Symbols, Compilation Units, and Pre-Processing

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March 10, 2016

Outline

- Compilation process
- Symbols: compilation units and linking
- The C pre-processor

Compilation Process

- How do you compile a program?

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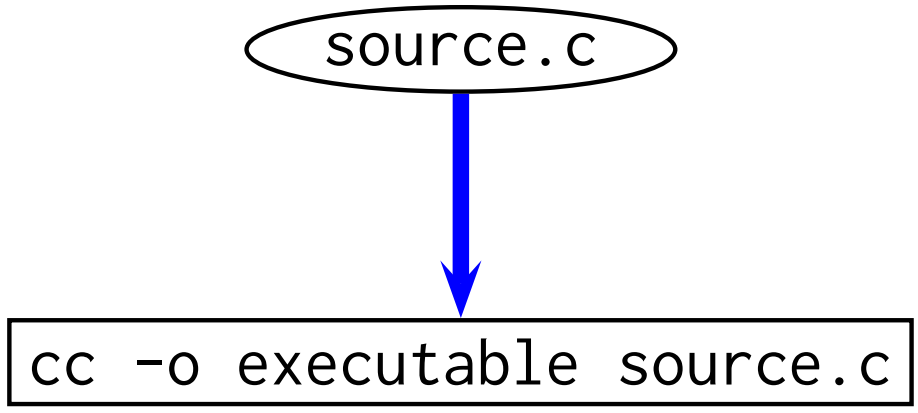

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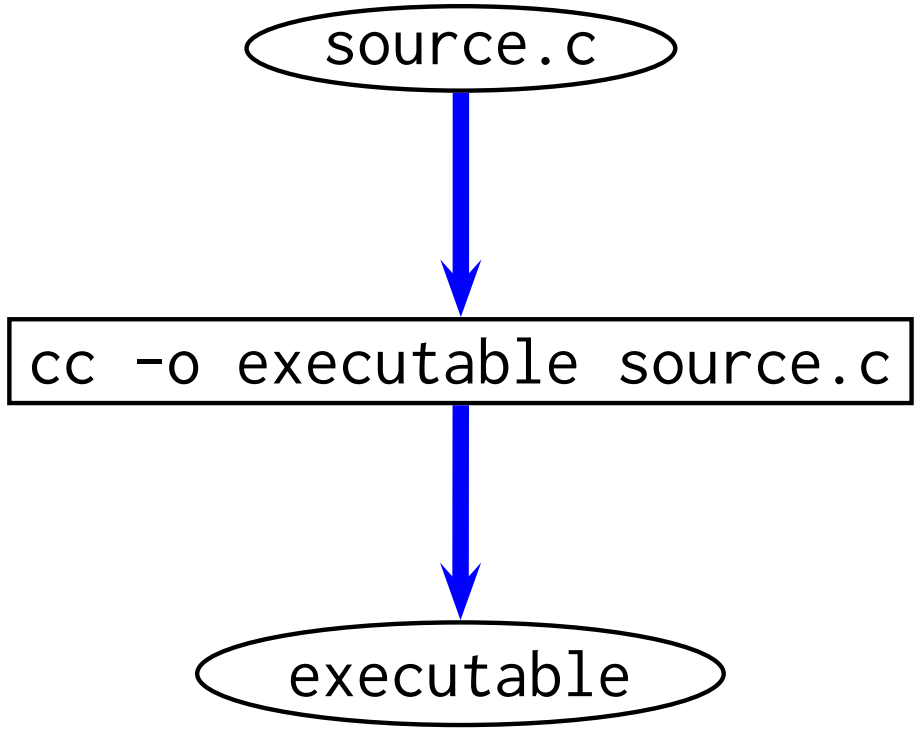

- Simple?

A More Detailed View

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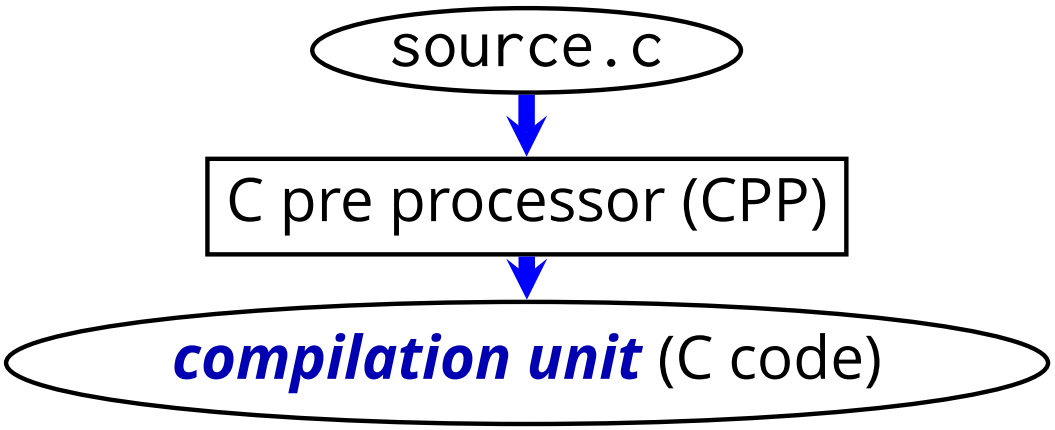

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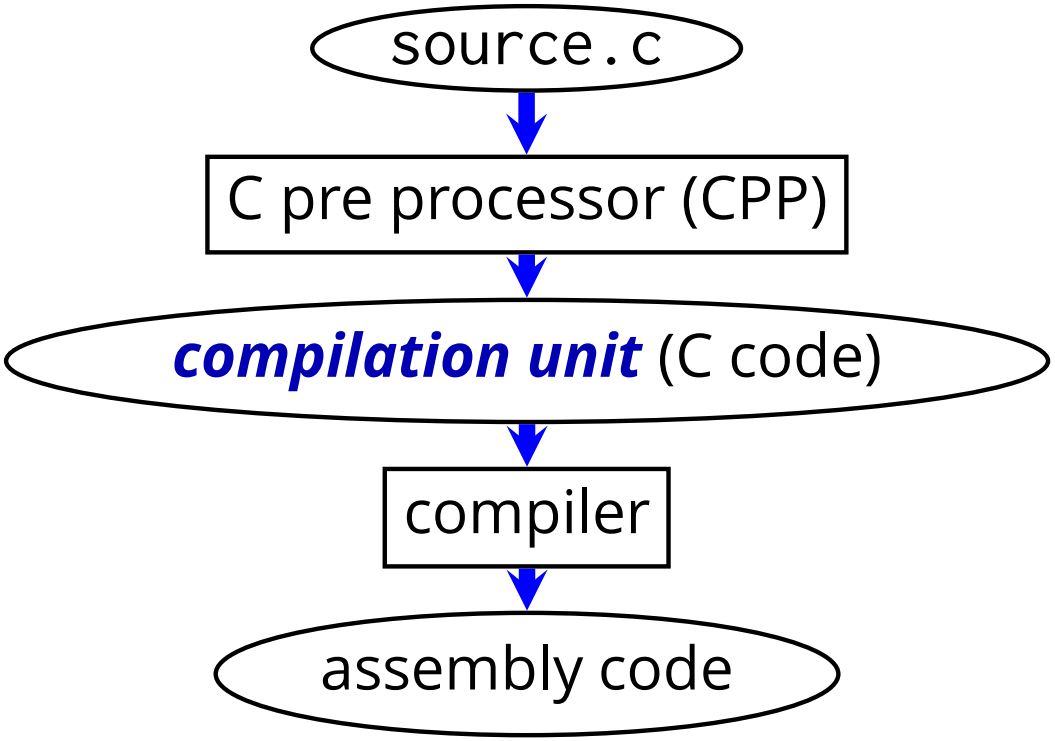

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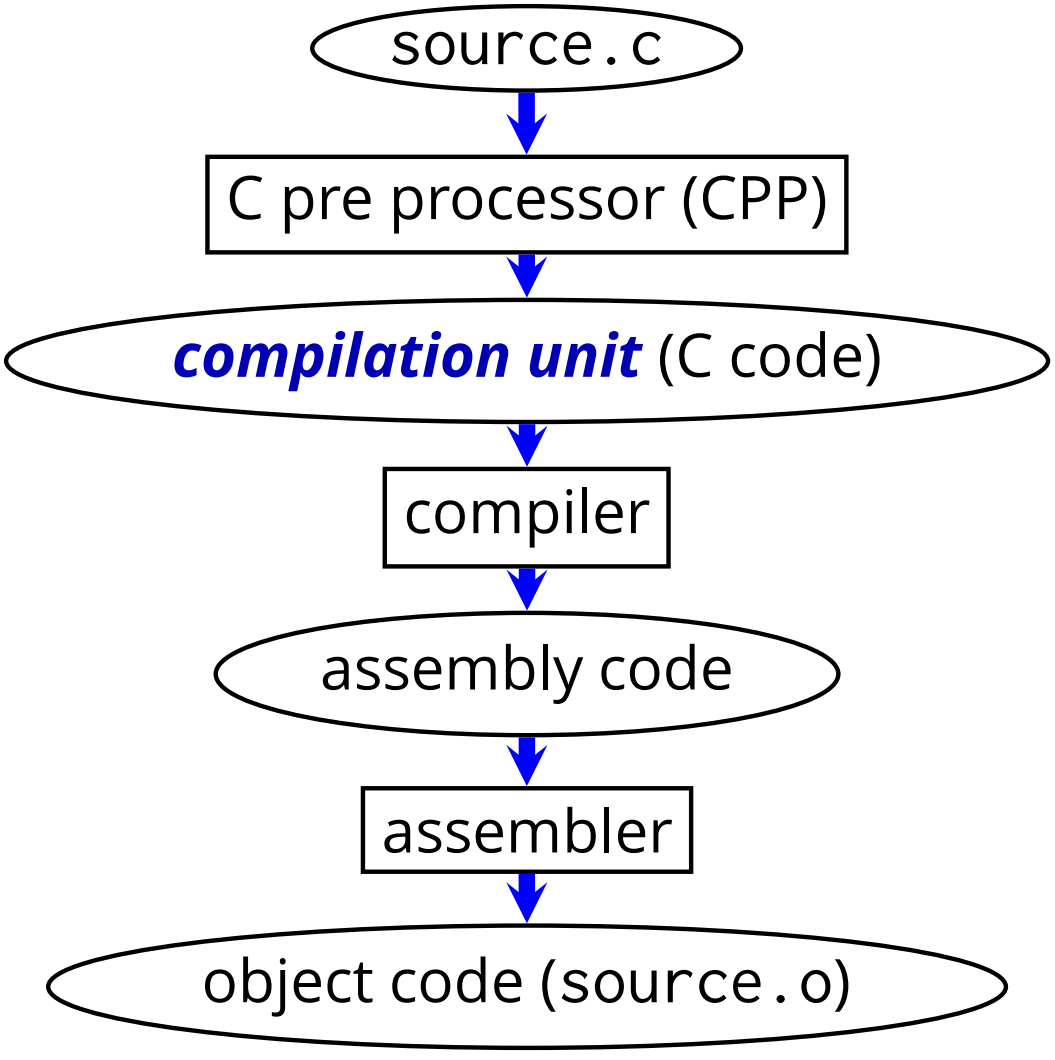

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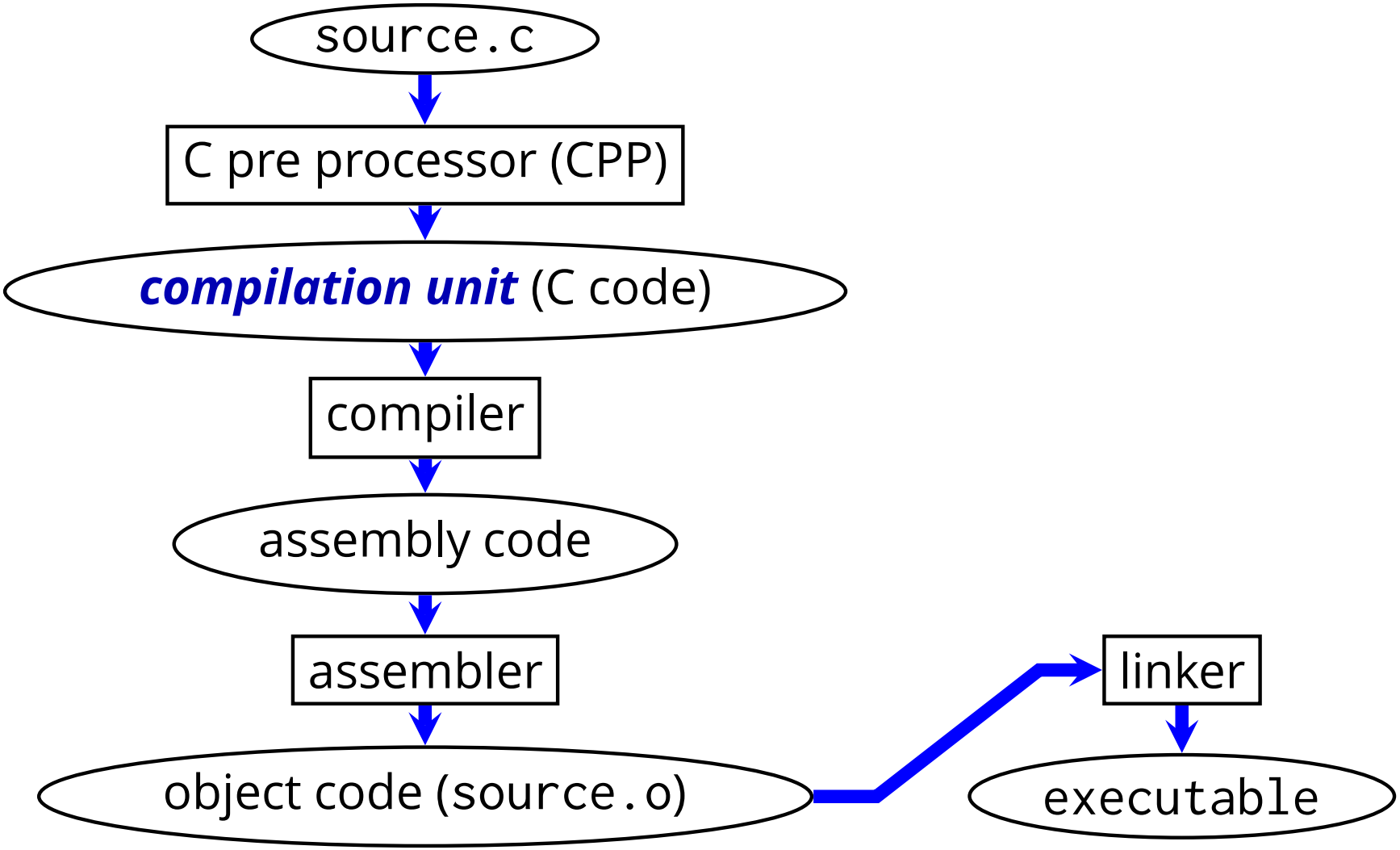

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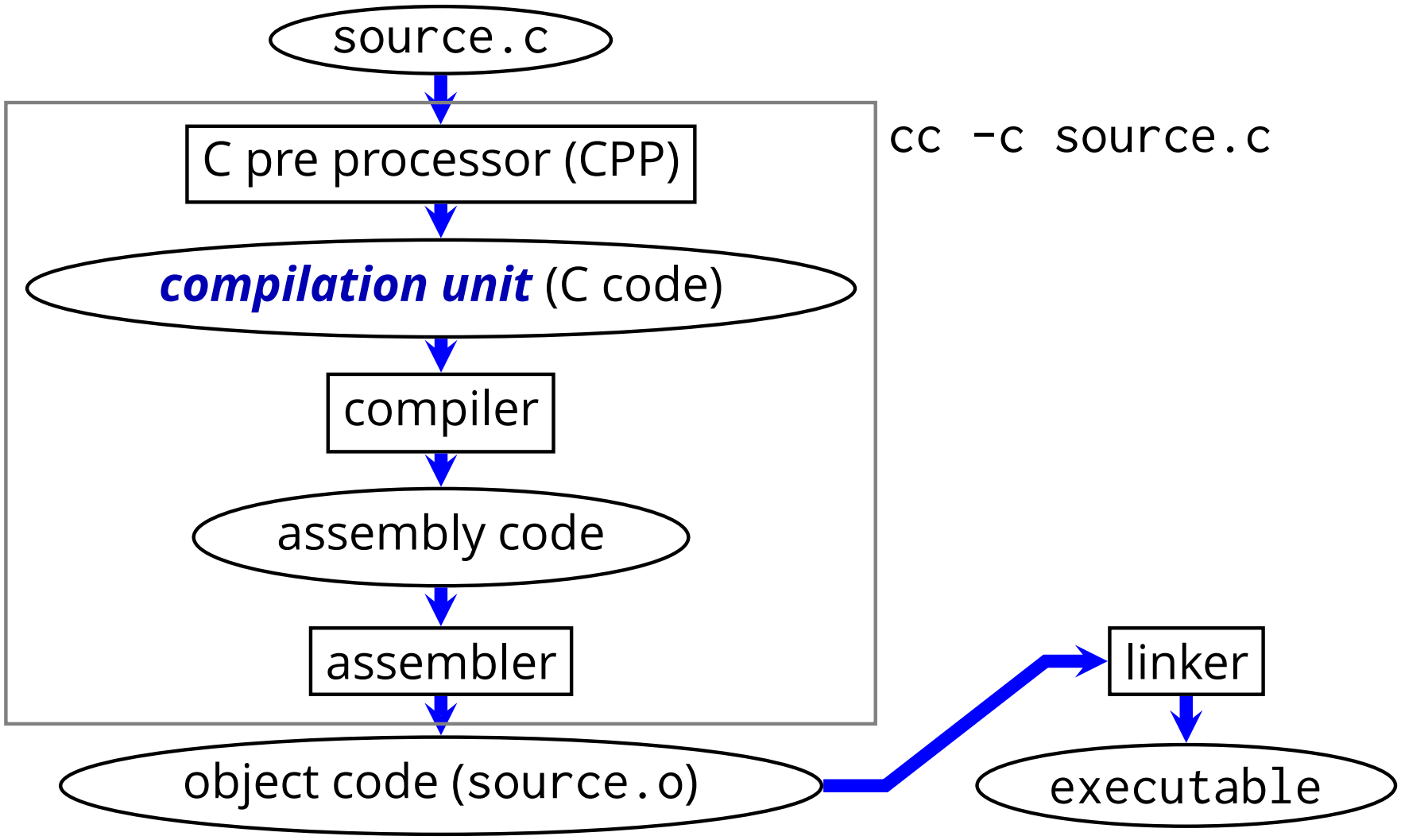

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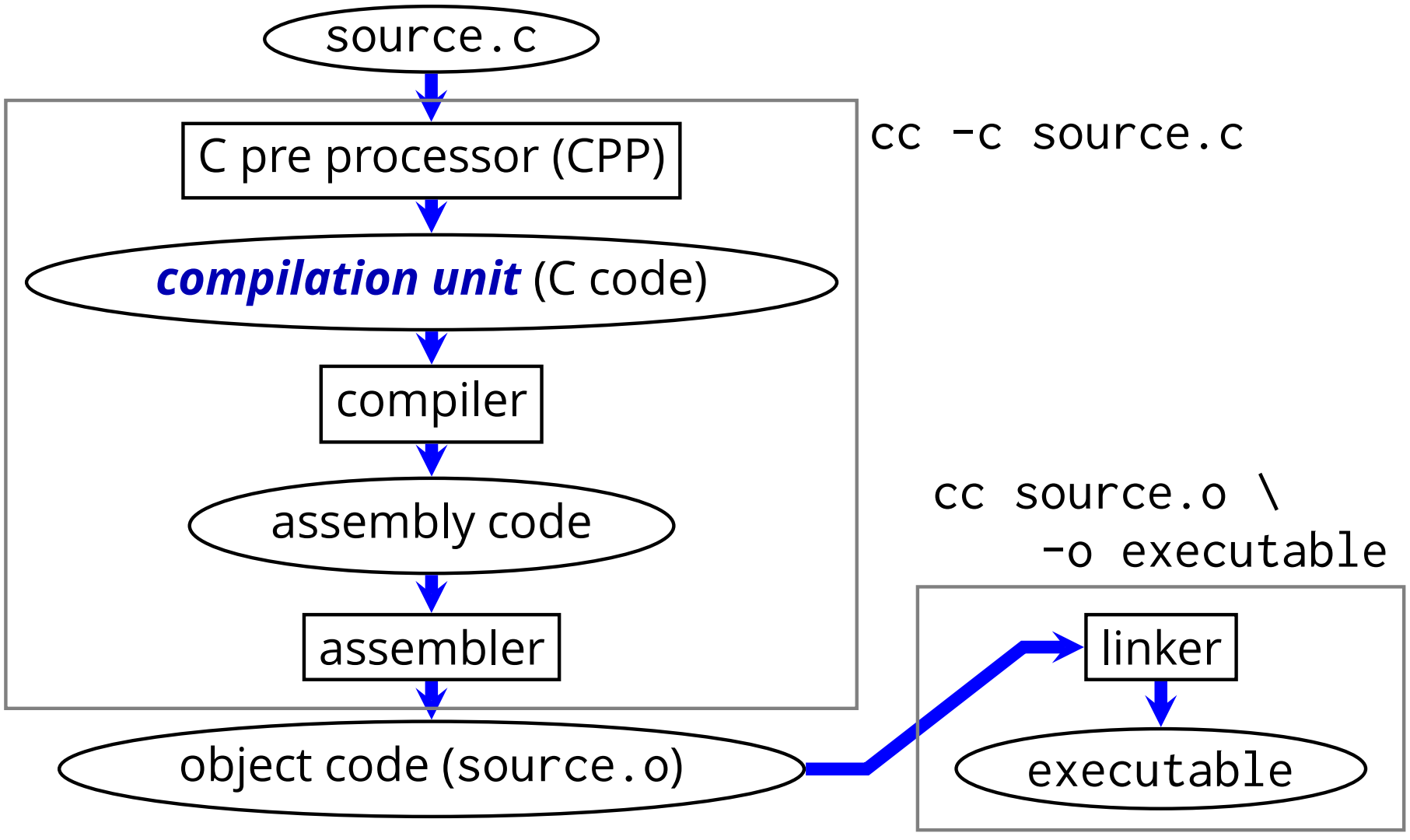

Example

(printarray.c)

```
#include <stdio.h>

#define ARRAY_SIZE 100

int A[ARRAY_SIZE];

void print_array(int * begin, int * end) {
    while(begin != end)
        printf("%d\n", *begin++);
}

int main() {
    int i;
    for(i = 0; i < ARRAY_SIZE; ++i)
        A[i] = 0;

    print_array(A, A + ARRAY_SIZE);
}
```

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  - *defines* `main()`
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  2. `cc -c printarray2.c`
  3. `cc printarray2.o program.o -o example`

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  - some will be ***undefined***

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- Actually, not all symbols will be visible outside their object file
  - symbols defined with `static` linkage
  - `static` linkage is used for “private” variables and functions

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Sharing Declarations

- What if a function `f` is used in several source files?
  - remember that `f` must be declared in all compilation units
- It is convenient to have the declaration in one file and then to *include* that file in every compilation unit
- This is done by the *C pre processor*
  - e.g.,

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

    includes the "header file" `stdio.h`, which declares

    ```
    extern int printf (const char * format, ...);
    ```

    (and many other functions, types, and variables)

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#include "person.h"

void input(FILE * inputfile, struct person * p) {
 /* ... */
}
```

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- Expands macros

```
#define MAX_LINE_LENGTH 1024

int main() {
    char buffer[MAX_LINE_LENGTH];

    while (fgets(buffer, MAX_LINE_LENGTH, stdin)) {
        /* ... */
    }
}
```

The C Pre Processor

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```
#define IS_NULL(x) (x == 0)
#define NEXT(x) (x + 1)
#define MAX(x,y) (( x > y ) ? x : y)

int i = MAX(10, getchar());
int * p1 = /* ... */;
int * p2 = NEXT(p);
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Good practice: avoid macros for *programming!*

Use them only for configuration purposes

- i.e., conditional compilation (coming up next)

The C Pre Processor

- Conditionally includes lines into a compilation unit

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```
#include "search.h"

int main(int argc, const char * argv[]) {
#ifdef USING_TST_ALGORITHM
    int result = tst_search(argv[1]);
#else
    int result = bsearch(argv[1]);
#endif
    if (result > 0)
        printf("%s is here.\n", argv[1]);
    else
        printf("who is %s?\n", argv[1]);
    return 0;
}
```

- Pre-processor symbols can be defined within the source

```
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- Pre-processor symbols can be defined within the source

```
#define WITH_TST_ALGORITHM
```

or they can be passed as command-line parameters to the compiler

```
cc -DWITH_TST_ALGORITHM -c test.c
```

- A more complex example

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```
#include "config.h"
#if (SET_SIZE > 20000) || (ALPHABET_SIZE > 256)
#ifdef WITH_TST_ALGORITHM
#undef WITH_TST_ALGORITHM
#endif
#include "big.h"
#else
#include "small.h"
#if HAVE_UNISTD_H
#include <sys/types.h>
#include <unistd.h>
#else
#error you need unistd.h to compile this program
#endif /* HAVE_UNISTD_H */
#endif /* SET_SIZE etc. */
```

Exercise

- Implement a program that reads lines from the standard input and outputs the lines in reverse order
- The program uses either a linked list or an array to store lines
  - you must implement both methods
- The pre-processor variable `WITH_ARRAY` can be passed to the compiler to select the array version
- The numeric pre-processor variable `MAX_LINE_SIZE` defines the maximum accepted line size
- The numeric pre-processor variable `MAX_INPUT_SIZE` defines the maximum number of lines accepted by the array implementation

Exercise (2)

- If you have not done so already, separate the previous implementation into three “modules”
  - the *list* module defines the list-based container
  - the *array* module defines the array-based container
  - the *main* module defines the `main` function, reads the input file, and uses one of the two container data structures to store and then print the lines