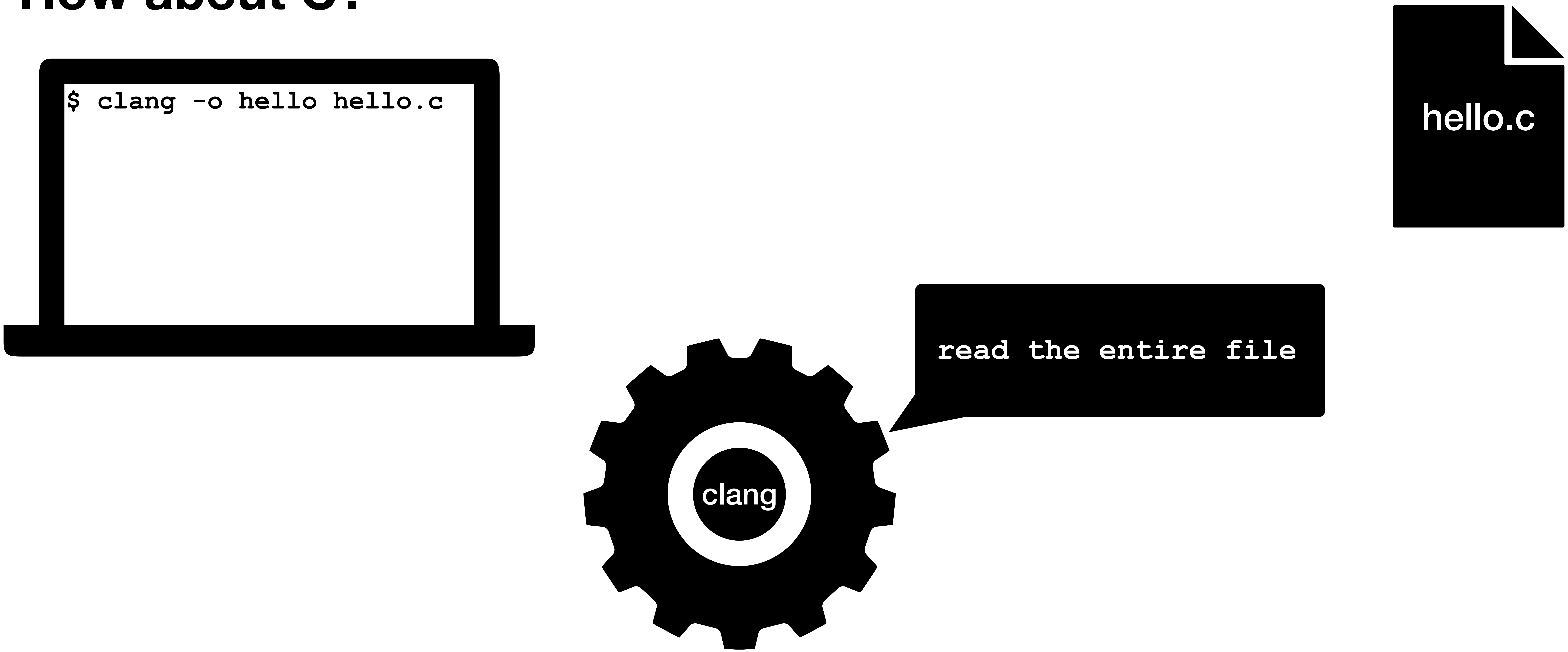

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How to Run C

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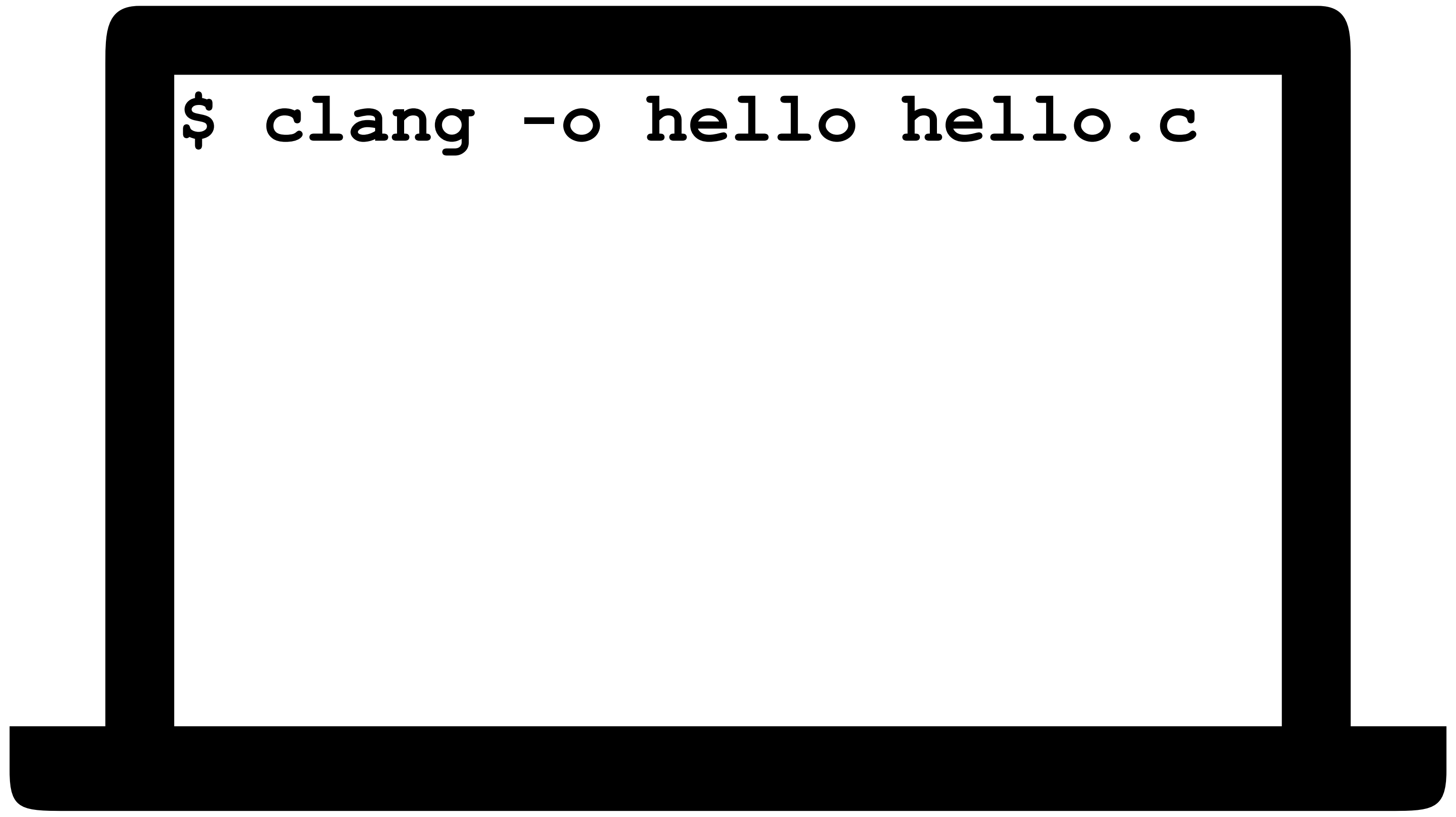
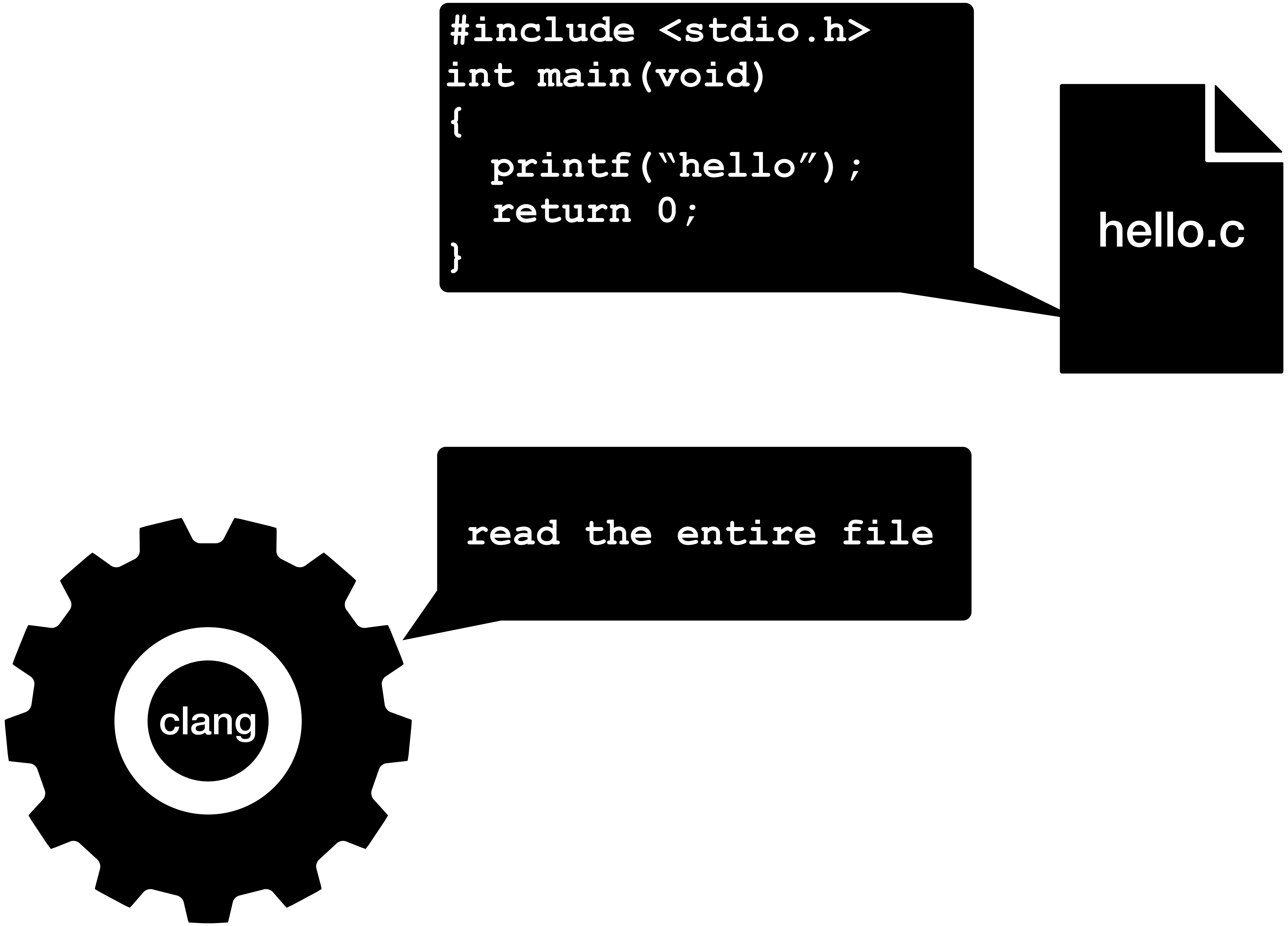


```
$ clang -o hello hello.c
```

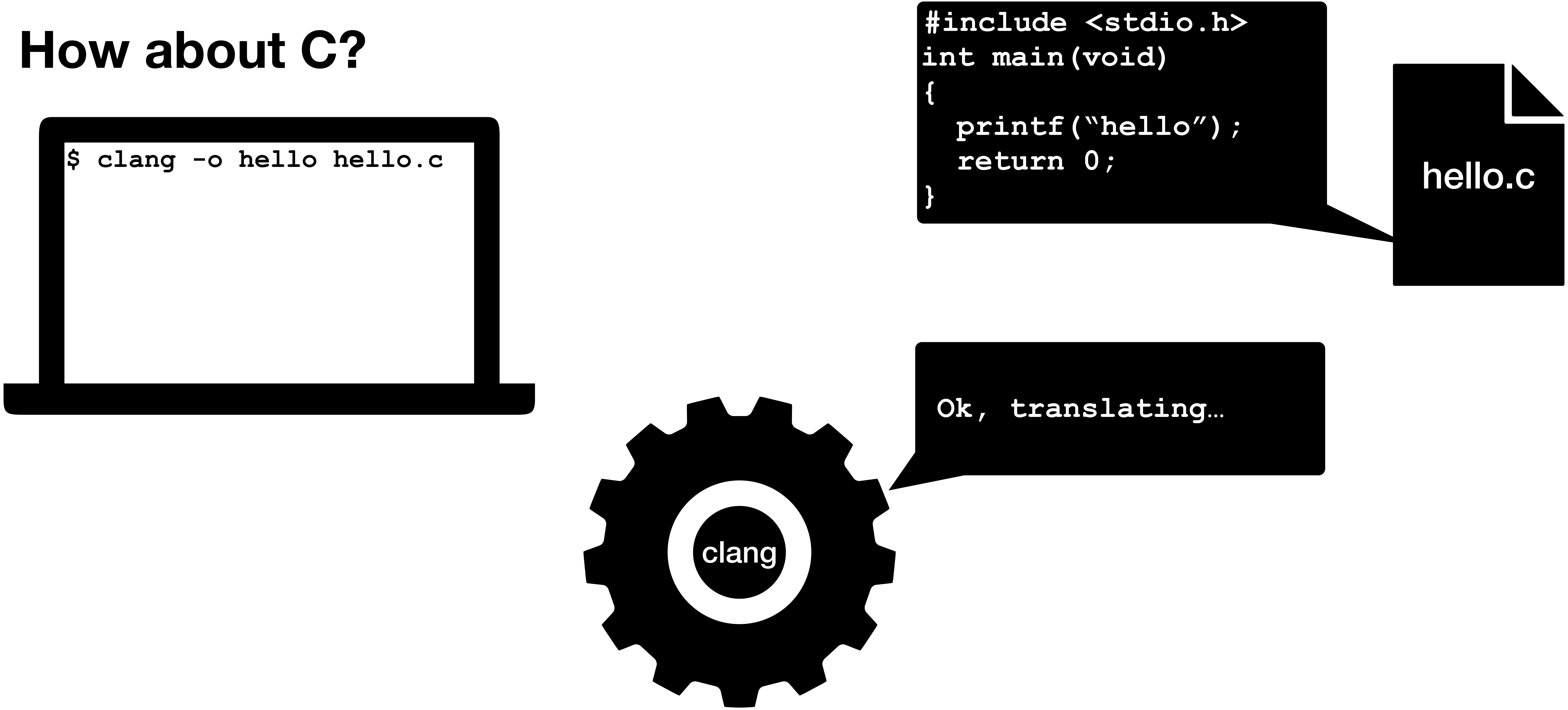


```
#include <stdio.h>
int main(void)
{
  printf(“hello”);
  return 0;
}
```

```
read the entire file
```

How to Run C

How about C?

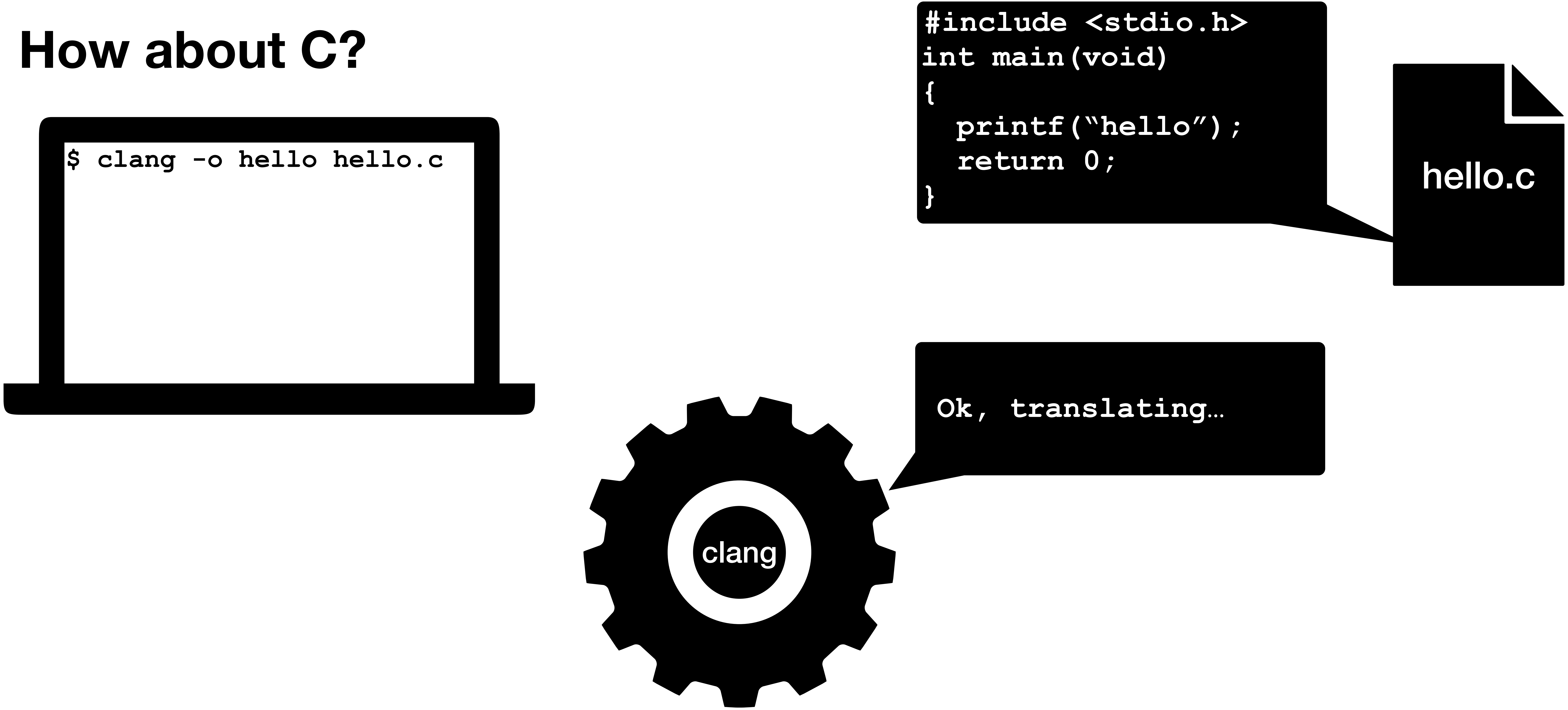


```
$ clang -o hello hello.c
```

```
#include <stdio.h>
int main(void)
{
  printf("hello");
  return 0;
}
```

How to Run C

How about C?



```
$ clang -o hello hello.c
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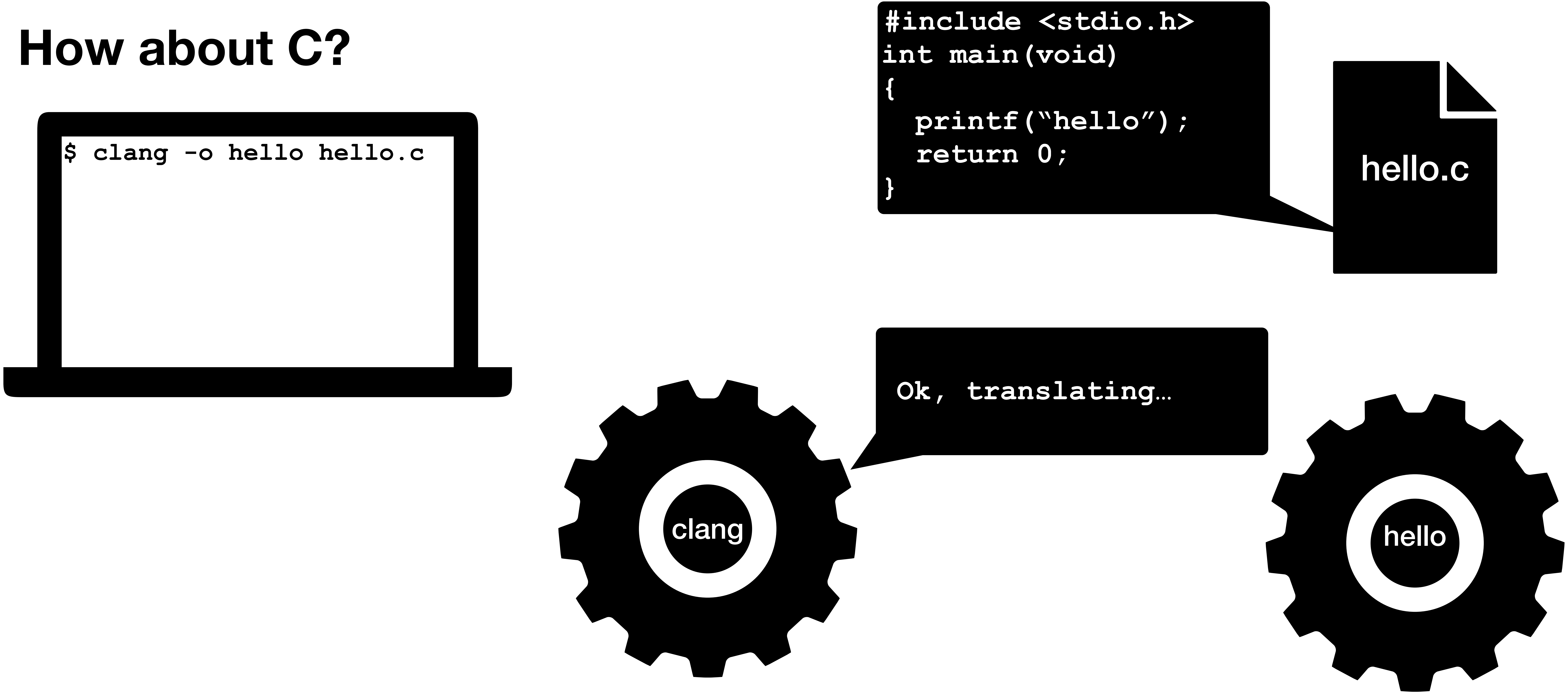
```
#include <stdio.h>
int main(void)
{
  printf("hello");
  return 0;
}
```

How to Run C

How about C?



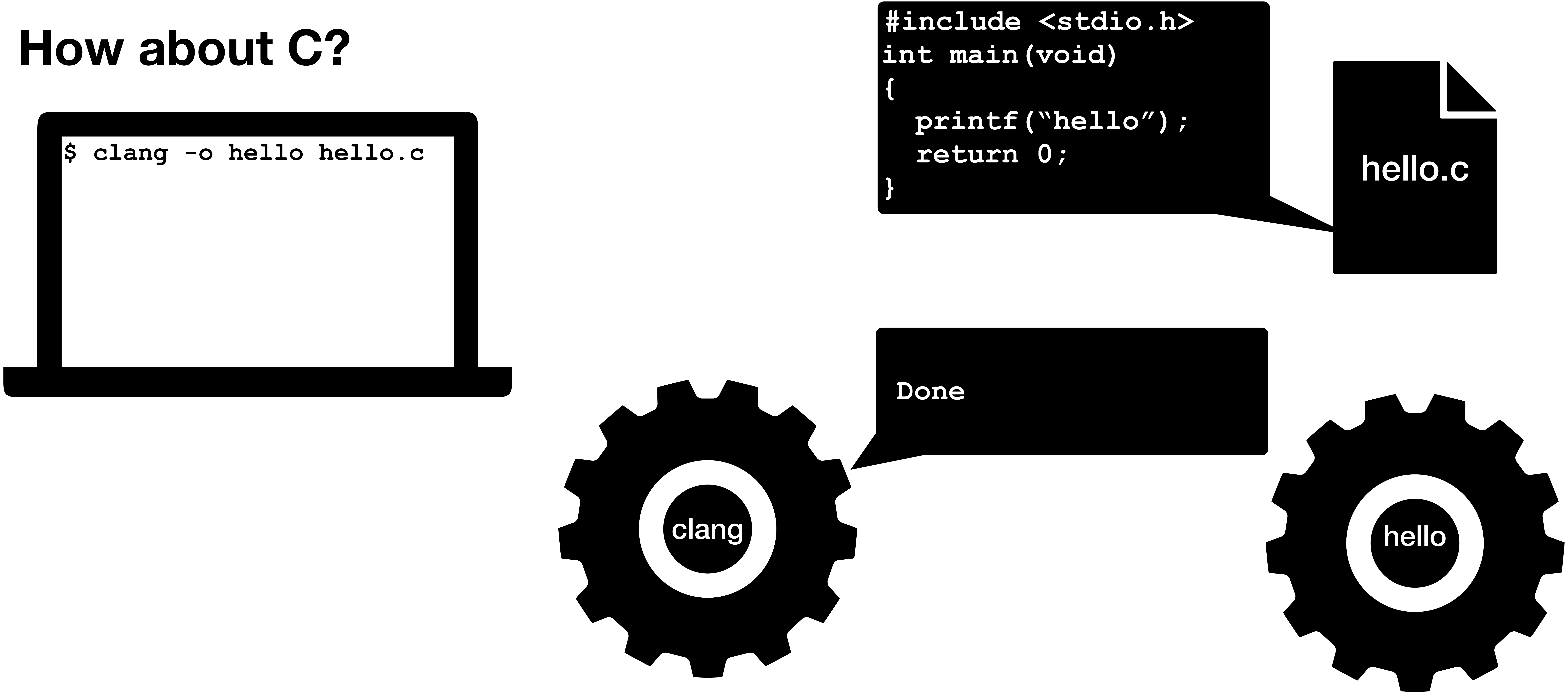
```
$ clang -o hello hello.c
```

```
#include <stdio.h>
int main(void)
{
  printf(“hello”);
  return 0;
}
```

Ok, translating…

How to Run C

How about C?



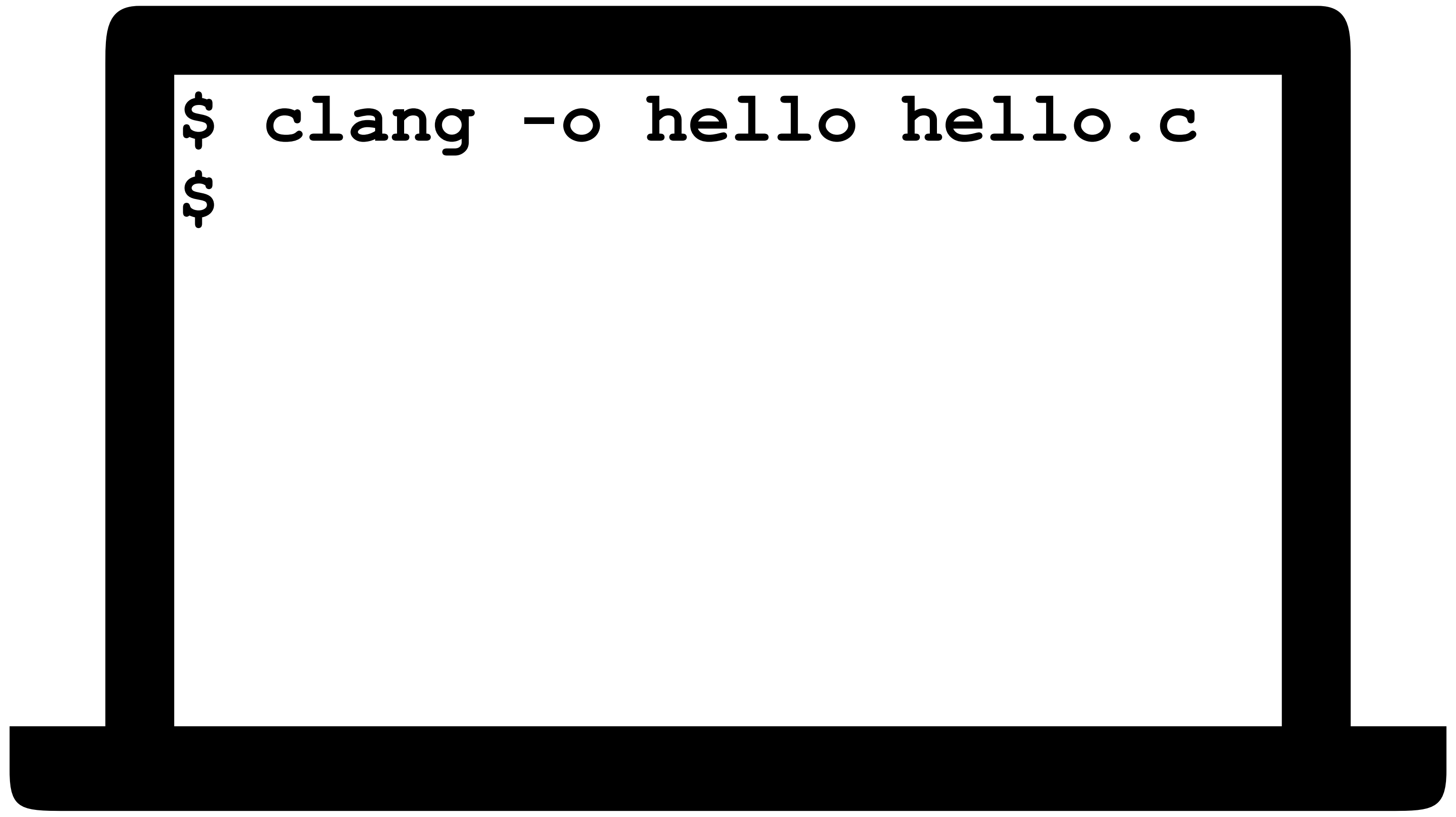
```
$ clang -o hello hello.c
```

```
#include <stdio.h>
int main(void)
{
  printf(“hello”);
  return 0;
}
```

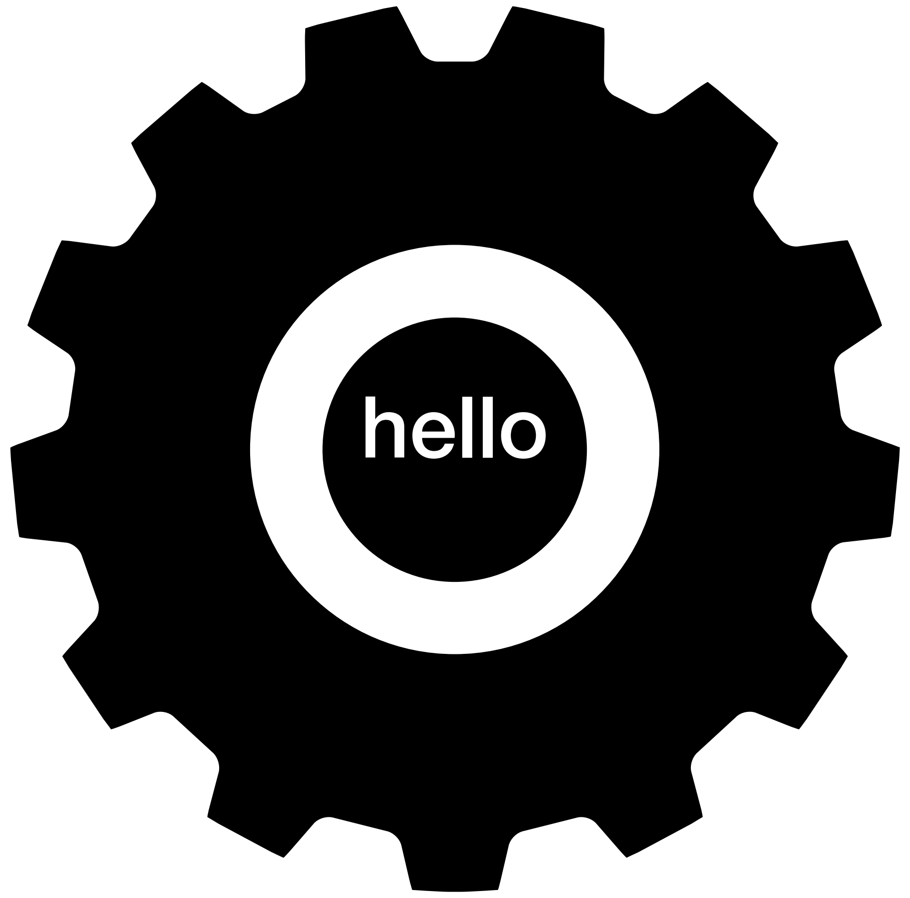
```
Done
```

How to Run C

How about C?



```
$ clang -o hello hello.c
$
```



How to Run C

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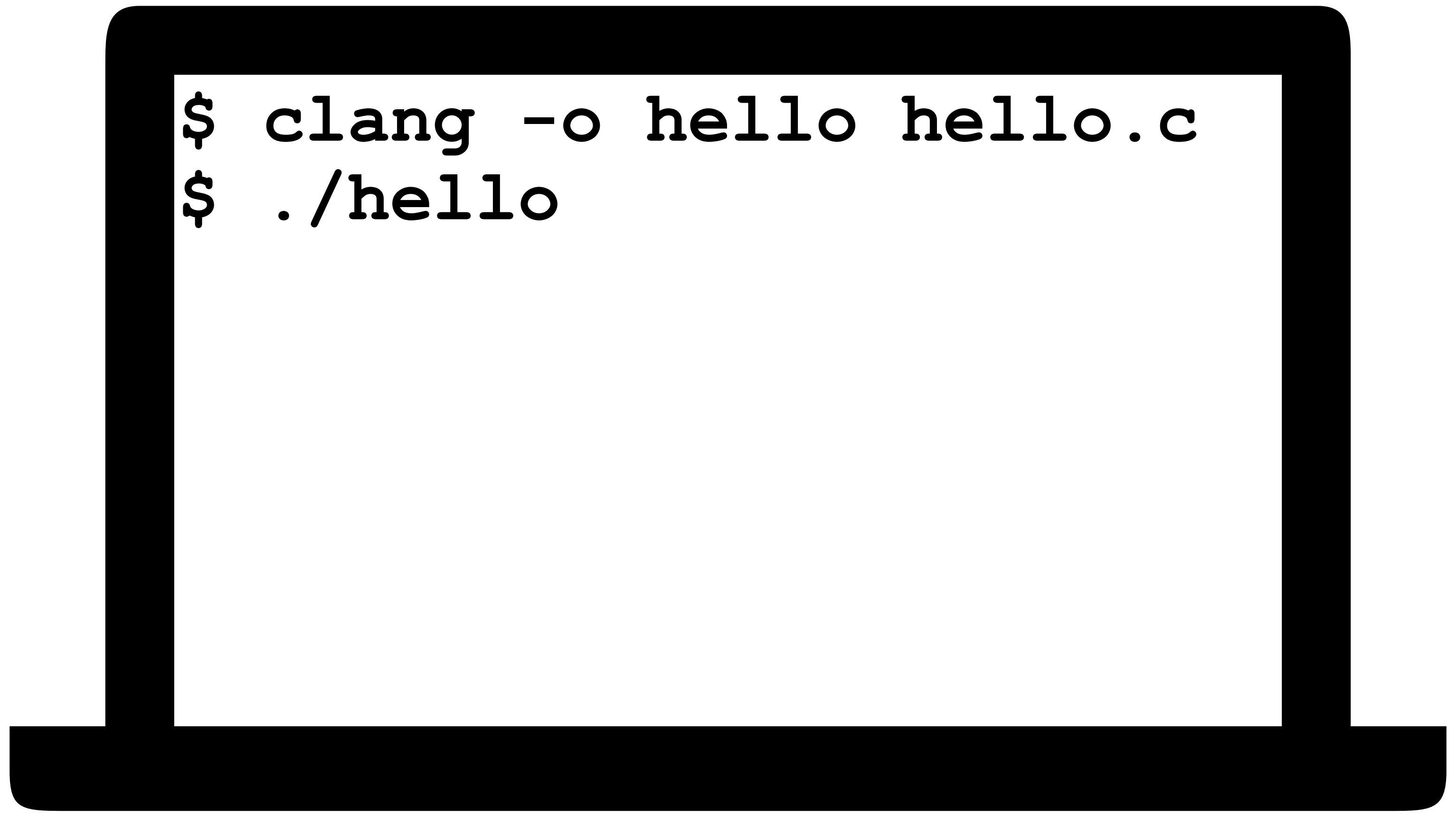
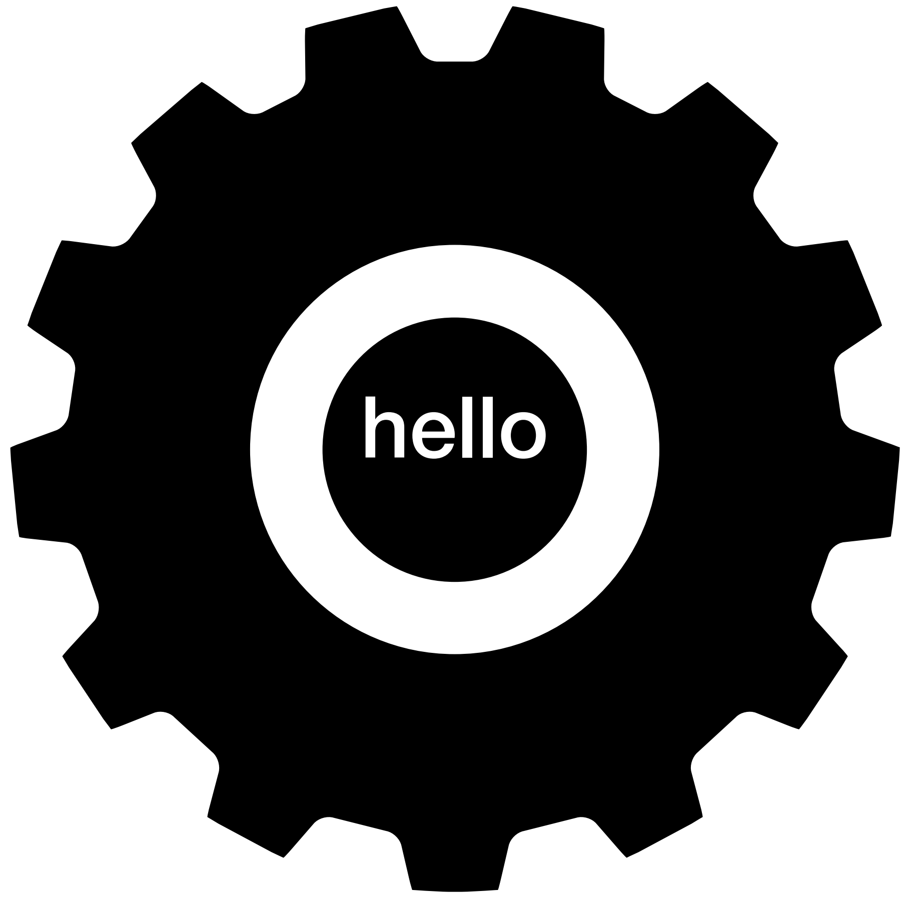
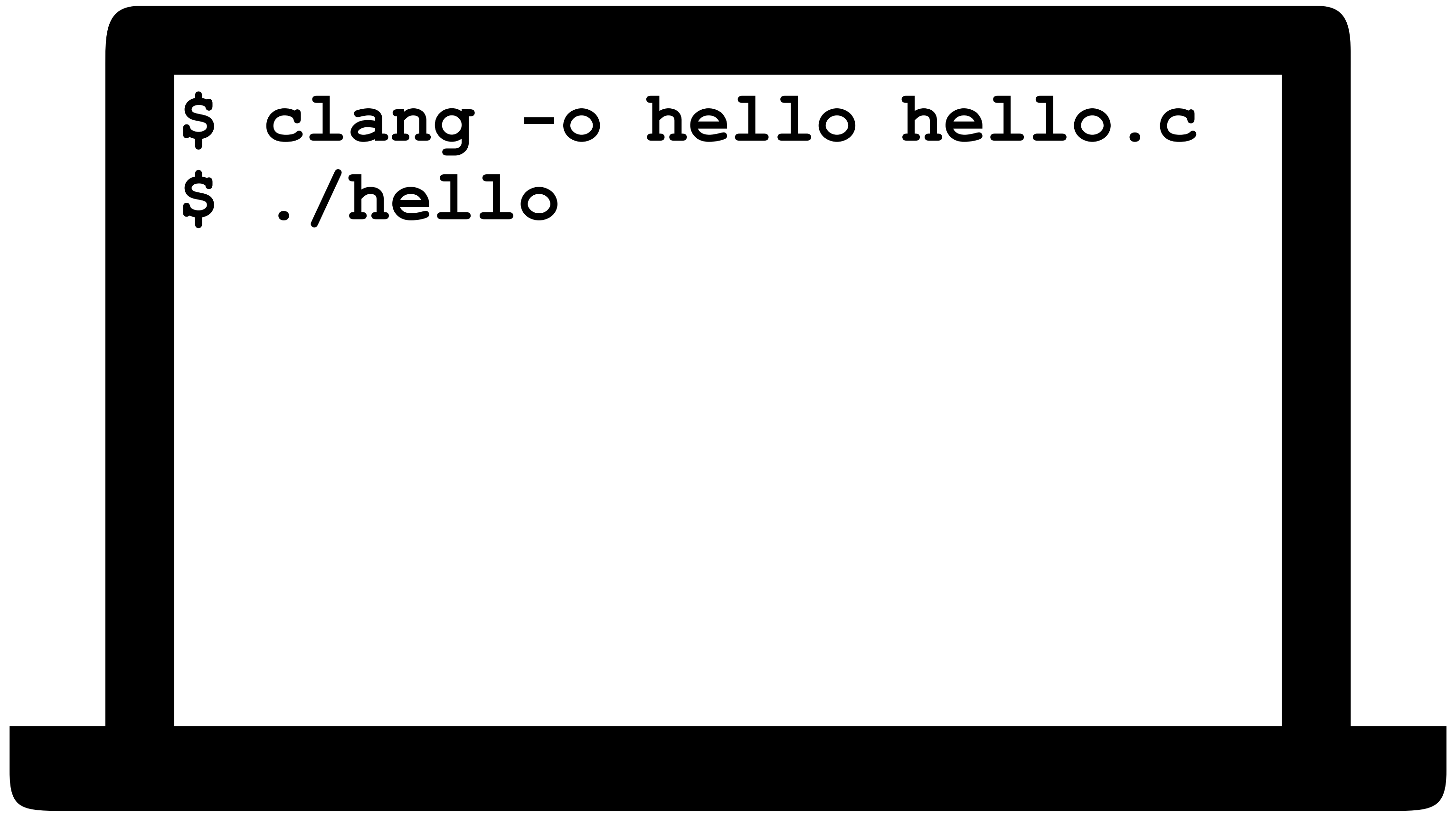


```
$ clang -o hello hello.c
$ ./hello
```

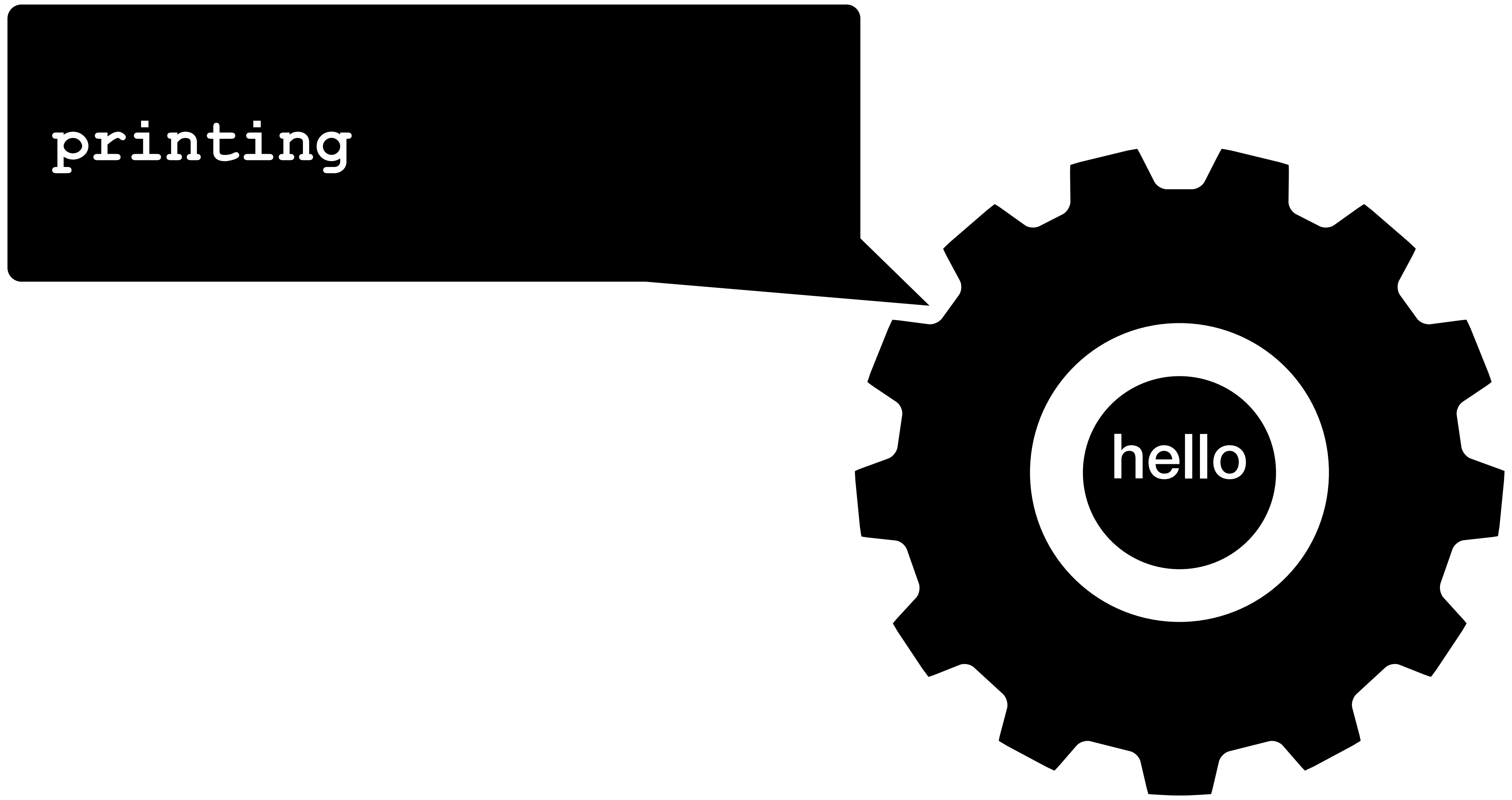


How to Run C

How about C?



```
$ clang -o hello hello.c
$ ./hello
```



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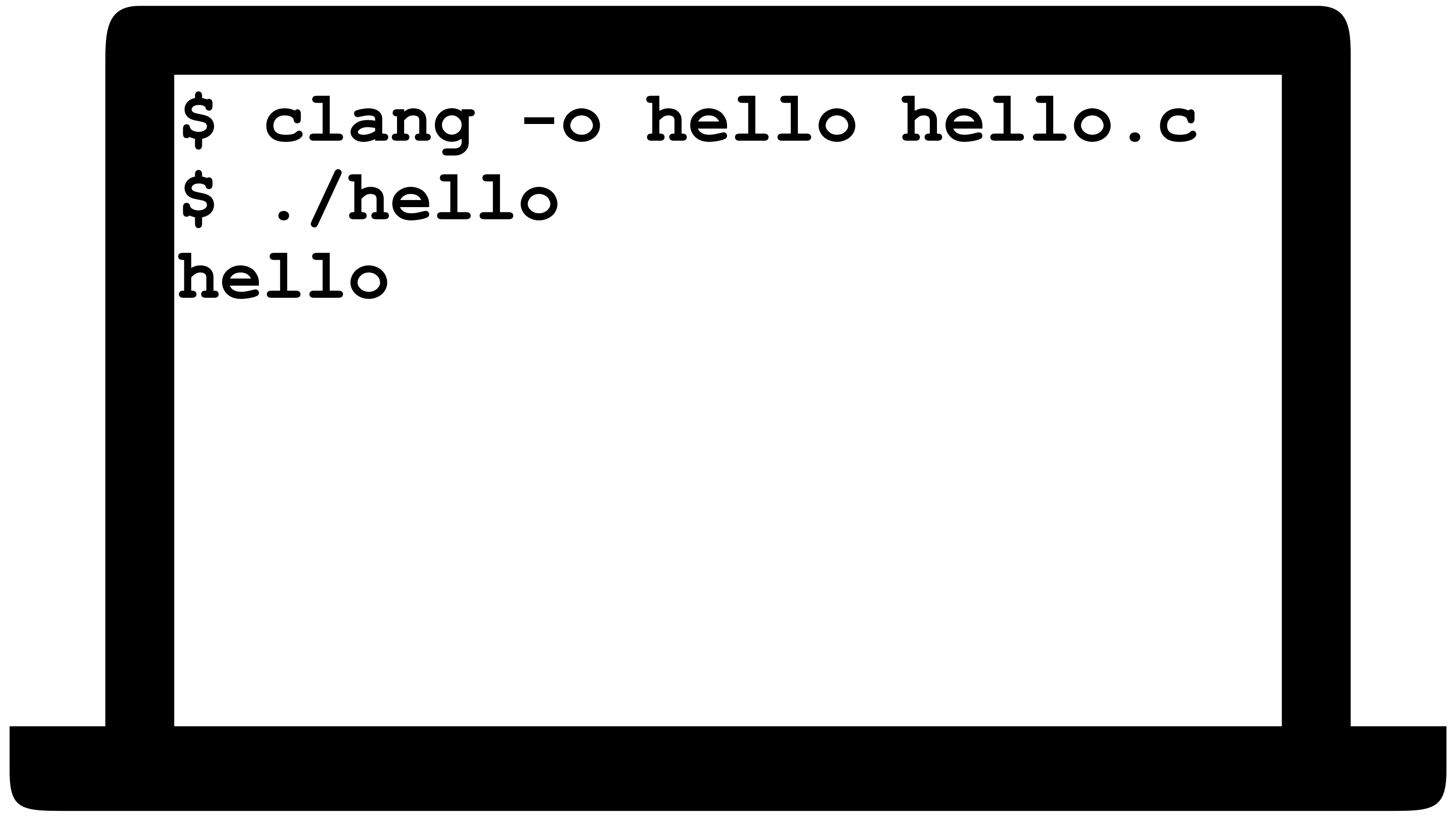

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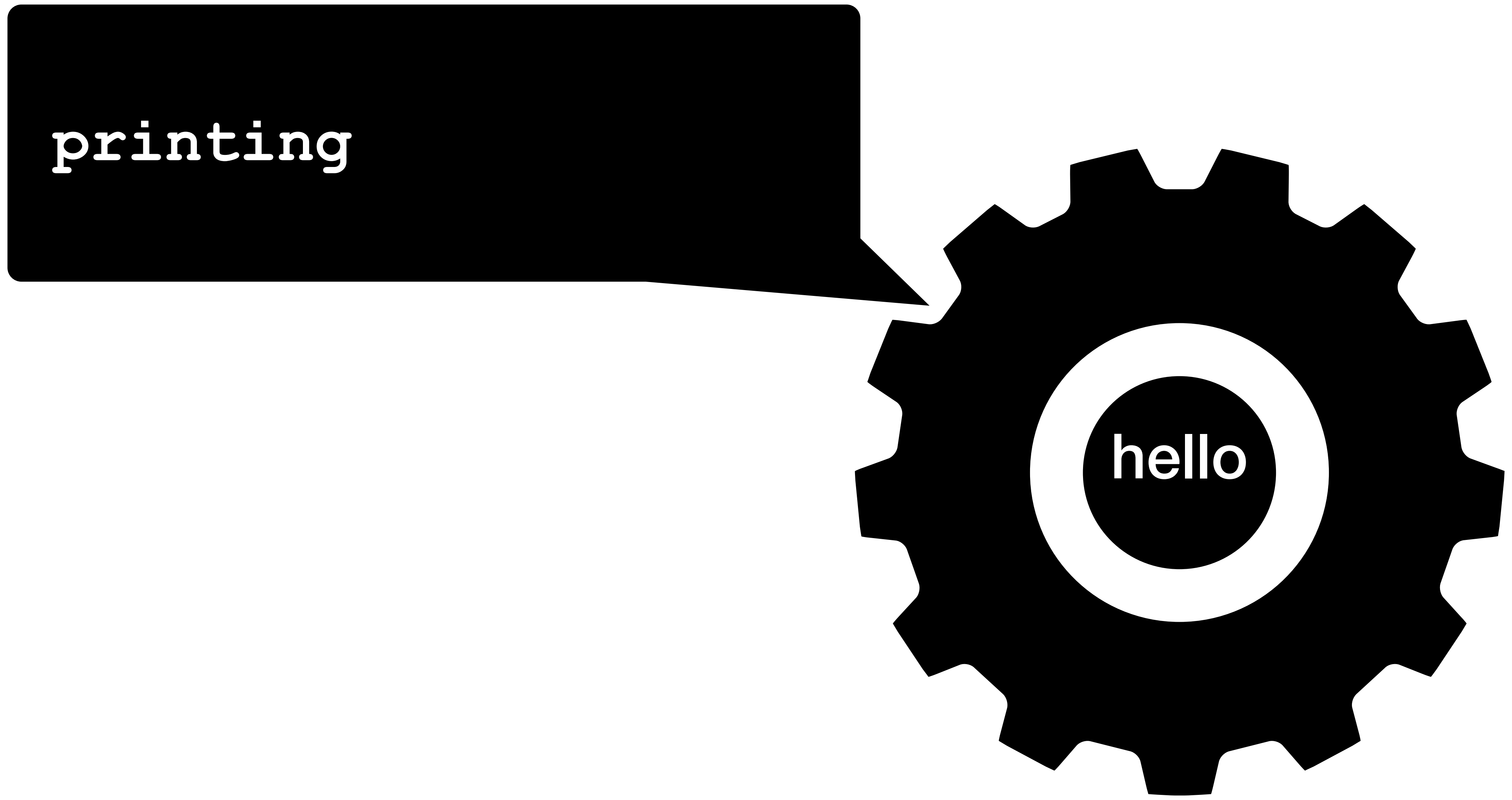

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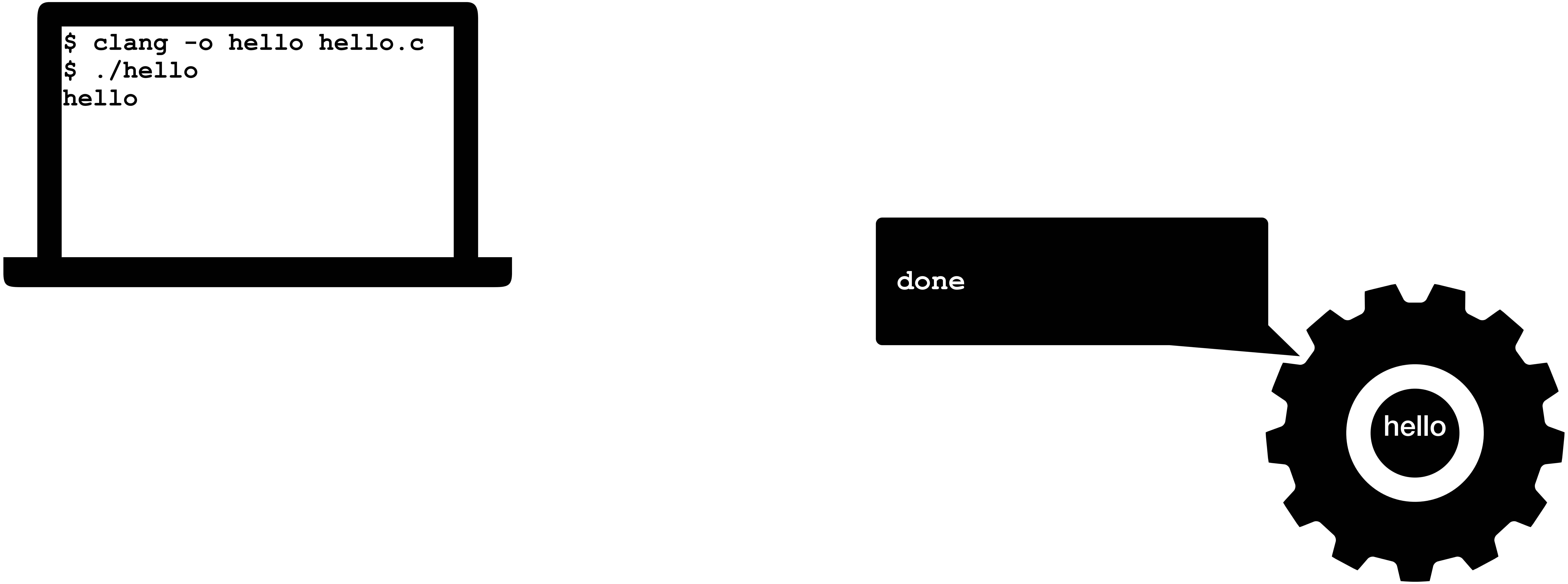

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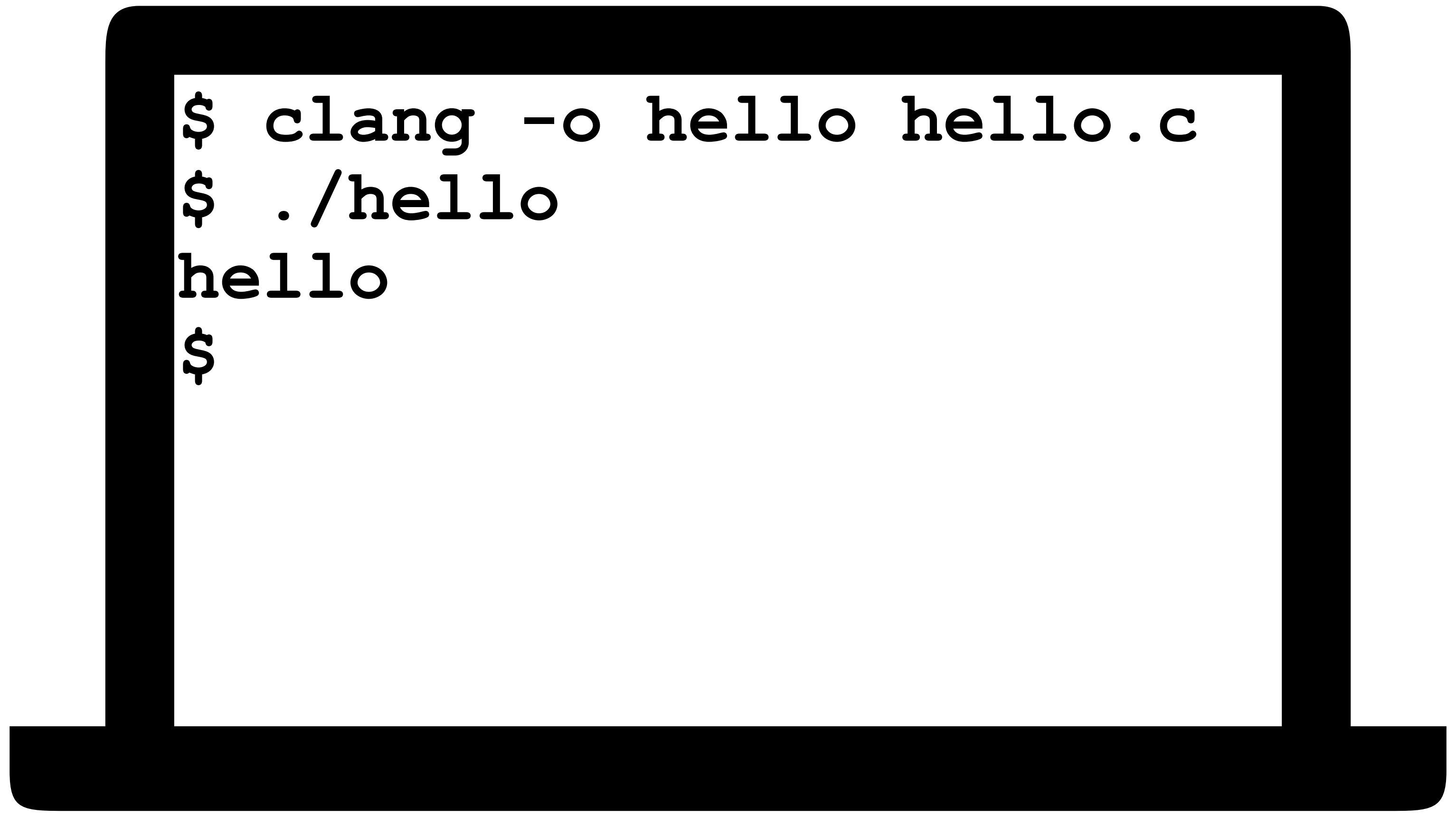

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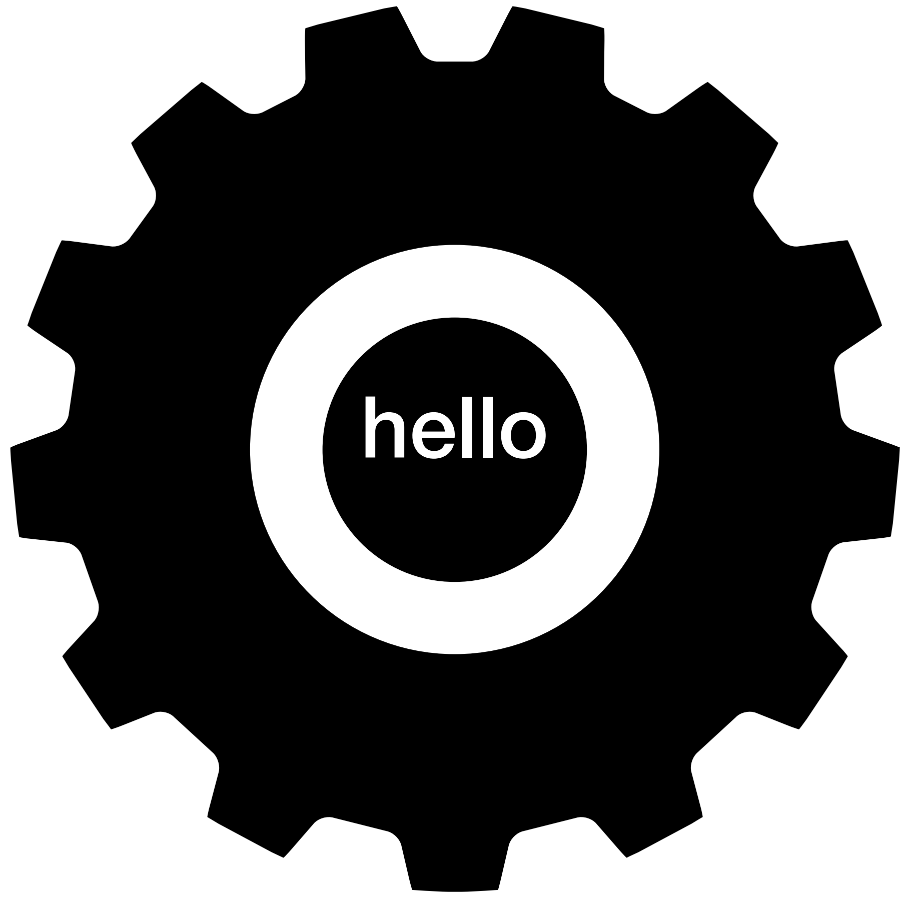

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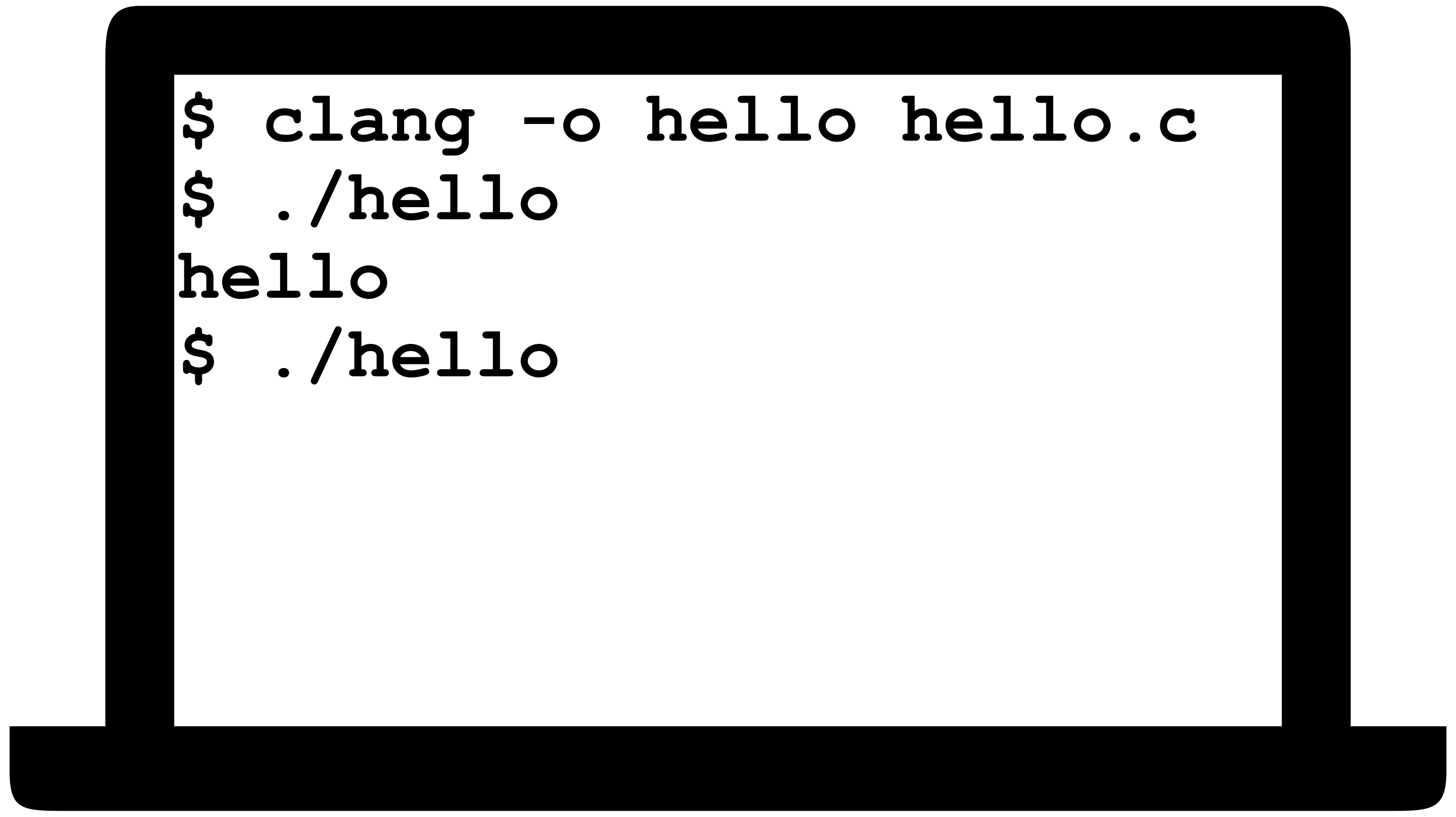

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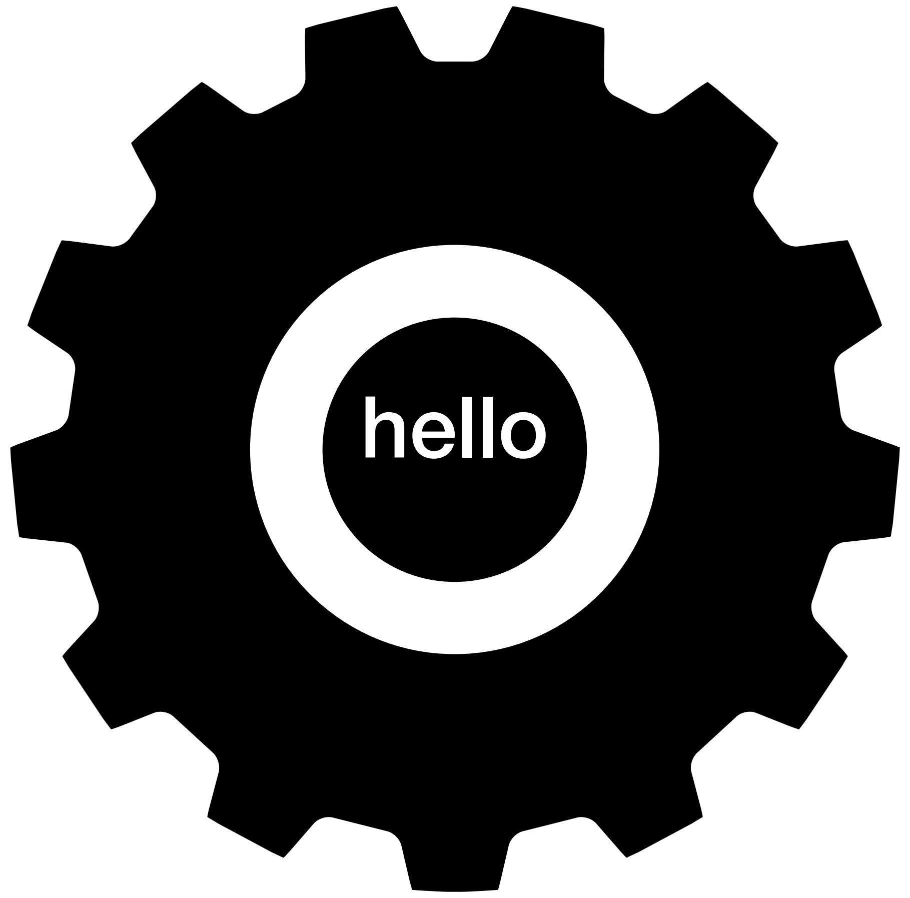

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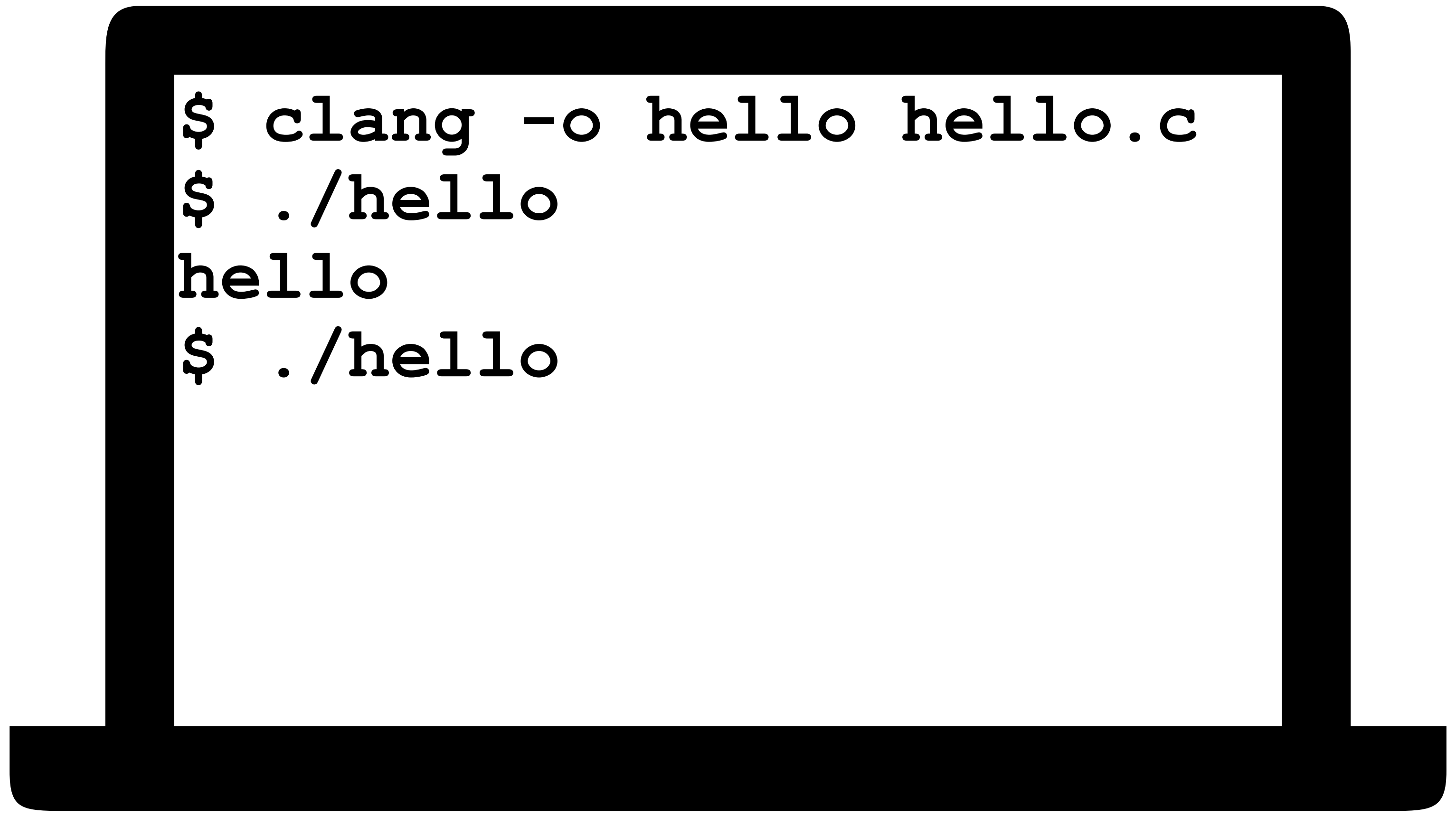

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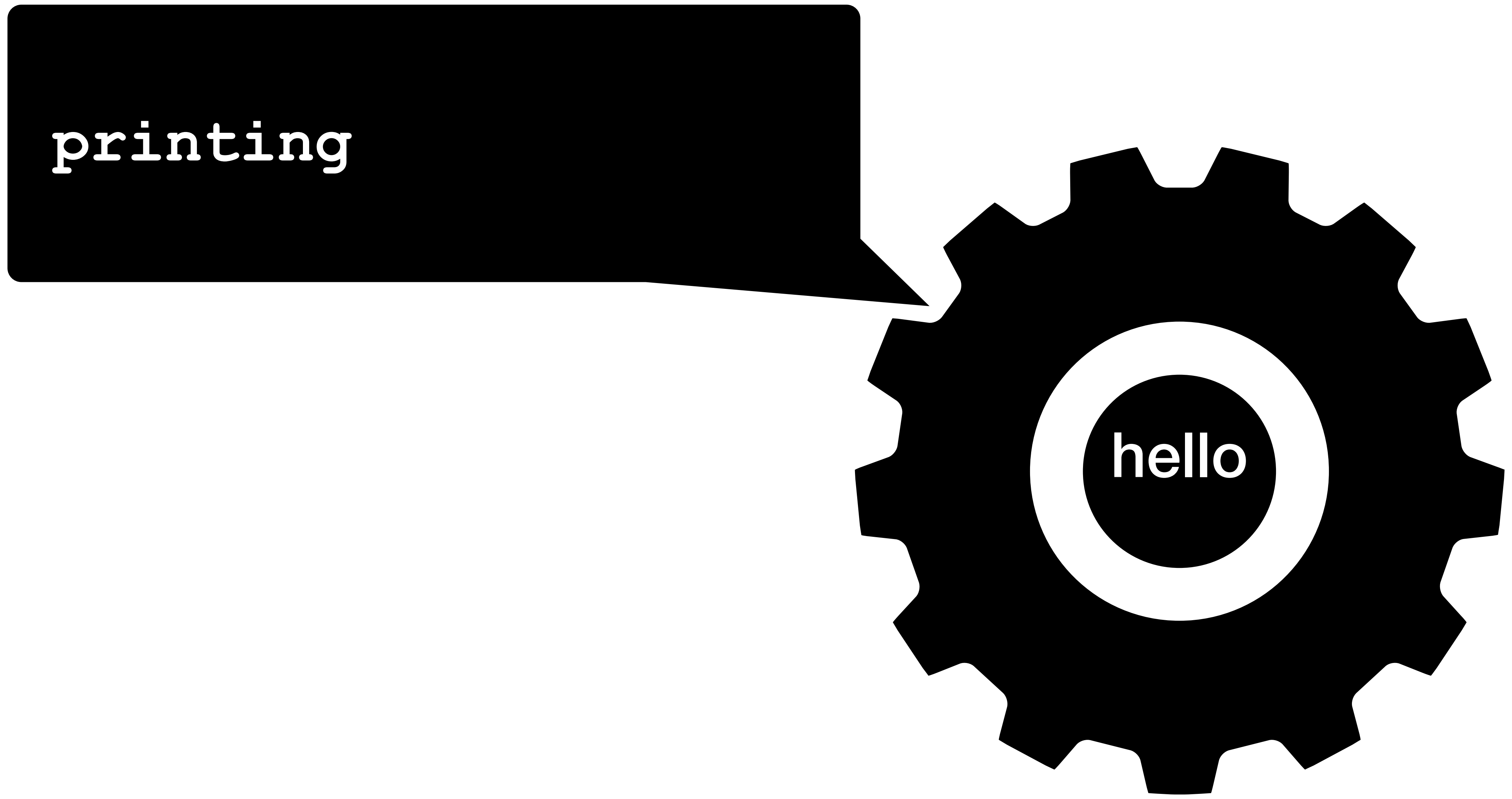
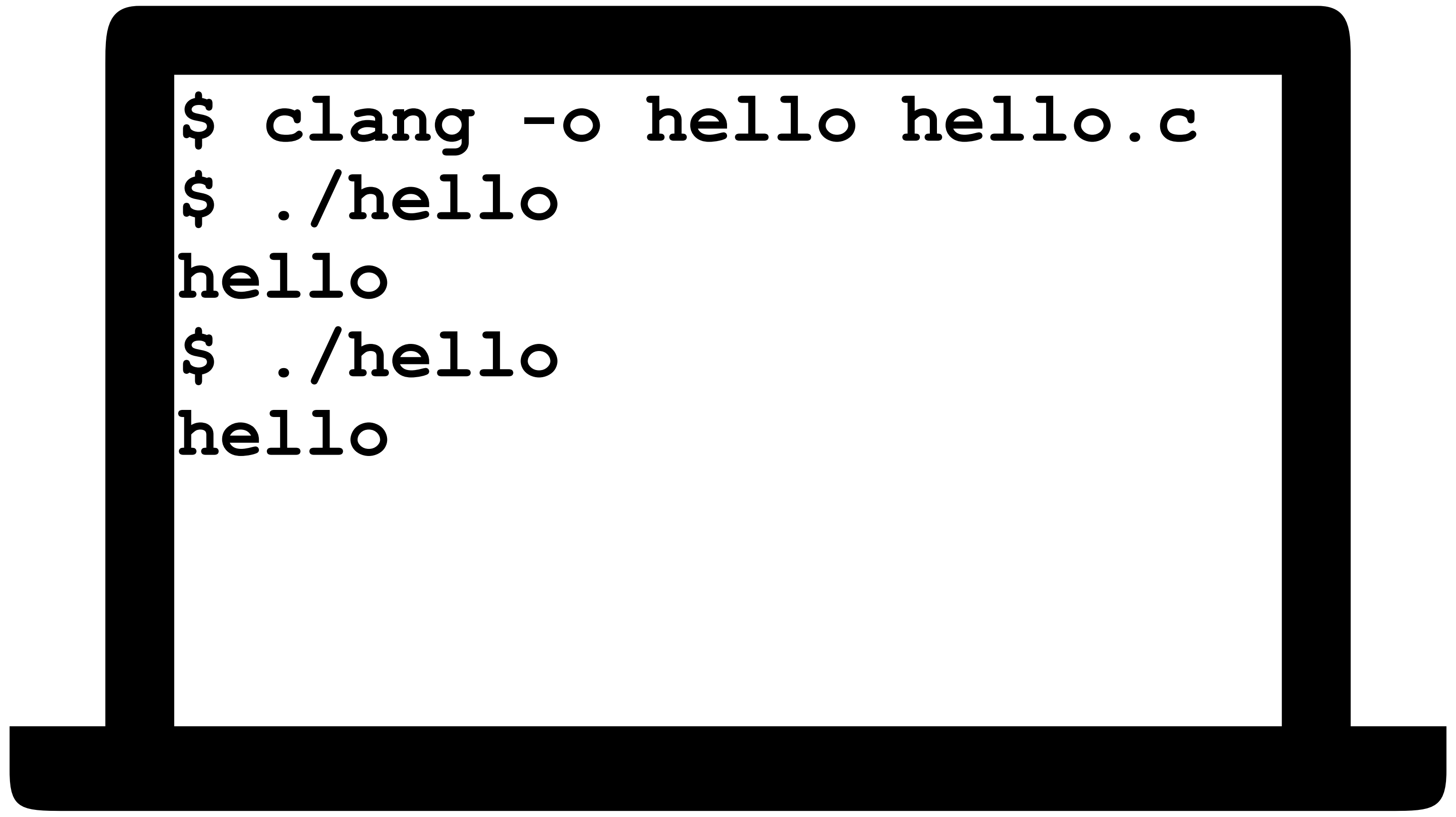


How to Run C

How about C?

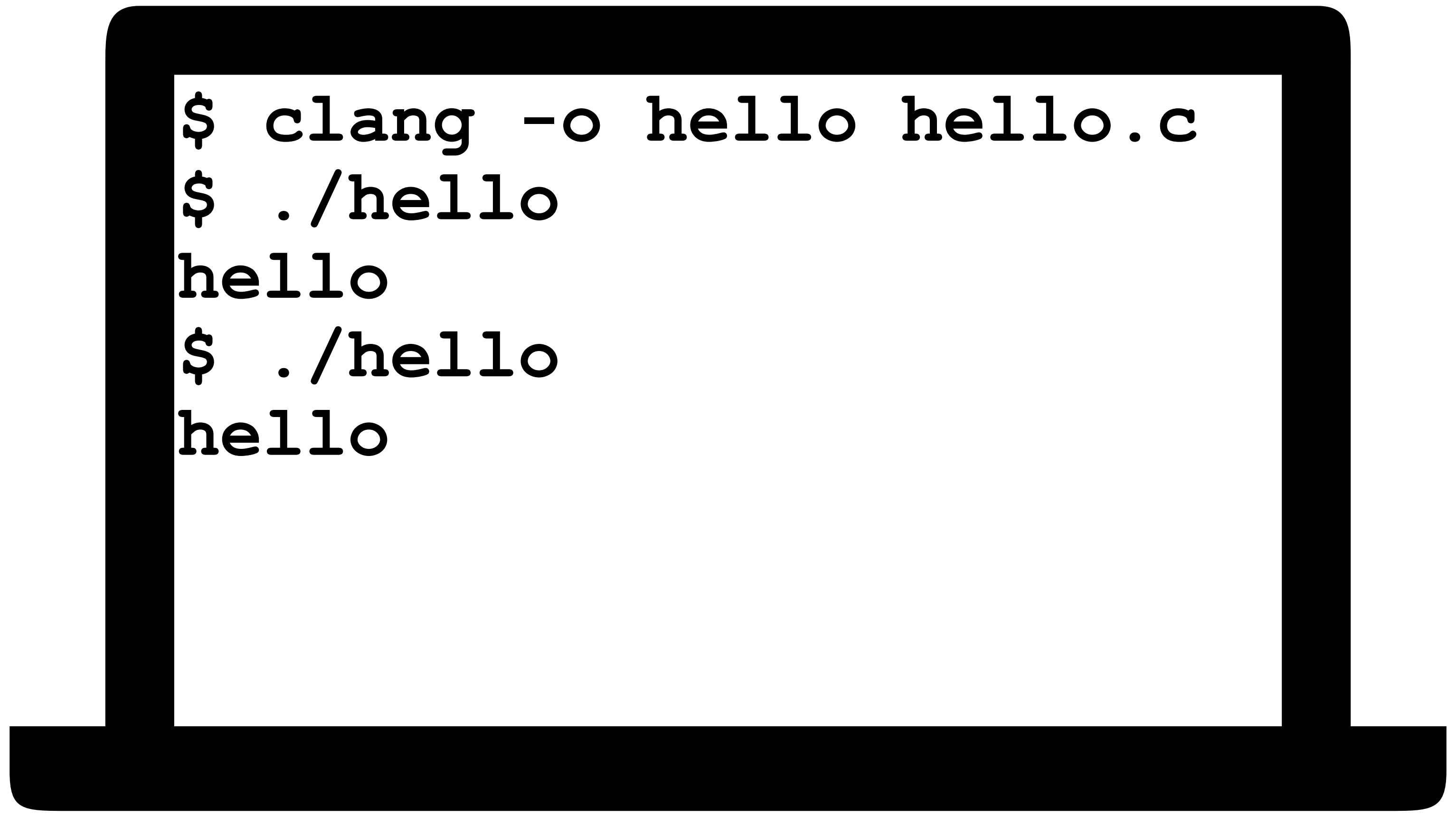


```
$ clang -o hello hello.c
$ ./hello
hello
$ ./hello
hello
```

printing
hello

How to Run C

How about C?



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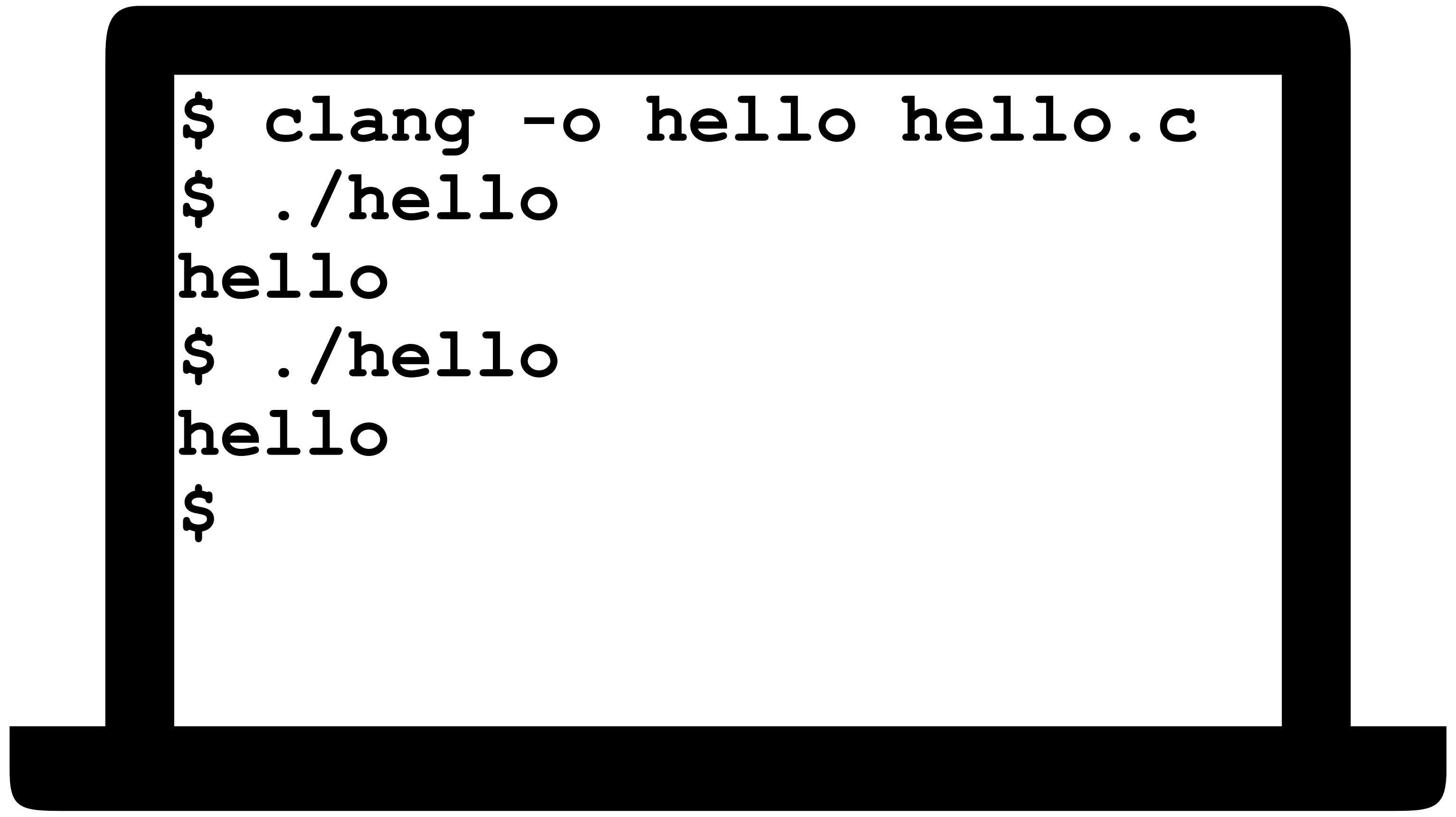

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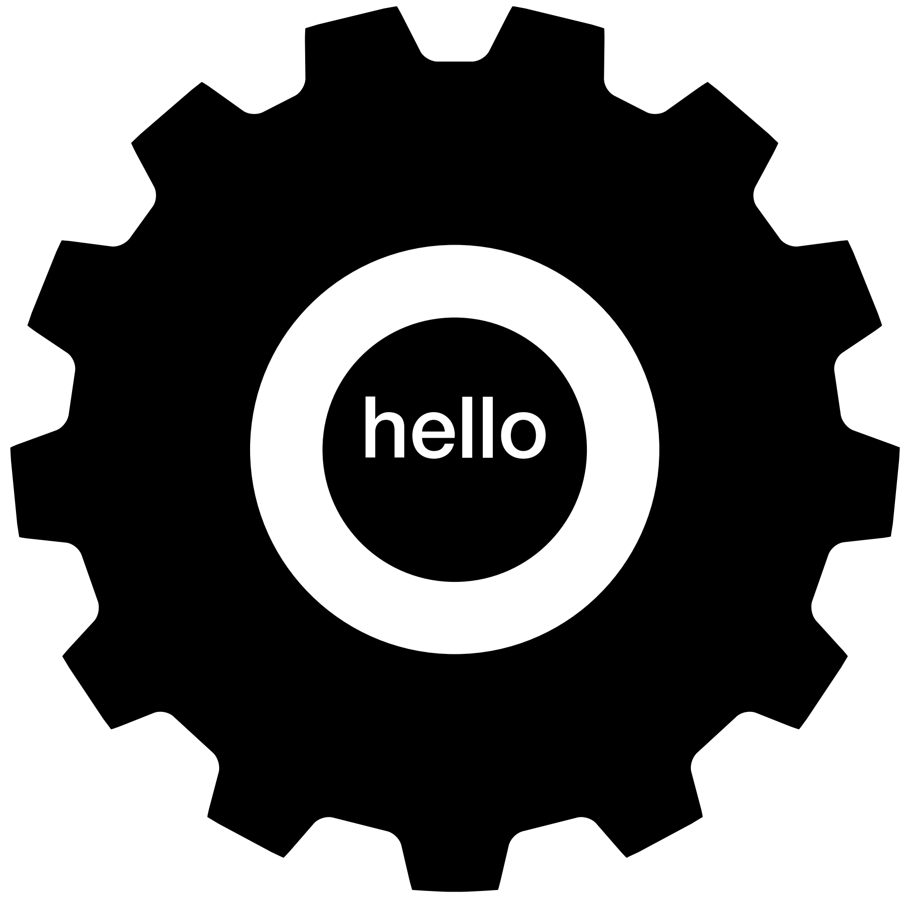

How to Run C

How about C?

- `clang` translates your source code (text) into a file containing machine instructions
- to “compile the source code into an executable”
- you have a new executable; running that executable doesn’t involve clang anymore
- `clang` is a compiler

To-do

- Fill out the survey (if you haven’t already)
- Read the homepage of the course website
- Get familiar with the Resources page (also open to suggestions)
- HW0 is out, due next Tuesday