

# CS 241: Systems Programming

## Lecture 8. Introduction to C

Spring 2020

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# Hello, World!

```
#include <stdio.h>

int main(void) {
    printf("Hello world!\n");
    return 0;
}
```

# Functions

```
/* Function declaration.  
 * - No return value.  
 * - Has three parameters, parameter names are optional.  
 * - Ends with a semicolon.  
 */
```

```
void foo(int x, float y, char z);
```

```
/* Function definition.  
 * - Must match declaration.  
 * - Parameter names are not optional.  
 * - Body of function wrapped in { }.  
 */
```

```
void foo(int x, float y, char z) {  
    /* ... */  
}
```

# Main function

```
// The main function is where execution begins.  
// - Returns an int, 0 is success, 1-127 are failure.  
// - Takes 0, 2, or implementation-defined number of parameters.  
// - argc is the number of command line parameters.  
// - argv points to an array of command line parameters.  
int main(void) { /* ... */ }  
int main(int argc, char **argv) { /* ... */ } // Use this one.  
int main(int argc, char **argv, char **envp) { /* ... */ }
```

# Jobs of a Compiler

## Inputs

- ▶ C program file and options
- ▶ Libraries

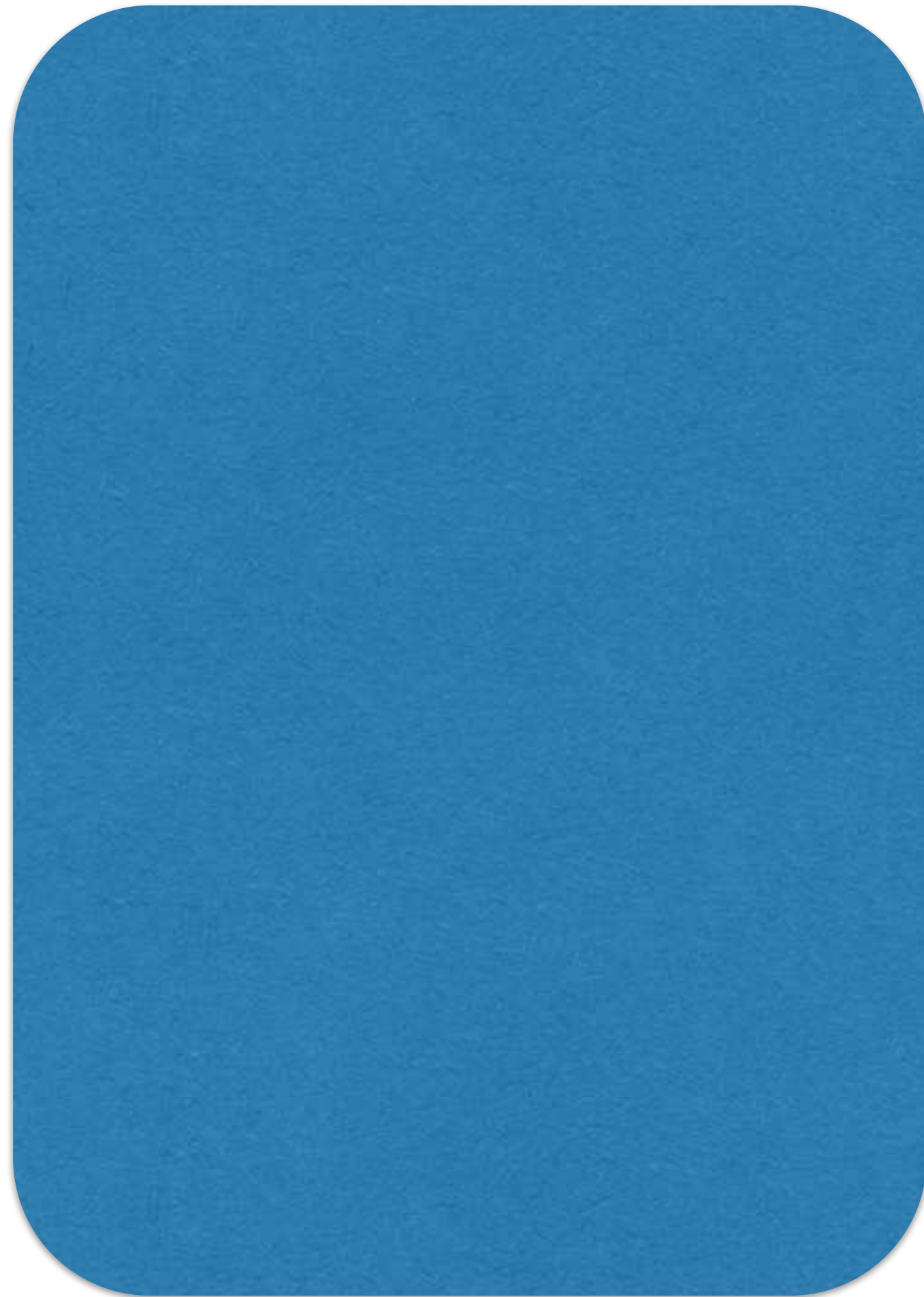
## Compilation phases

- ▶ Preprocessing
- ▶ Compilation
- ▶ Linking

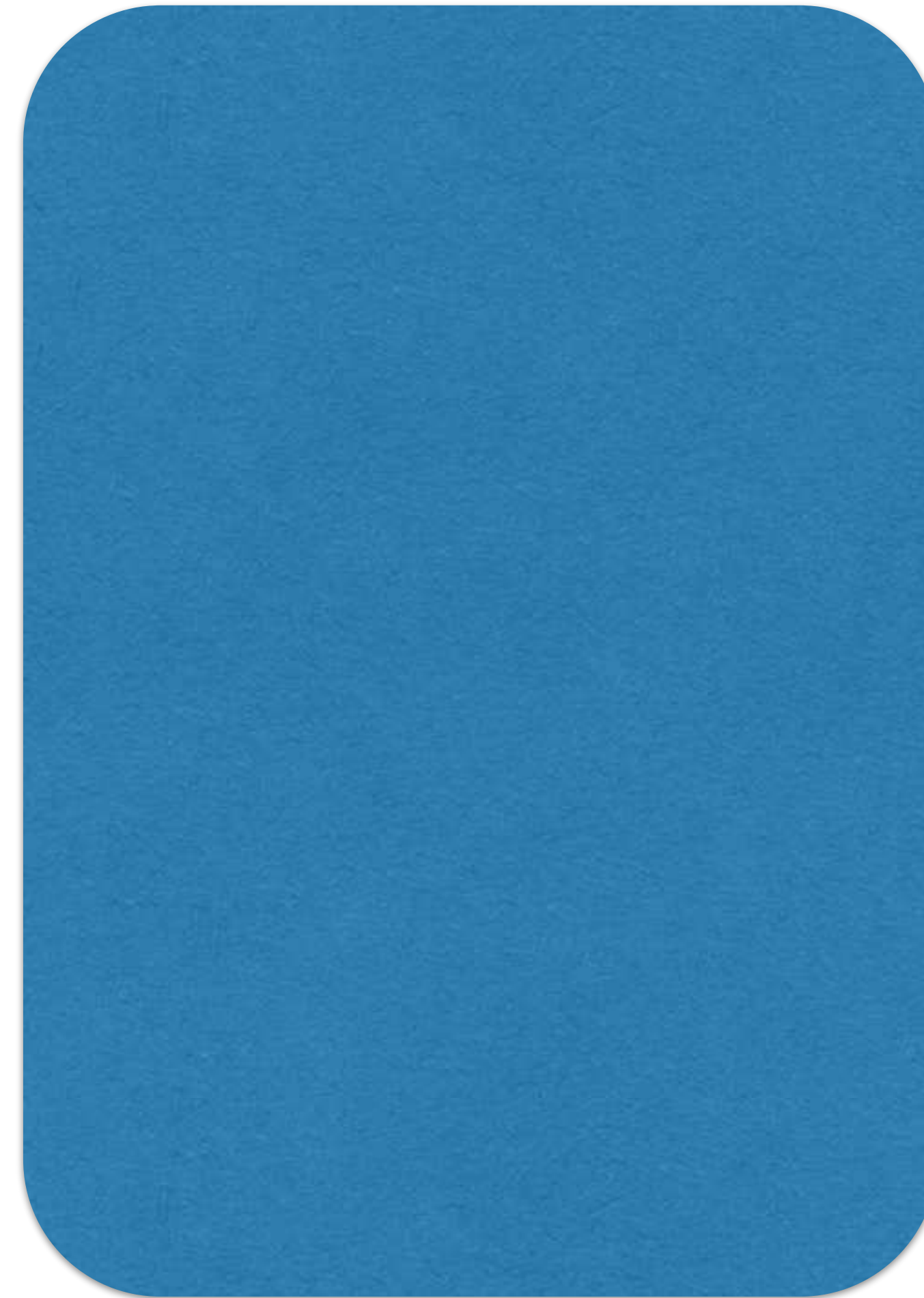
## Outputs

- ▶ Executable
- ▶ Warnings and errors

# Compilation



Java Model



C Model

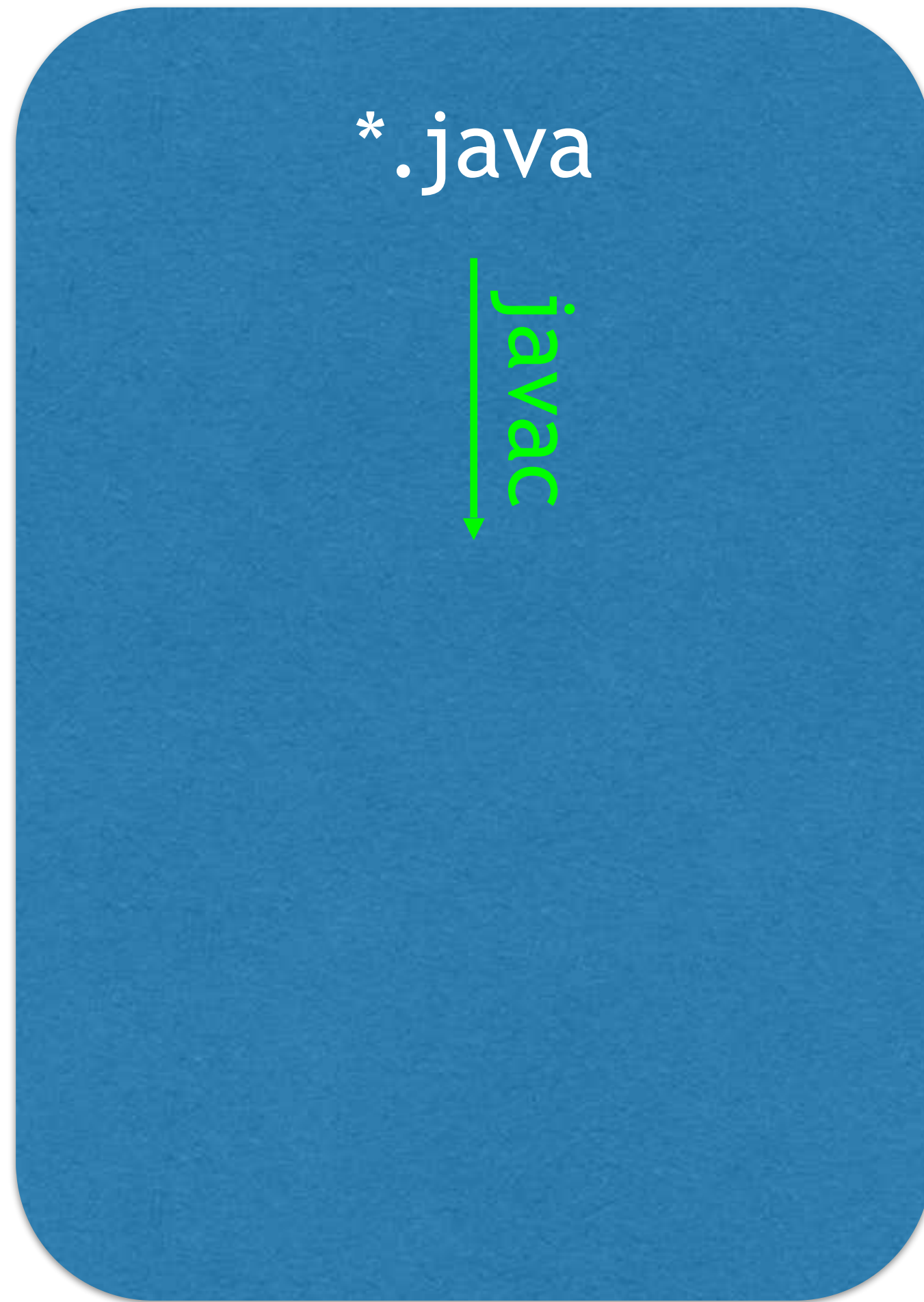
# Compilation

\*.java

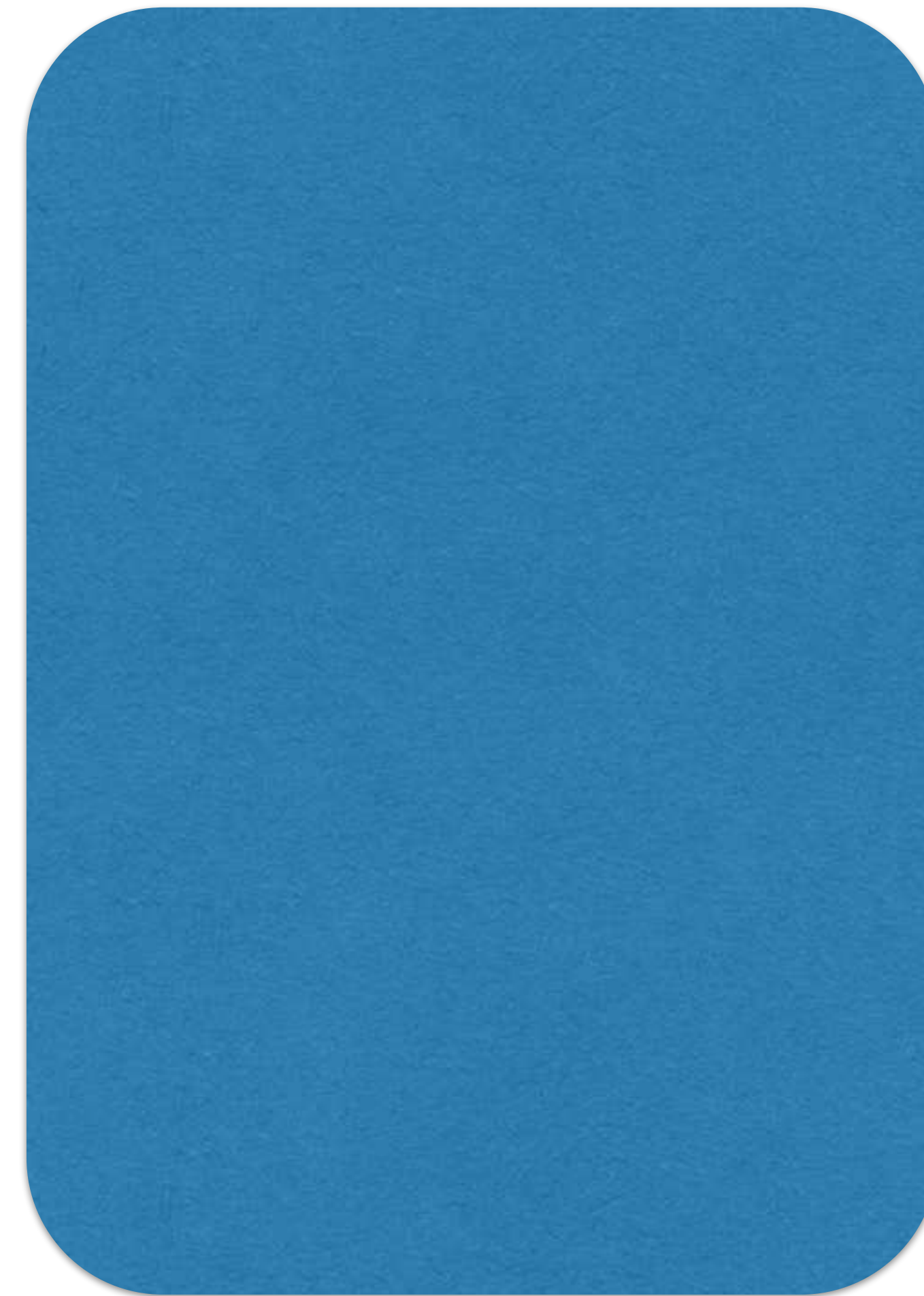
Java Model

C Model

# Compilation



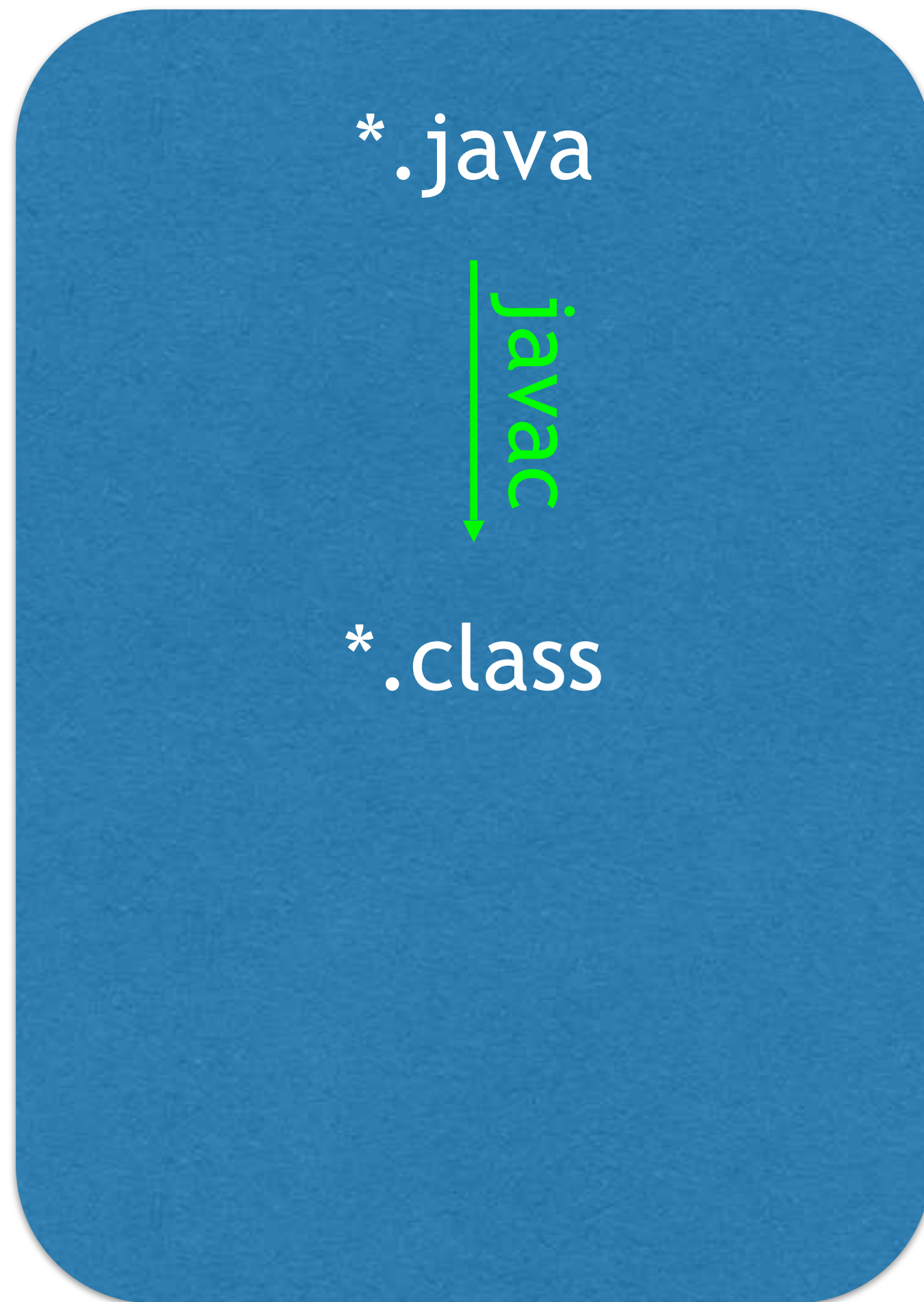
Java Model



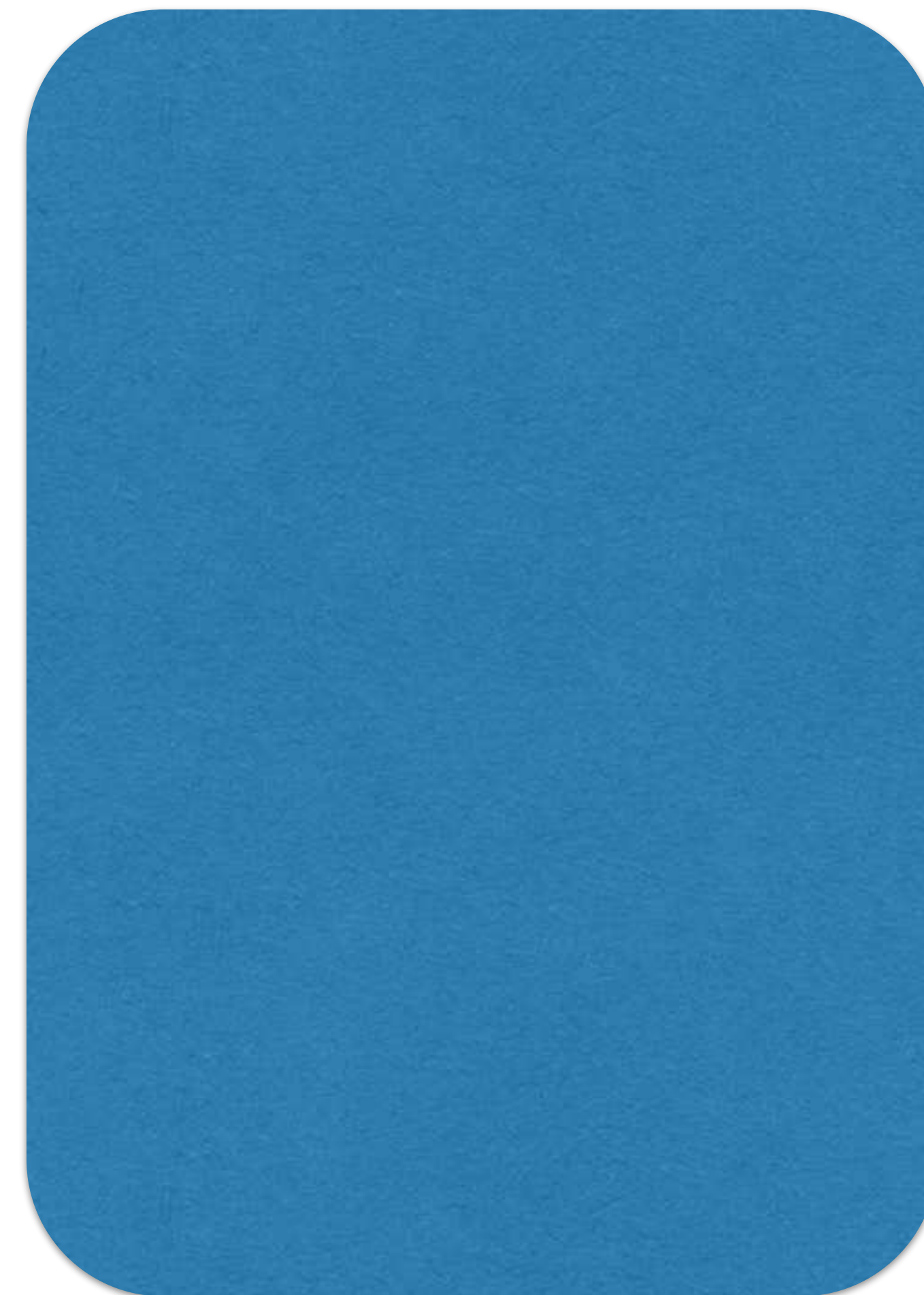
C Model



# Compilation

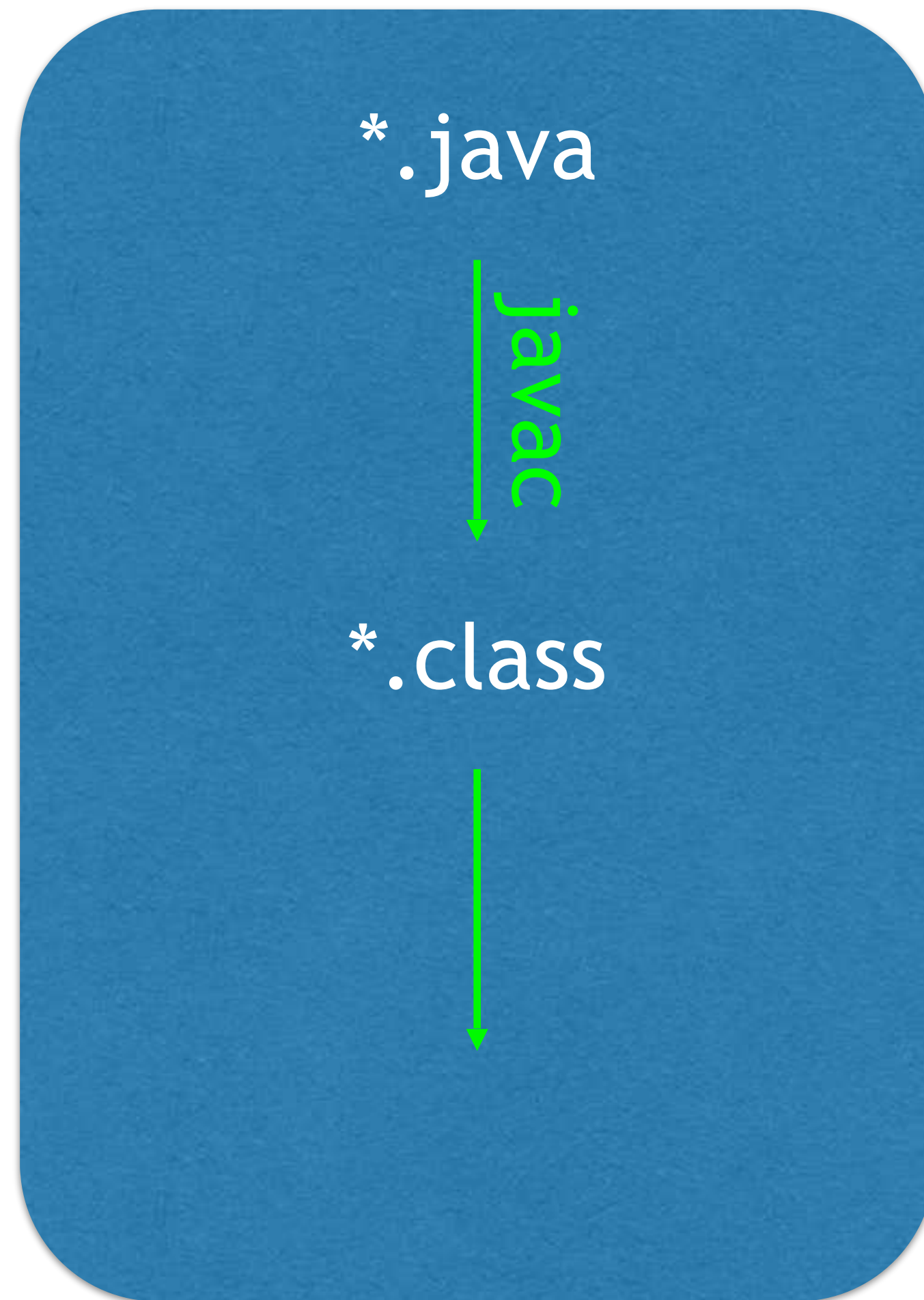


Java Model

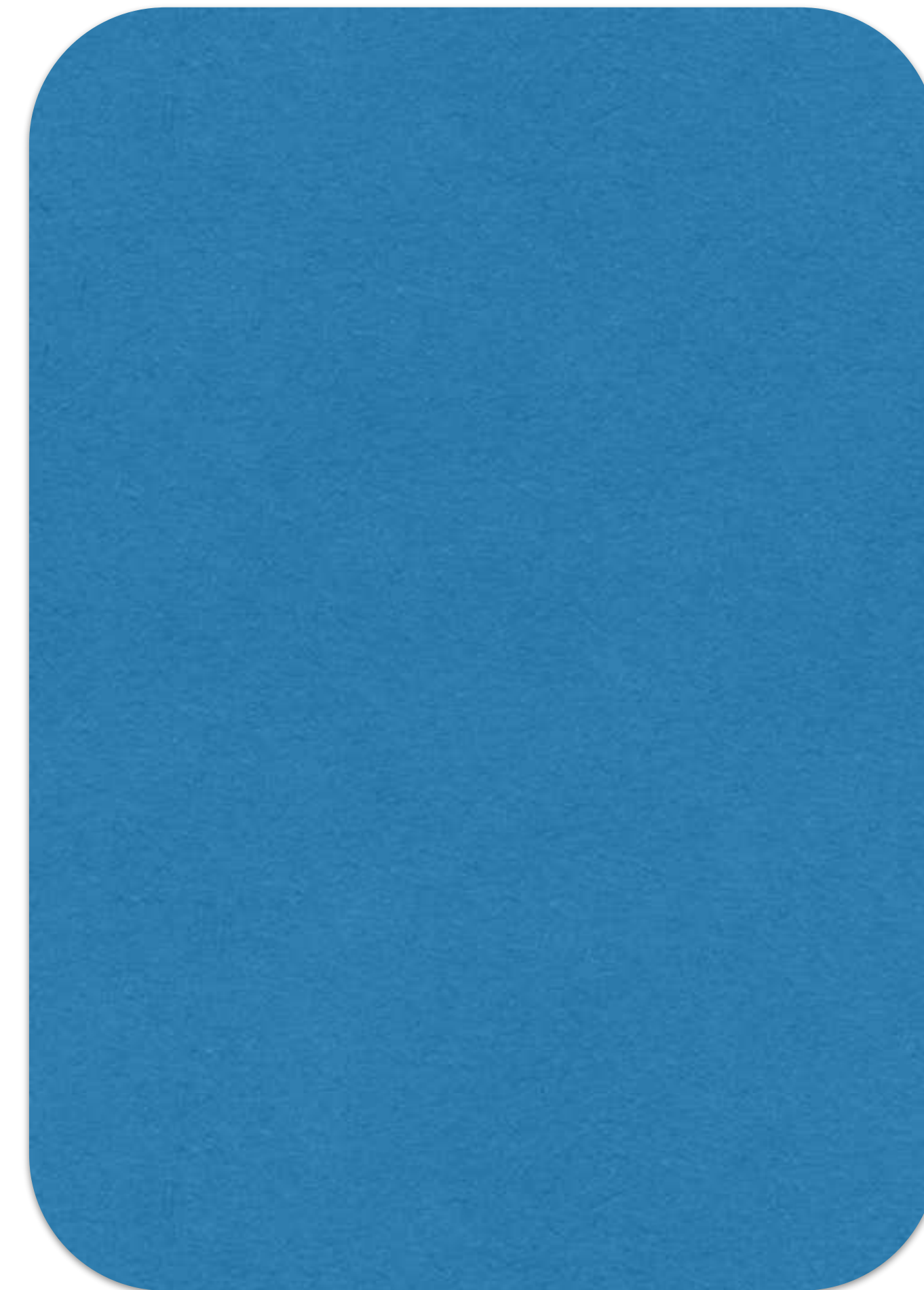


C Model

# Compilation

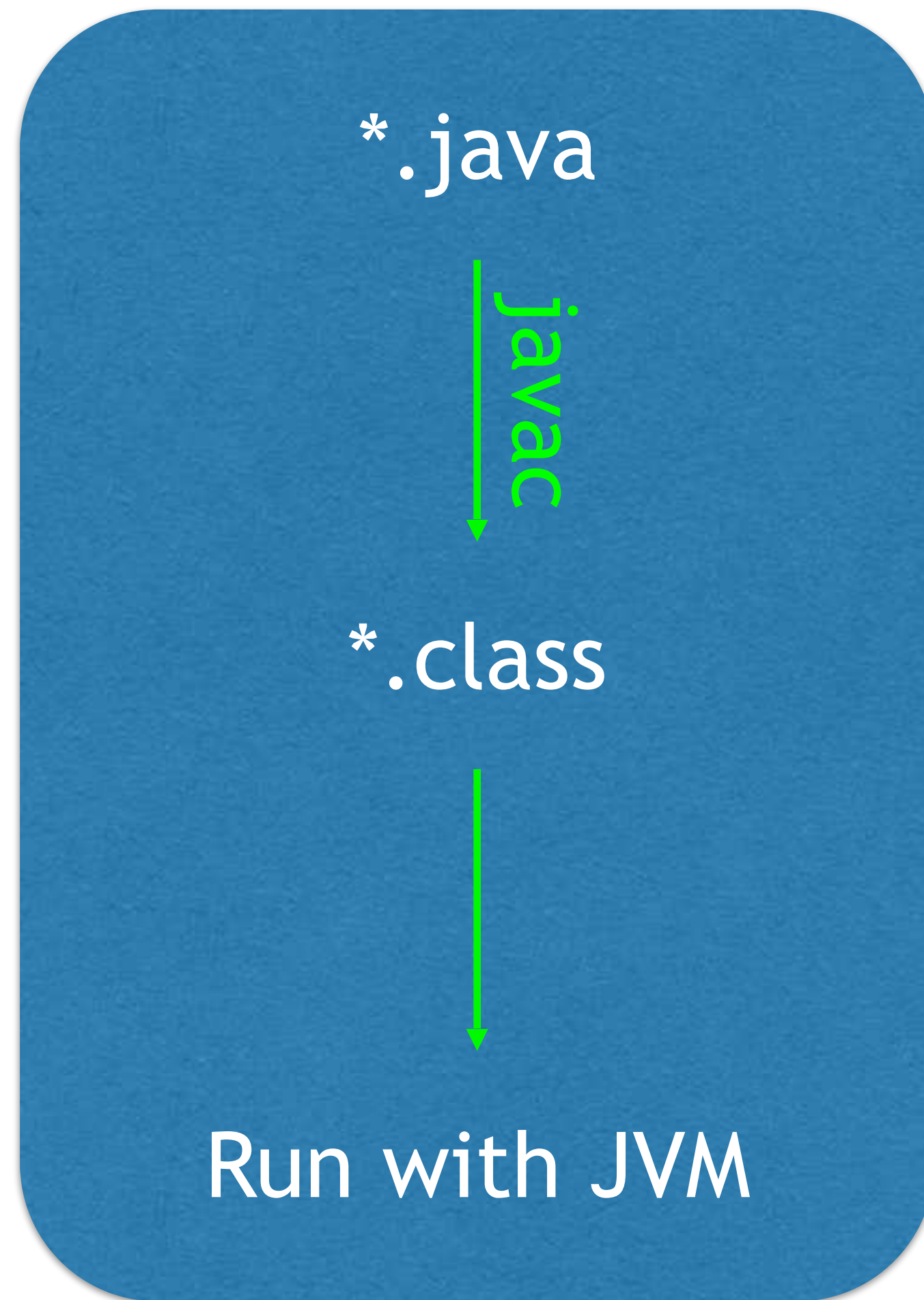


Java Model

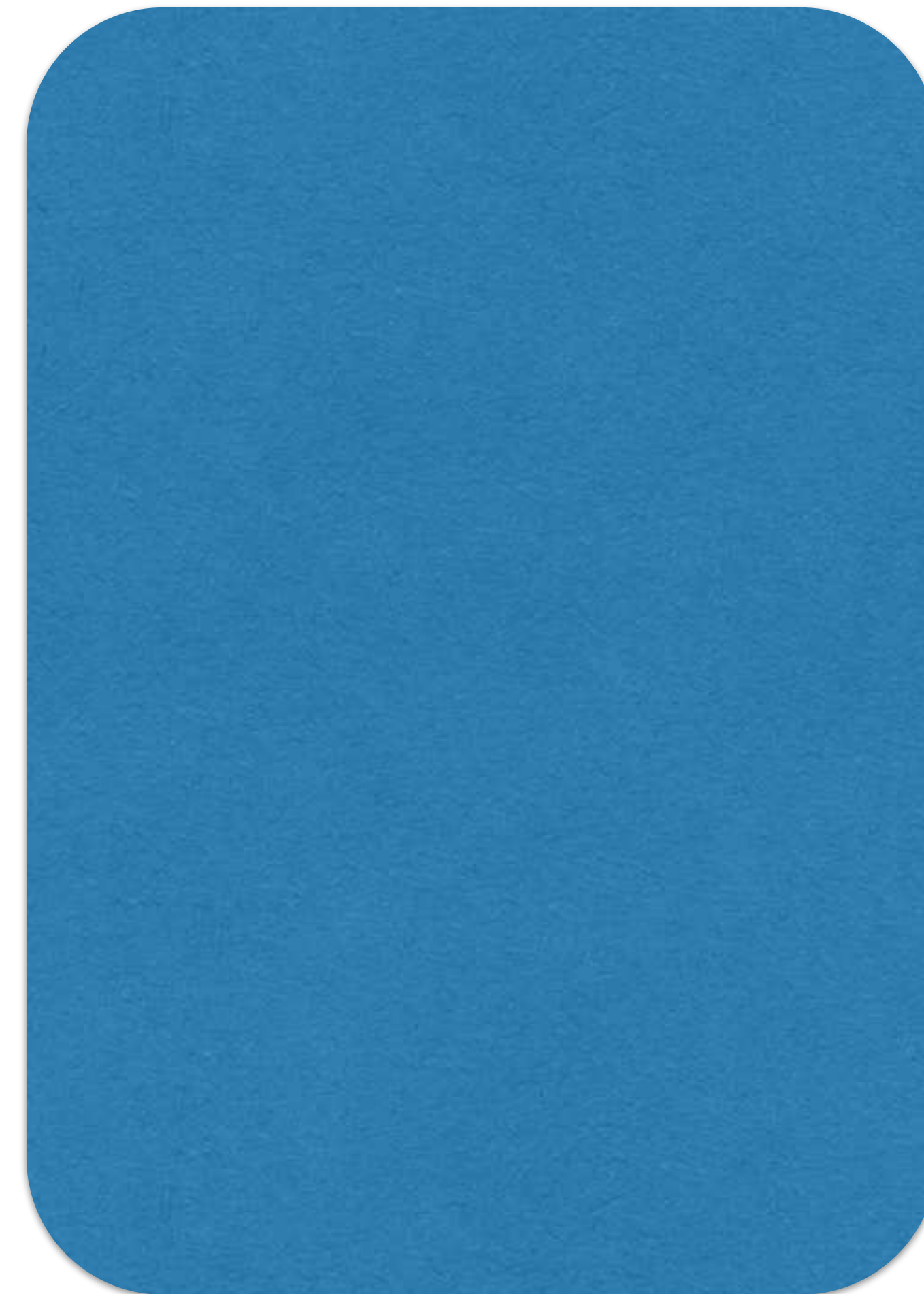


C Model

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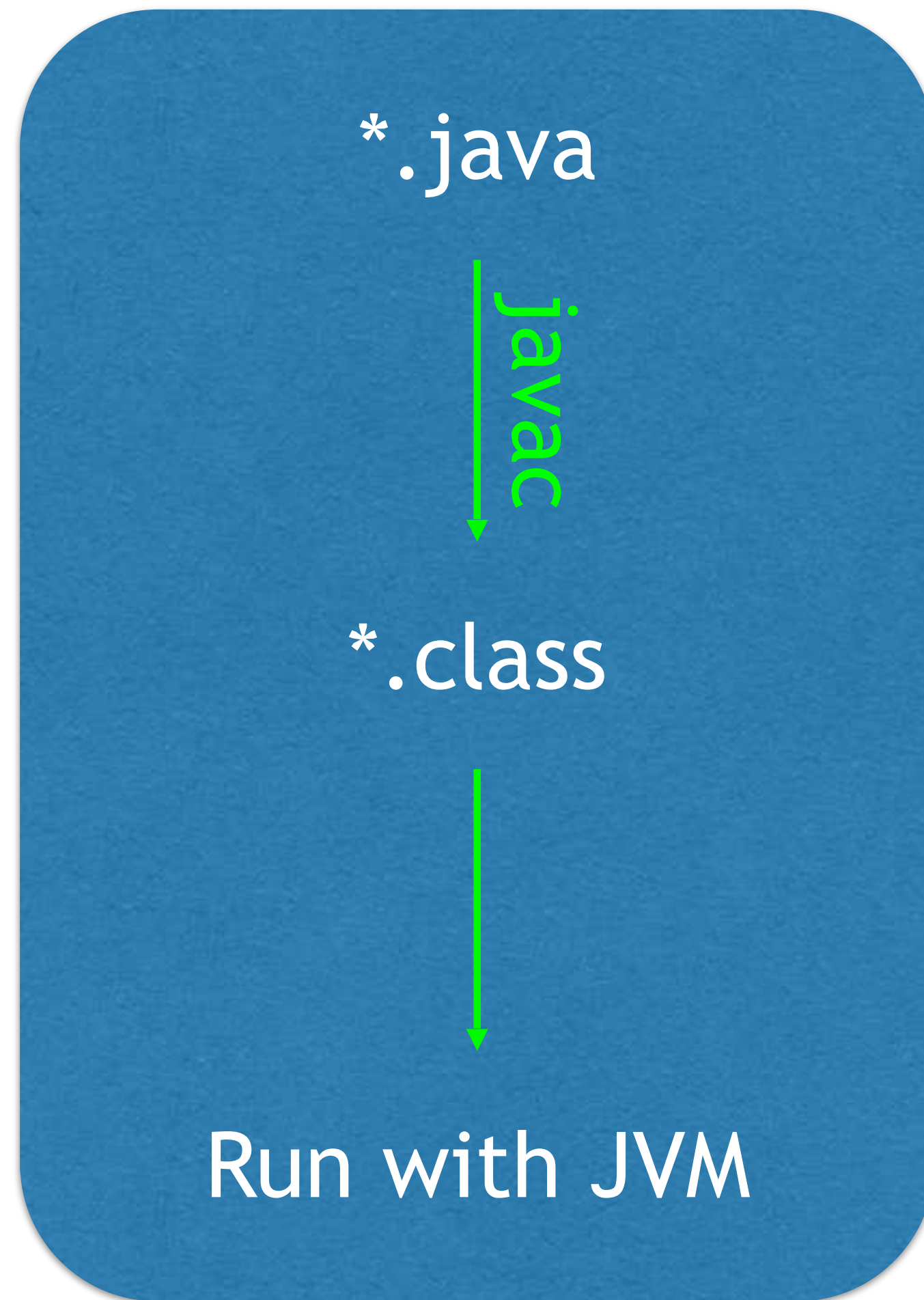


Java Model

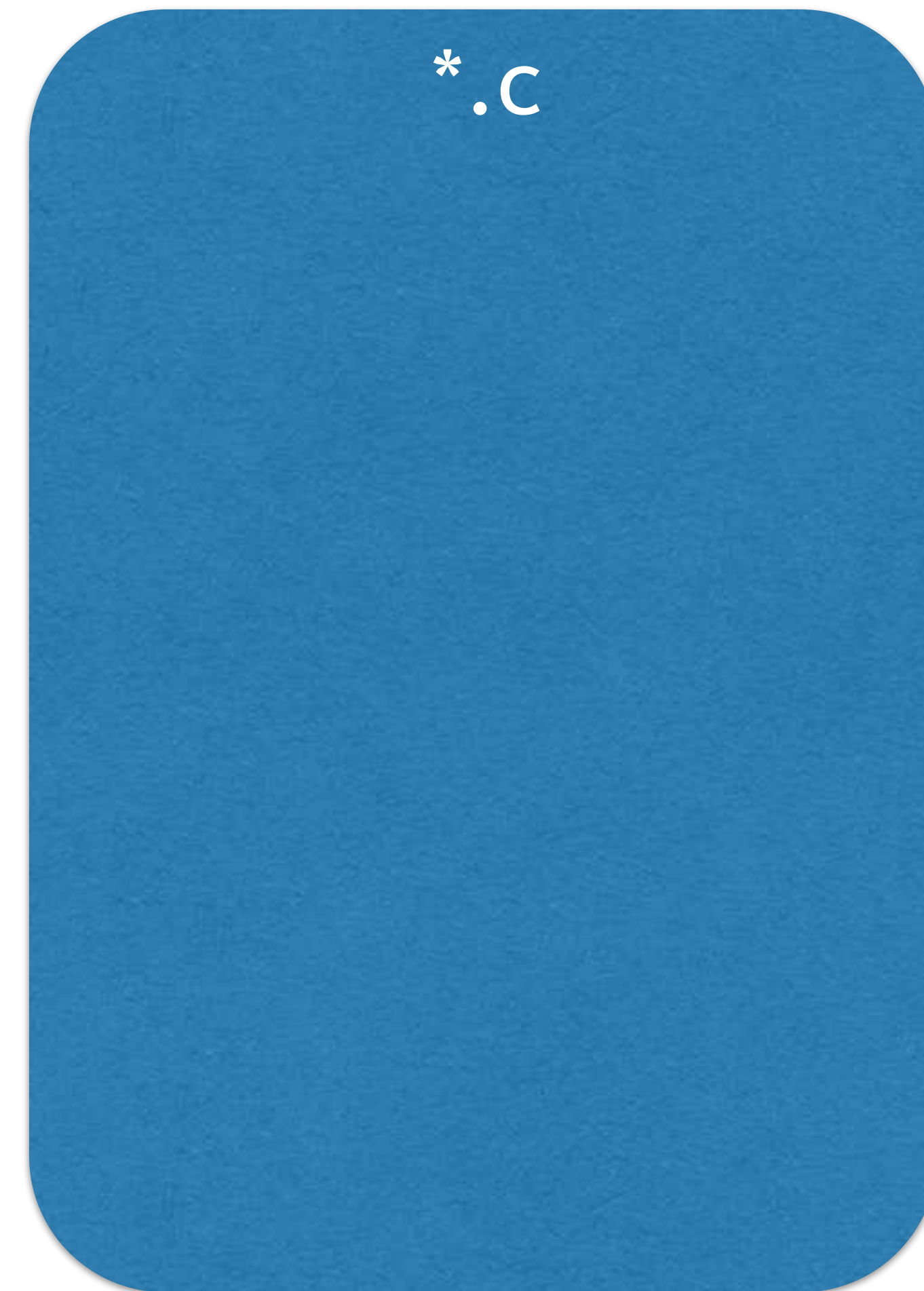


C Model

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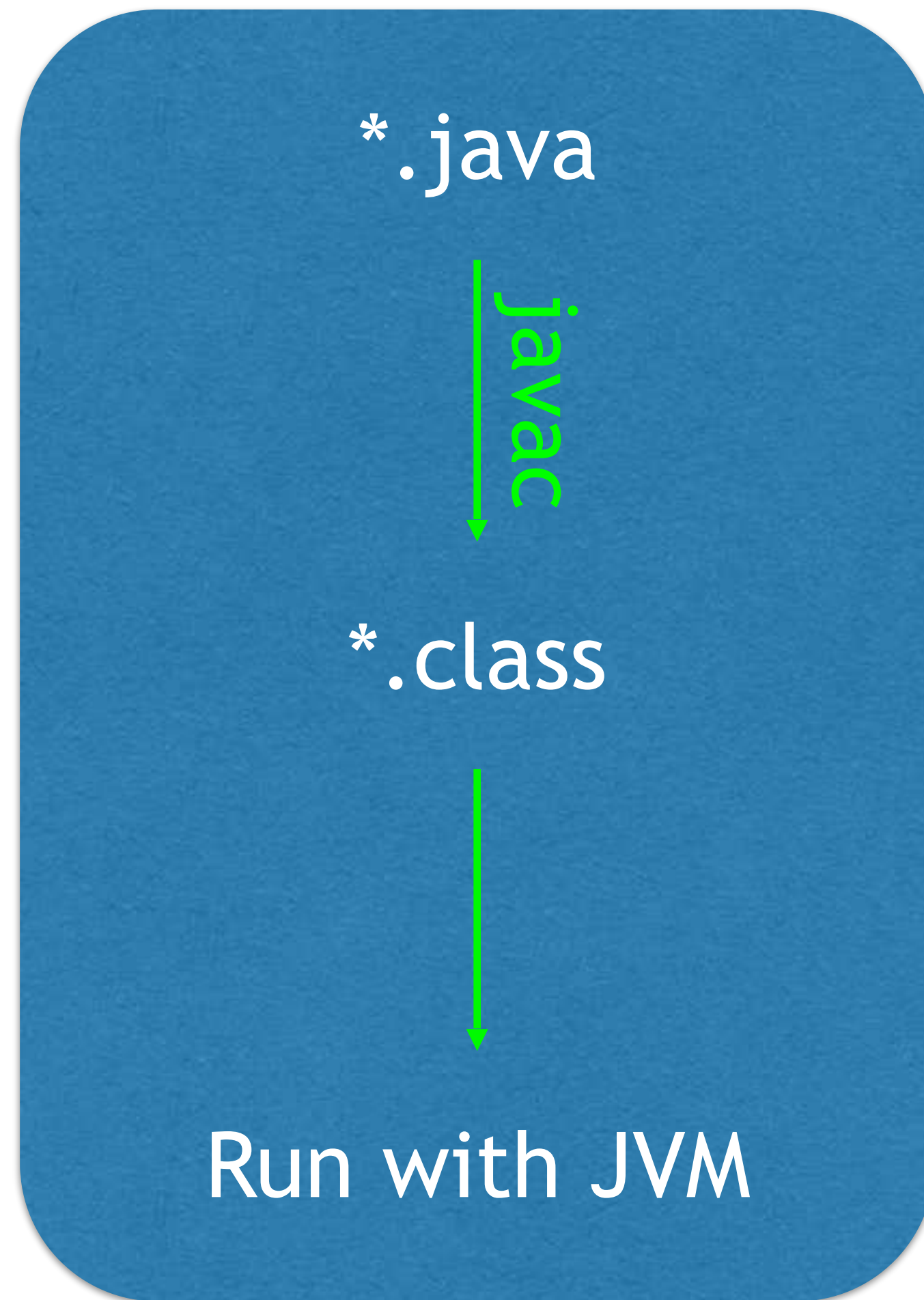


Java Model

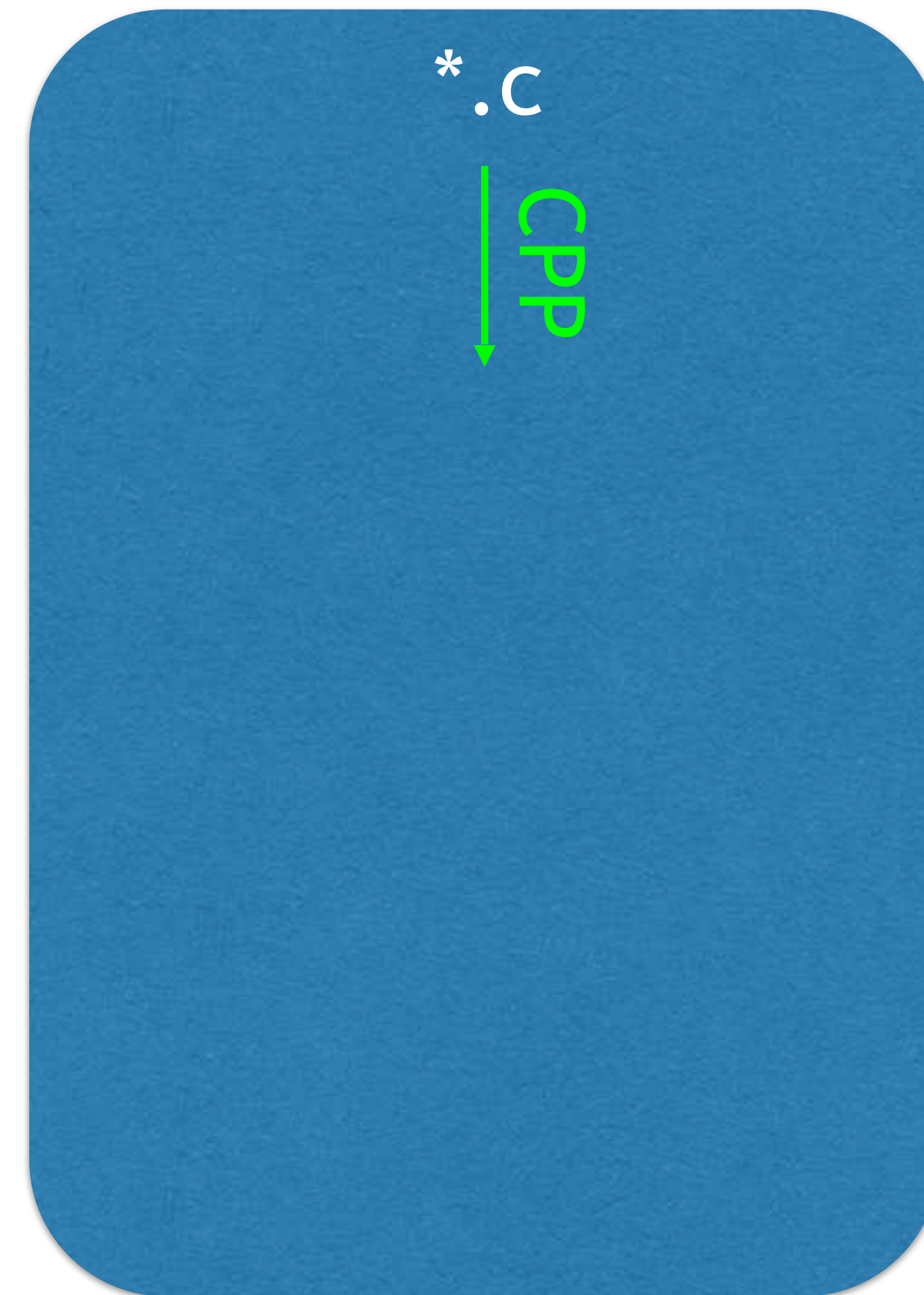


C Model

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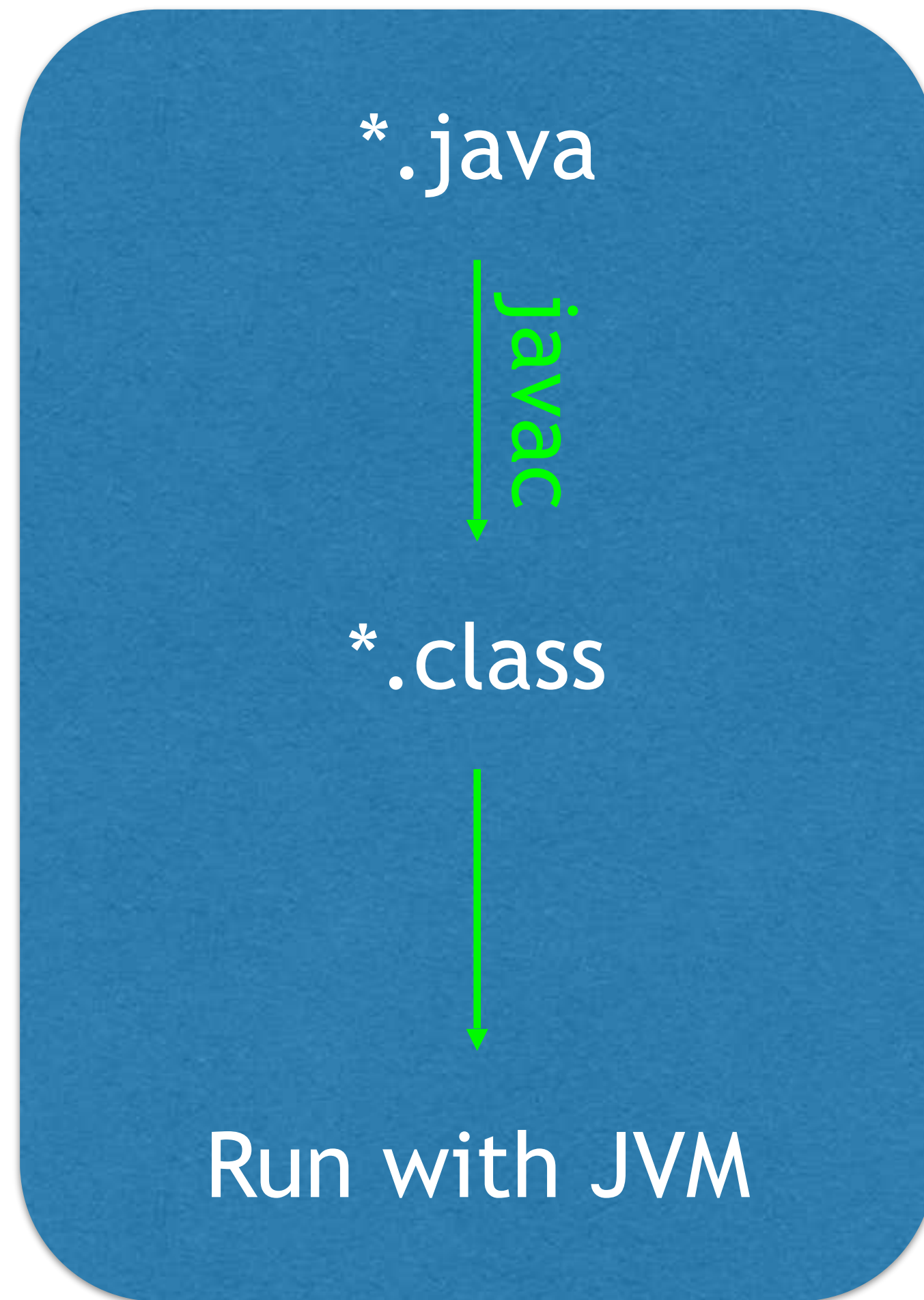


Java Model

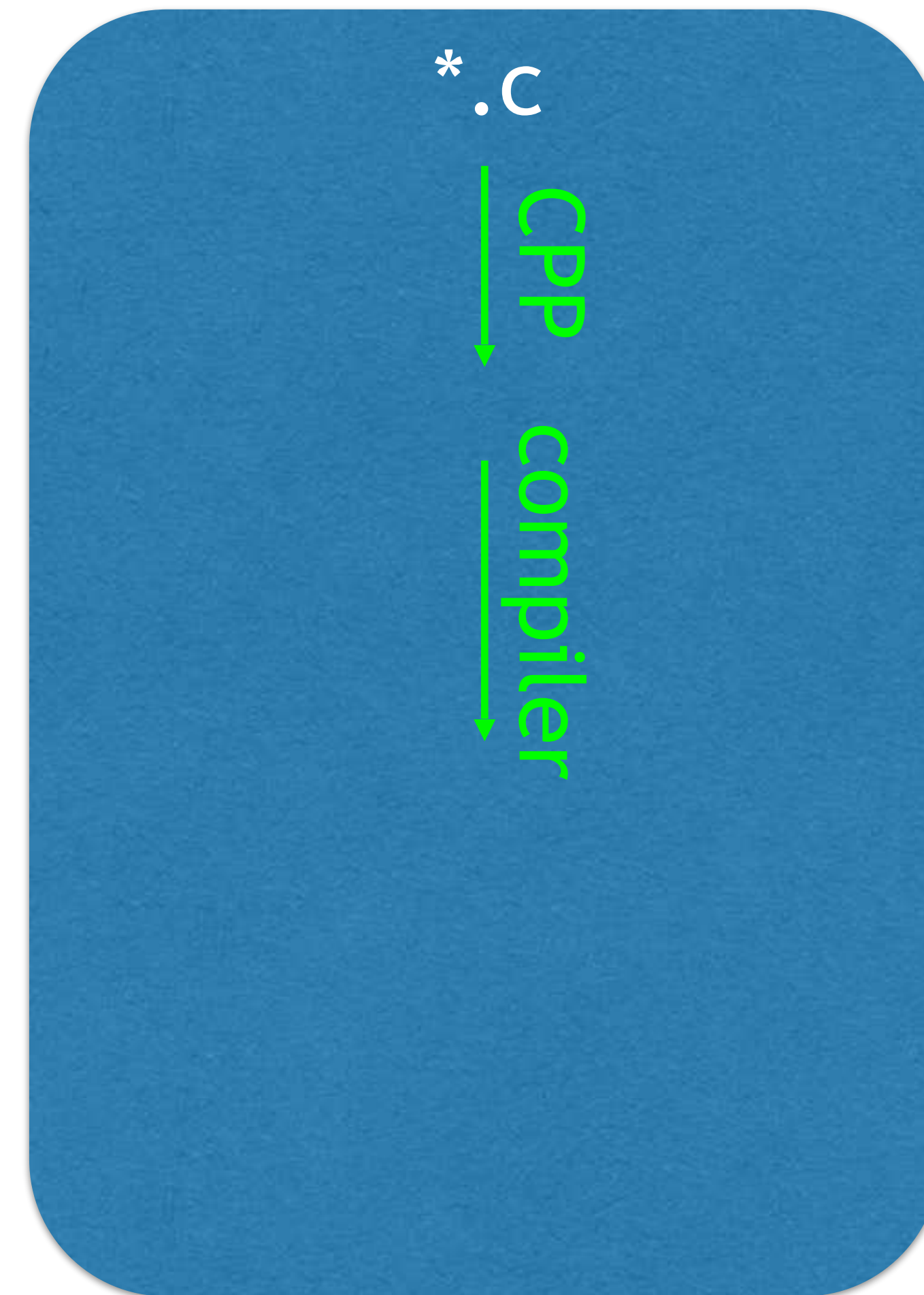


C Model

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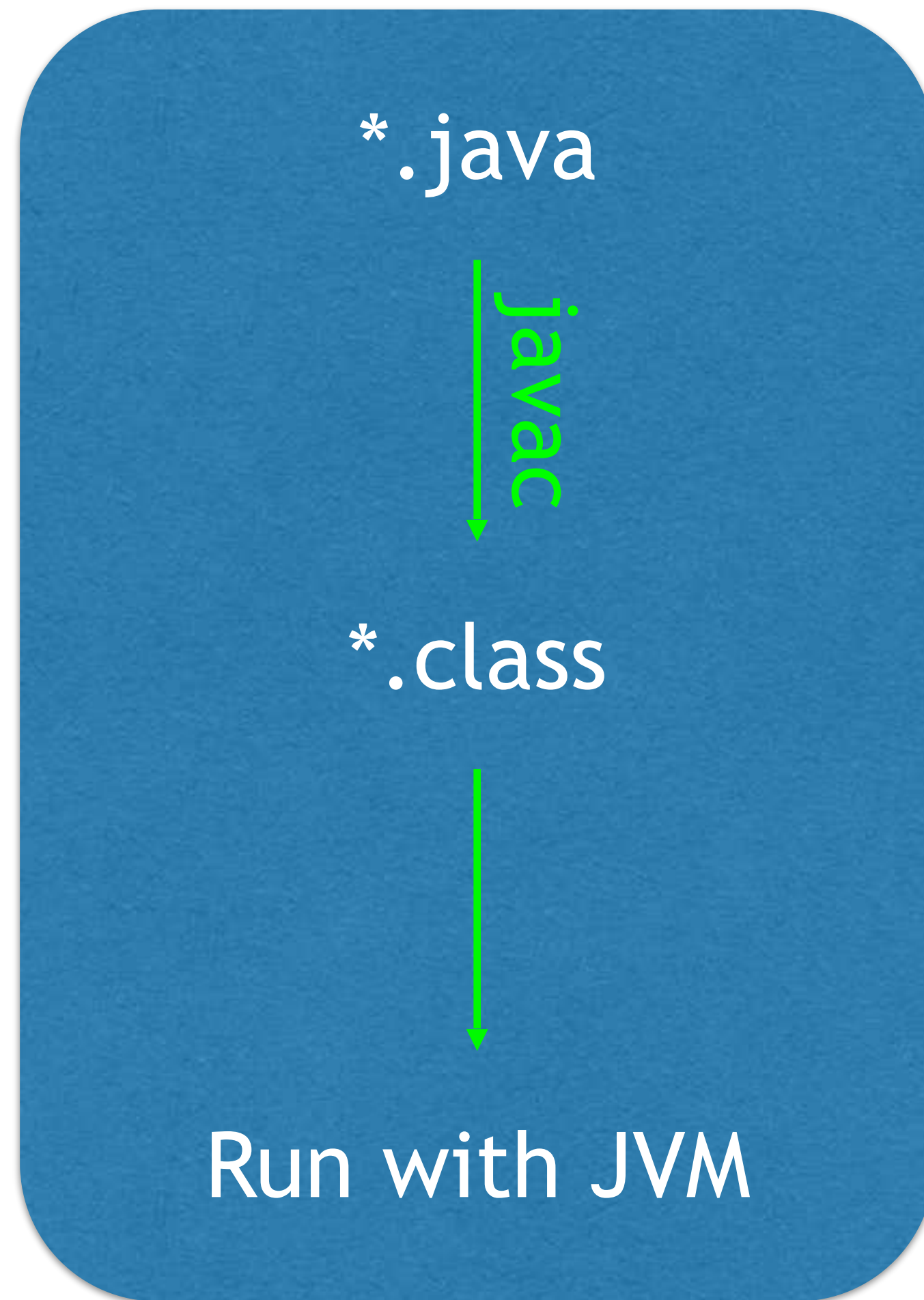


Java Model

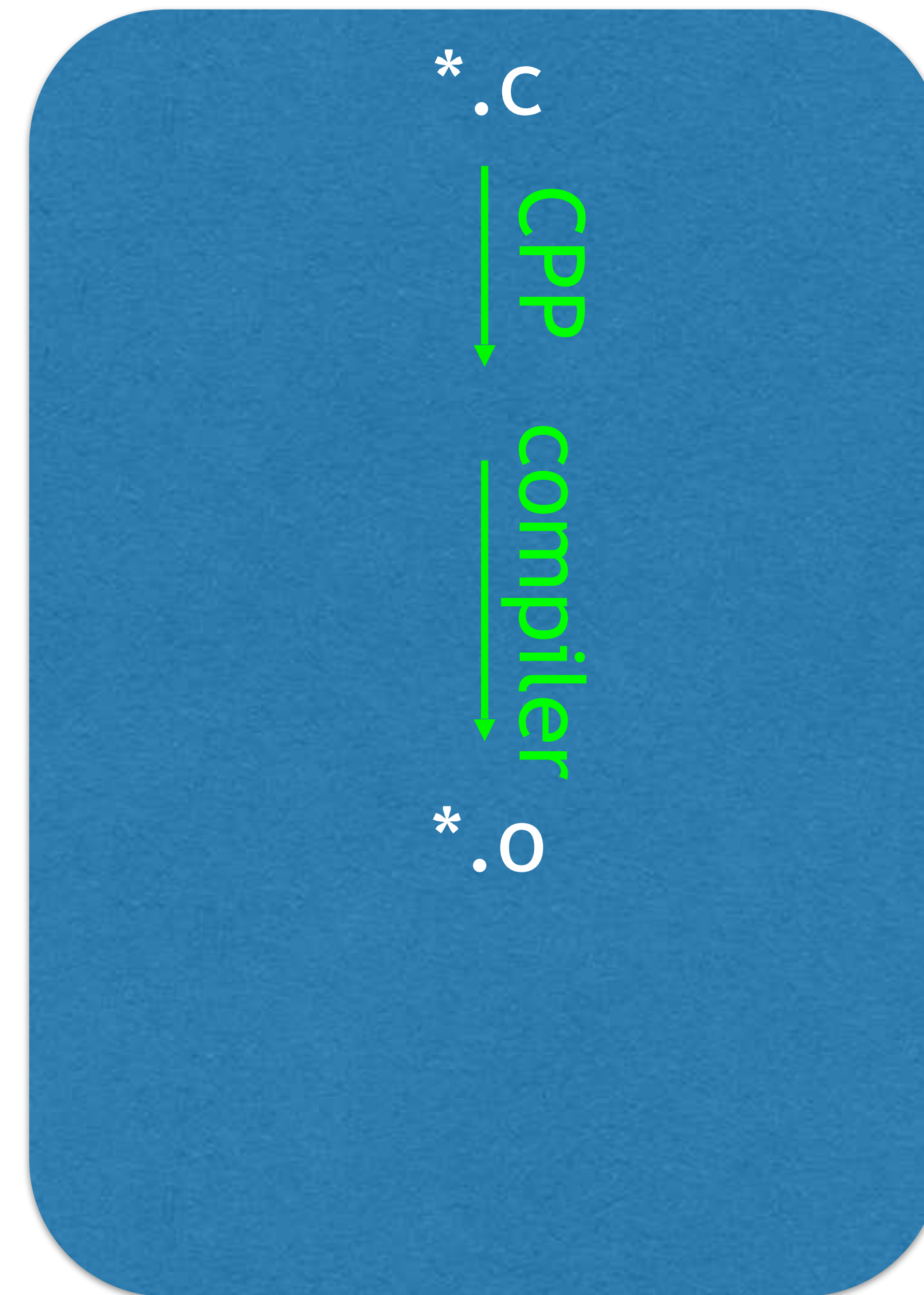


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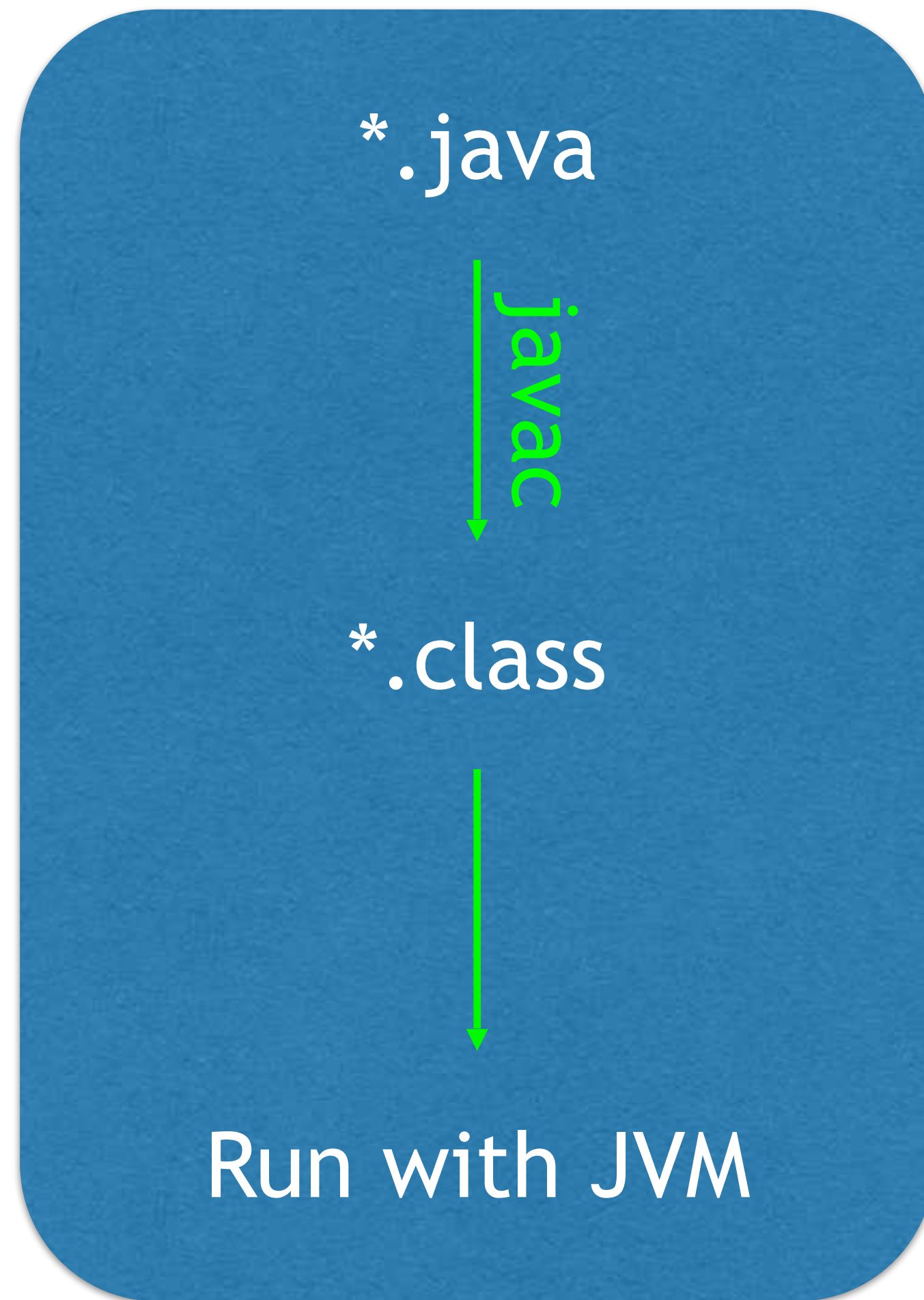


Java Model

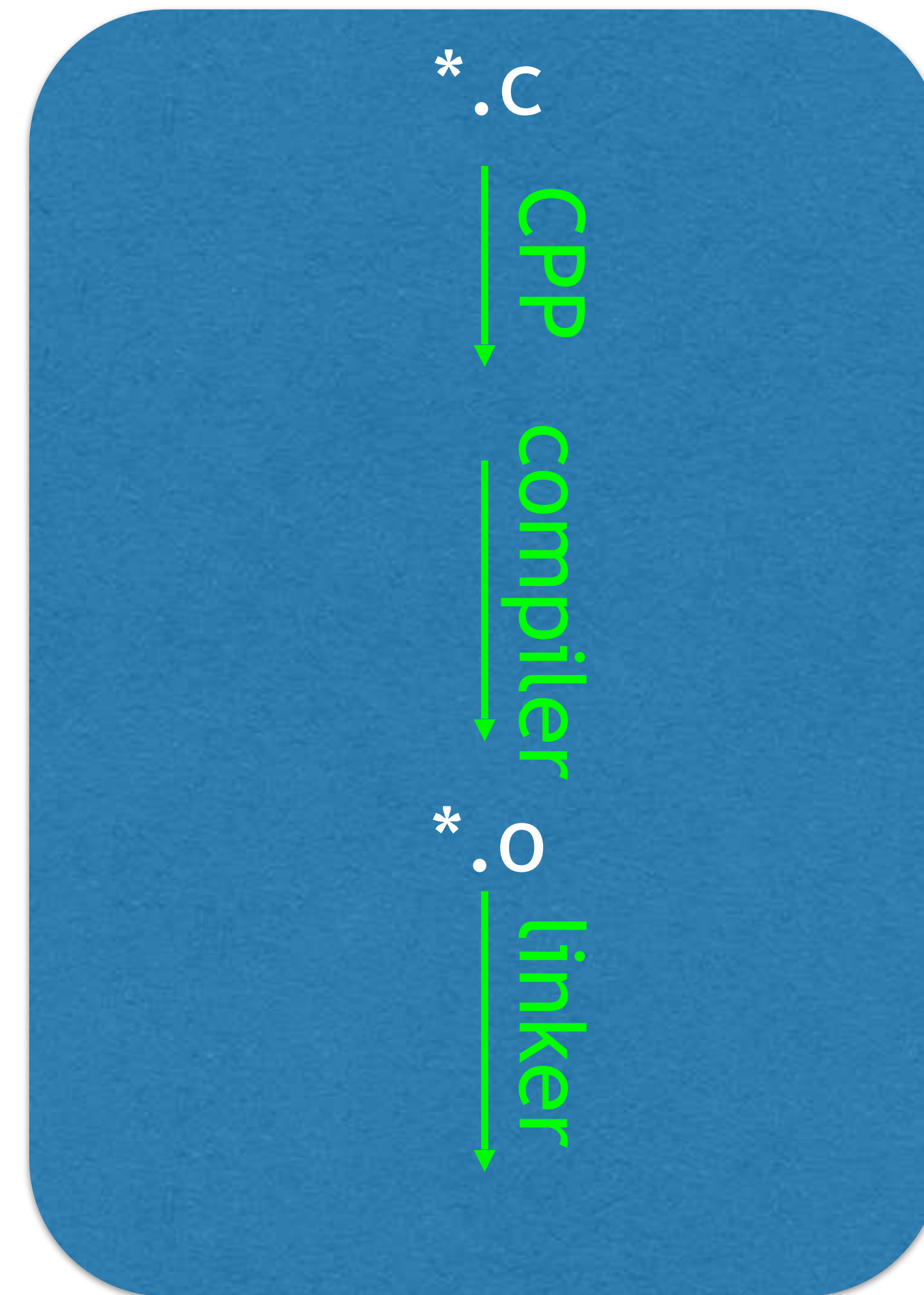


C Model

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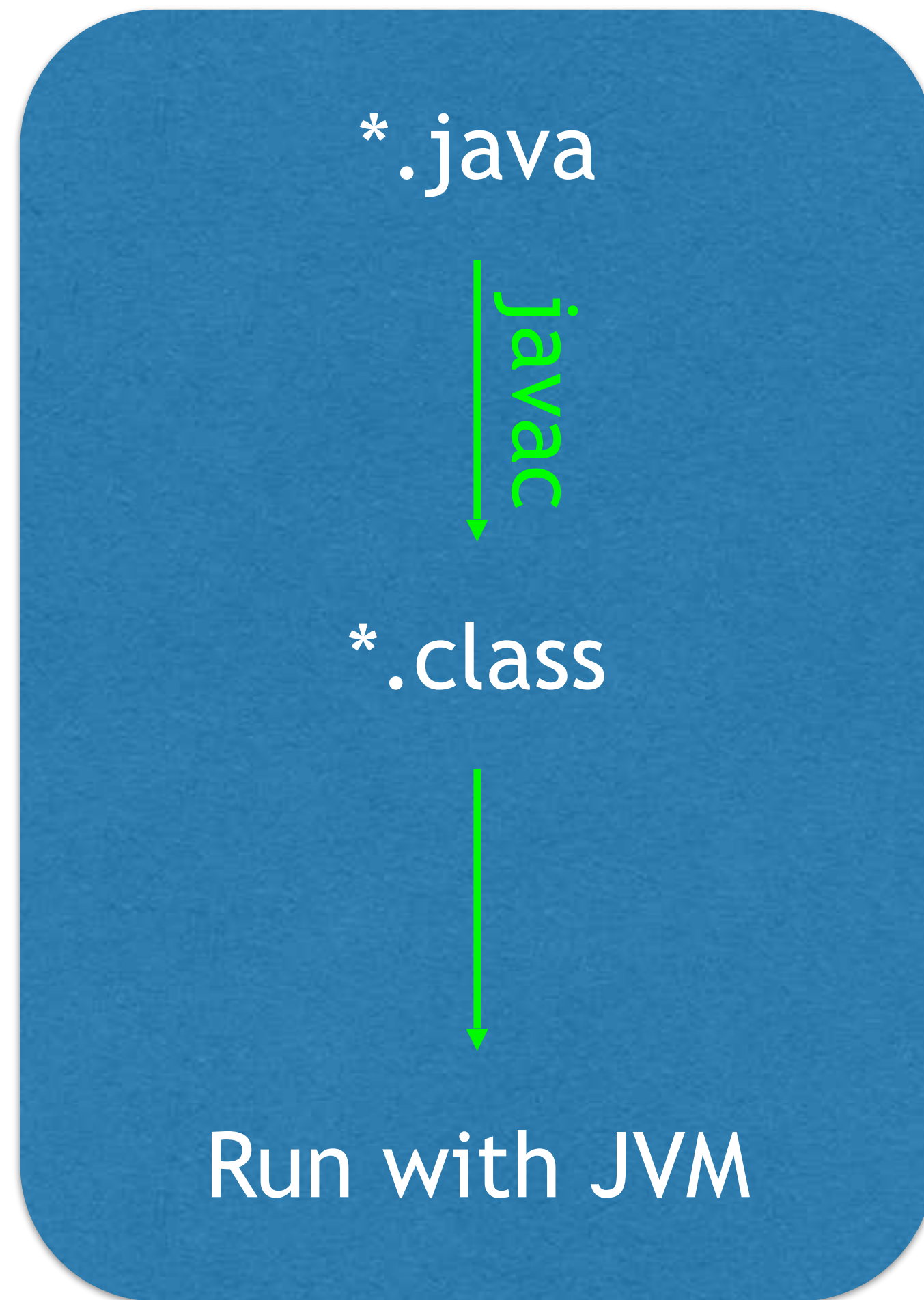
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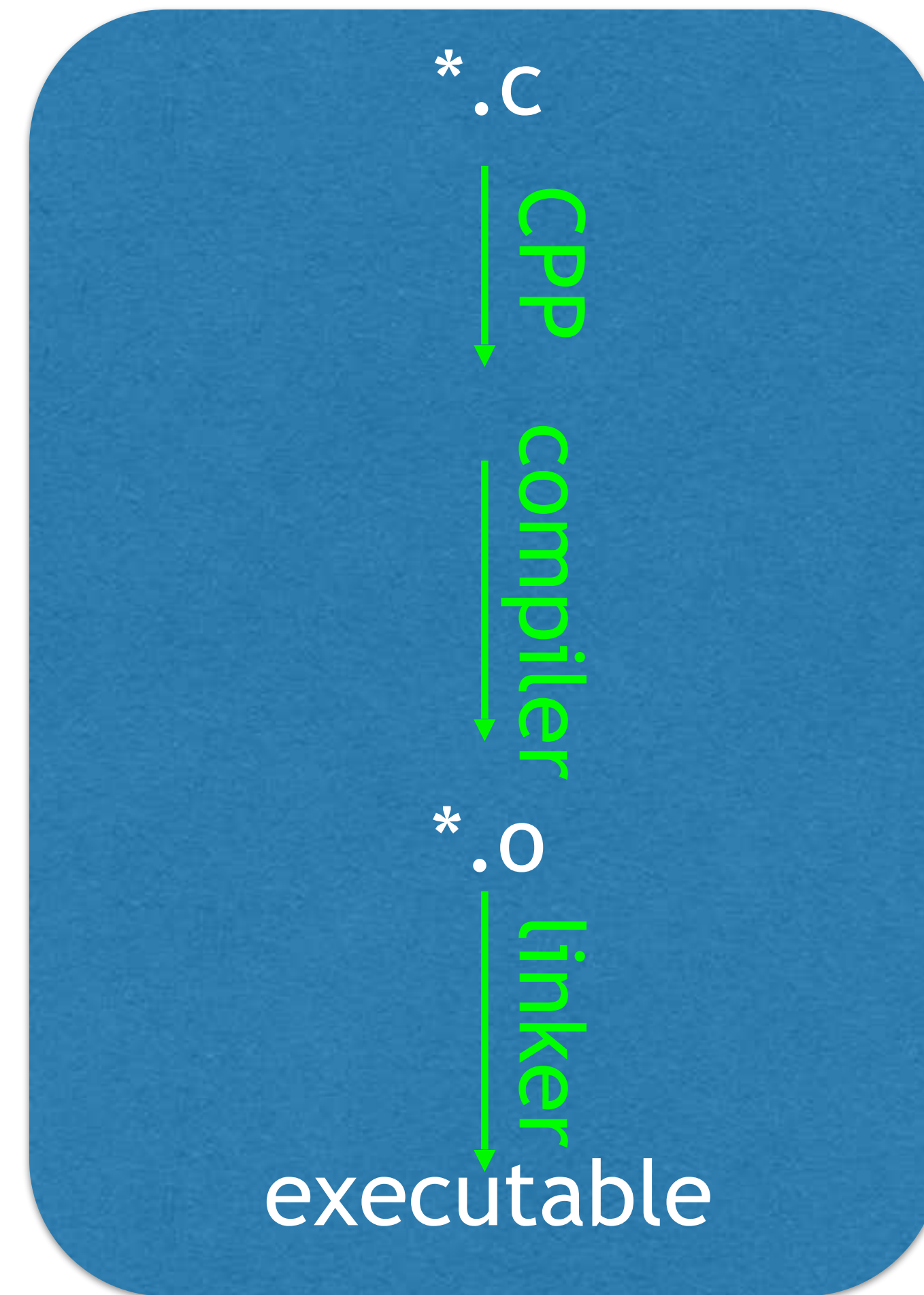
C Model



# Compilation



Java Model



C Model

# Types of files

## Source files (.c extension)

- ▶ Include header files; lets the source file use functions declared in header
- ▶ Define functions and global variables
- ▶ Compiled to object files

## Header files (.h extension)

- ▶ Declare (but typically not define) functions and global variables
- ▶ Standard library's functions are declared in system header files
- ▶ Functions used by multiple source files are declared in some header file

## Object files (.o extension)

- ▶ Linked together into the executable by the linker

# C Preprocessor Directives

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`#include` — literal inclusion of a file

- ▶ `#include <foo.h>`
- ▶ `#include "foo.h"`
- ▶ No (meaningful) differences between `<foo.h>` and `"foo.h"`

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`#define foo bar` — *literal replacement* of “foo” with “bar”

- ▶ Useful for symbolic constants (and other things)
- ▶ Use UPPERCASE for constants
  - Usually these are at the top of the file
  - `#define NUM_WIDGETS 20`

In C, a function must be *declared* (or defined) before the point in the source file it is called. (I.e., before calling a `int fun(double x)` function, `fun` must be declared or defined.)

How can `fun` be called from two source files, `foo.c` and `bar.c`?

- A. Declare `fun` at the top of both `foo.c` and `bar.c`
- B. Define `fun` at the top of both `foo.c` and `bar.c`
- C. Declare `fun` in a header file and `#include` that file in `foo.c` and `bar.c`
- D. Define `fun` in a header file and `#include` that file in `foo.c` and `bar.c`
- E. None of the above

Consider the two files header\_file.h and source\_file.c shown to the right.

What is the value of x after the first line of main?

- A. 10
- B. 12
- C. 20

```
// In header_file.h
#define BAR 10
#define FOO BAR+1

// In source_file.c
#include "header_file.h"
int main(void) {
    int x = FOO * 2;
    /* ... */
}
```

- D. 22
- E. It's an error

# Command line parameters

```
1 // stdio.h contains printf's declaration.
2 #include <stdio.h>
3
4 // argc is like Bash's $# (but off-by-one)
5 // argv[0] is like $0
6 // argv[1], ..., argv[argc-1] is like $1, $2 ...
7 int main(int argc, char **argv) {
8     for (int idx = 0; idx < argc; ++idx) {
9         // %d means print an integer,
10        // %s means print a string
11        printf("%d: %s\n", idx, argv[idx]);
12    }
13    return 0;
14 }
```



# Command line parameters

```
$ ./arguments 'First argument' second third etc.  
0: ./arguments  
1: First argument  
2: second  
3: third  
4: etc.
```

# Basic types

class	systematic name	other name
integers	<b>_Bool</b>	<b>bool</b>
	<b>unsigned char</b>	
	<b>unsigned short</b>	
	<b>unsigned int</b>	<b>unsigned</b>
	<b>unsigned long</b>	
	<b>unsigned long long</b>	
	<b>[un]signed char</b>	
	<b>signed char</b>	
	<b>signed short</b>	<b>short</b>
	<b>signed int</b>	<b>signed or int</b>
	<b>signed long</b>	<b>long</b>
	<b>signed long long</b>	<b>long long</b>
floating point	<b>float</b>	
	<b>double</b>	
	<b>long double</b>	
	<b>float _Complex</b>	<b>float complex</b>
	<b>double _Complex</b>	<b>double complex</b>
	<b>long double _Complex</b>	<b>long double complex</b>

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`sizeof(bool)` is implementation defined

**A byte isn't always 8 bits!** (But it is on most systems.)



# In-class exercise

<https://checkoway.net/teaching/cs241/2020-spring/exercises/Lecture-08.html>

Grab a laptop and a partner and try to get as much of that done as you can!