Computer Programming: Skills & Concepts (CP1)
Functions II (Parameters, & and *)

13th October, 2015

Last lecture, this lecture

Yesterday (Monday 12th Oct)

- Functions.
- Examples of simple functions.
- Program structure and the program environment.

Today (Tuesday 13th Oct)

- Rules for *declaring* functions.
- "Scope" of a variable.
- Parameter-passing in C
- "Pointers", `&`, `*`.

Declaring functions, revisited

Functions must be *declared* before use.

- But the body of the function does not have to be part of this initial declaration.

You might prefer to read (and write) programs 'top-down':
high-level structure first, coding details later.

- compiler only needs the function *header* to check it's correctly used;
- so declare the header first (before *anywhere* the function is called), then define the body of function later (e.g. after the `main` program).

The header is called a function *prototype* or a *type declaration*.

- All the header files like `stdlib.h` and `descartes.h` contain function prototypes, not code.
- The `#include` for these header files is deliberately *right at the top of the program file*.

Example: SumTo again

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

int SumTo(int n);

int main(void) {
  int  n;
  printf("The integer n, please: ");
  scanf("%d",&n);
  printf("sum = %d\n", SumTo(n));
  return EXIT_SUCCESS;
}

int SumTo(int n) {       /* computes 1 + 2+ ... + n */
  int i, sum =0;
  for (i = 1;  i <= n;  ++i) {
    sum = sum + i;
  }
  return sum;
}
```

Identifiers are optional in prototypes

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

int SumTo(int);     /* NO NAME NEEDED FOR THE PARAMETER HERE */

int main(void) {
  int  n;
  printf("The integer n, please: ");
  scanf("%d",&n);
  printf("sum = %d\n", SumTo(n));
  return EXIT_SUCCESS;
}

int SumTo(int n) {       /* NAME DEFINITELY NEEDED HERE */
  int i, sum =0;
  for (i = 1;  i <= n;  ++i) {
    sum = sum + i;
  }
  return sum;
}
```

Scope

"Scope" refers to the program sections where a (particular) variable is active/valid:

- global variables are defined above the `main` function (or indeed any functions) and are valid *everywhere*.
  - Unless the name of a global variable is re-used for a local one somewhere.
- Local variables are defined within a function and are only valid within that function.
- `main` is also a function: its variables are only valid there.
- The scope of local variables overshadows the scope of global variables with the same name

Scope Example

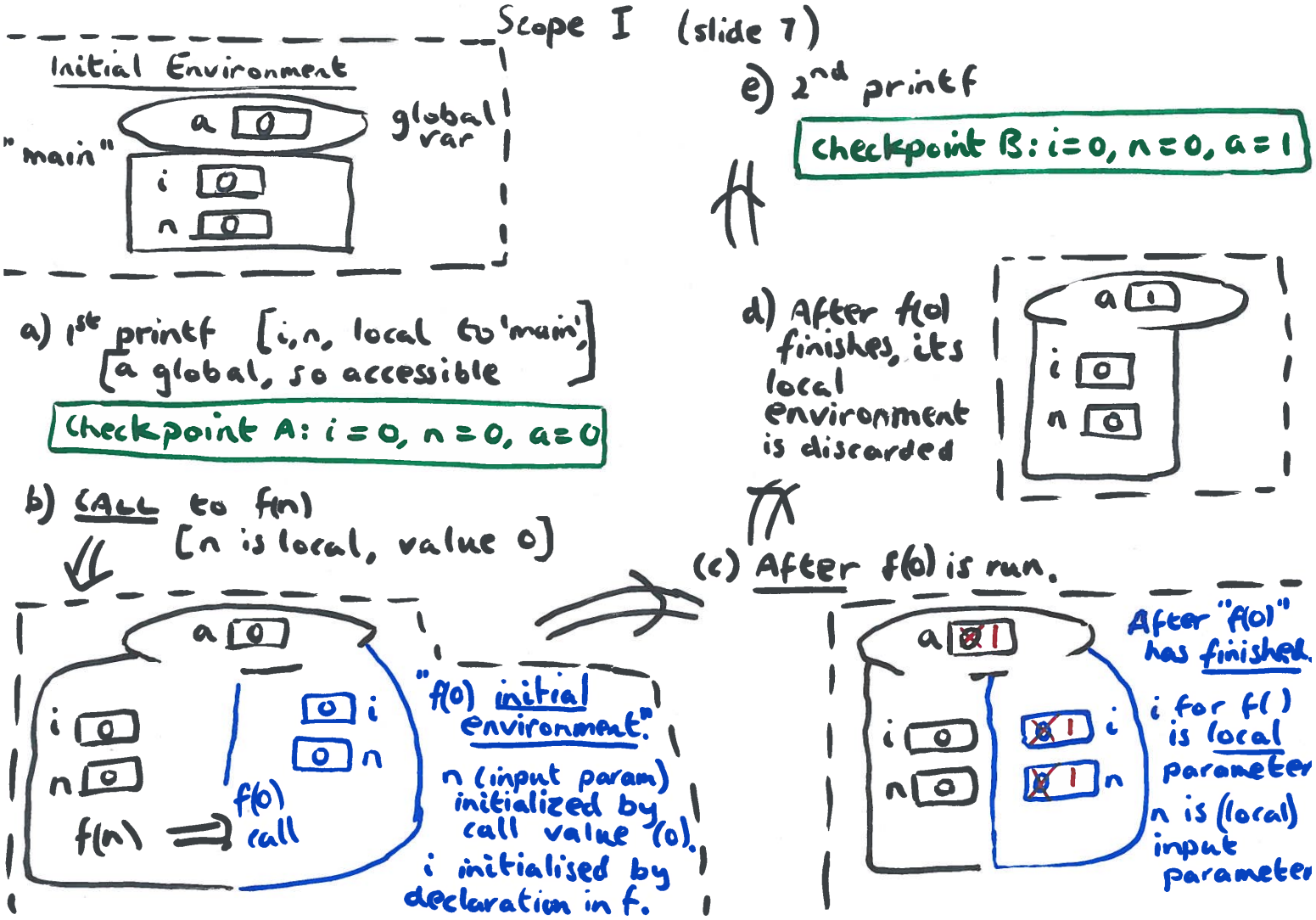
```
#include <stdio.h>
#include <stdlib.h>
int a = 0;

void f(int n) {
  int i=0;  i = i + 1;  n = n + 1;  a = a + 1;
}

int main(void) {
  int i = 0, n = 0;
  printf("Checkpoint A:  i = %d, n = %d and a = %d\n",  i, n, a);
  f(n);
  printf("Checkpoint B:  i = %d, n = %d and a = %d\n", i, n, a);
  return EXIT_SUCCESS;
}
```

SCOPE of variables in `printfs`?

Environment of first Scope Example



Scope Example 2. (Spot the difference!)

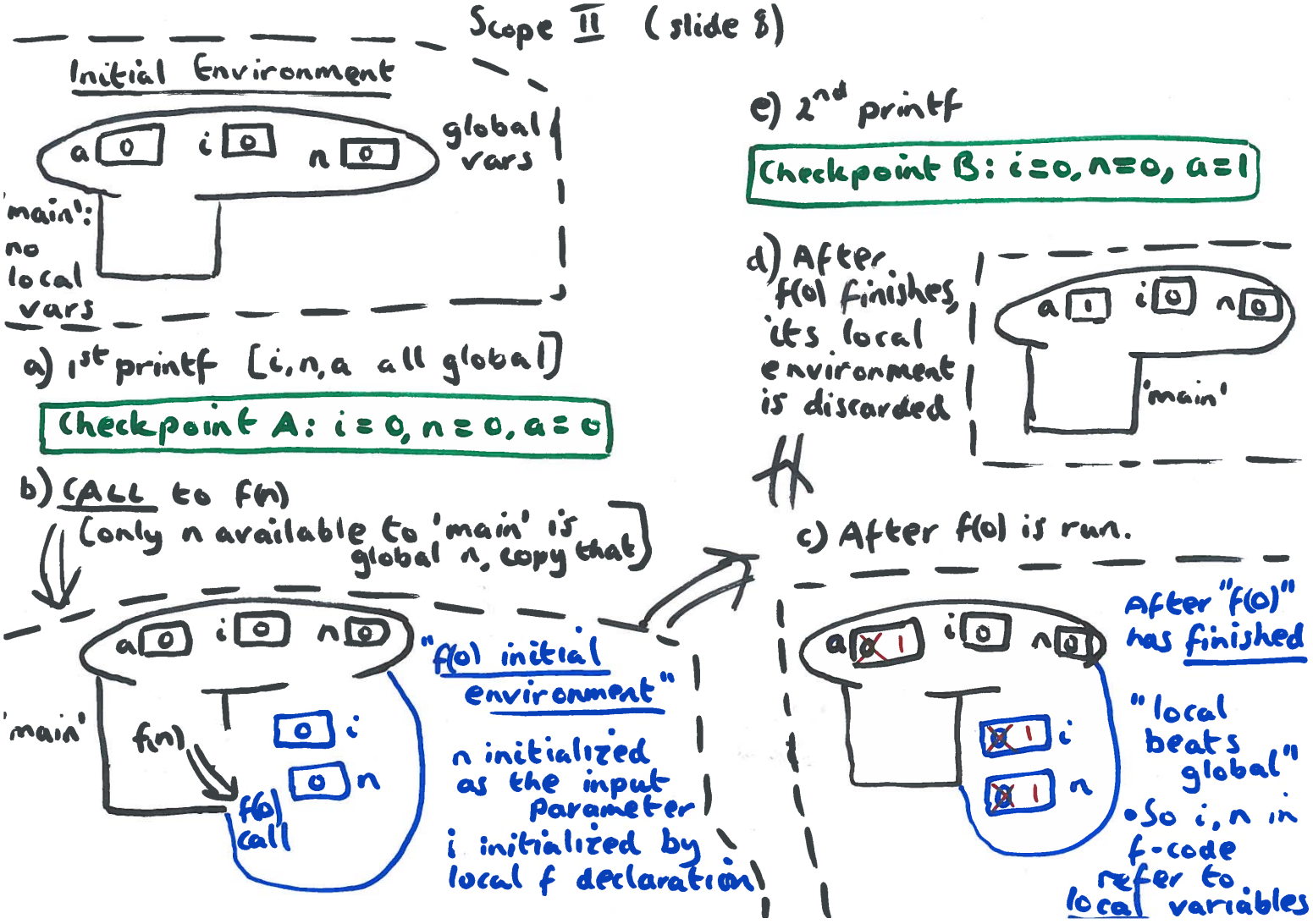
```
#include <stdio.h>
#include <stdlib.h>
int a = 0, i = 0, n = 0;

void f(int n) {
  int i=0;  i = i + 1;  n = n + 1;  a = a + 1;
}

int main(void)
{
  printf("Checkpoint A:  i = %d, n = %d and a = %d\n", i, n, a);
  f(n);
  printf("Checkpoint B:  i = %d, n = %d and a = %d\n", i, n, a);
  return EXIT_SUCCESS;
}
```

SCOPE of variables in `printfs`?

Environment of second Scope Example



A closer look at parameters

- We have a function declared (and coded) of type
  `int SumTo(int n)`
- We can make calls to this function, eg
  `SumTo(i+2)`
- What is the relation between the formal parameter `n` and the actual parameter `i+2` ?

In C, there is only one way to pass the actual parameter into the real one: *call by value - remember discussion in Lecture 7*.

This applies to several parameters just as well as to one – each parameter is treated separately.

Call by value

Again, consider `int SumTo(int n)` being called as `SumTo(i+2)`.

- The *actual parameter* is an *expression* of a certain type (`int` here).
- The formal parameter is a variable of the same type.

How a function call is *evaluated* wrt call-by-value:

- The *actual parameter* is evaluated to yield a value of the specified type. (Whatever the value of `i+2` is.)
- The formal parameter is initialised to that value.
  (the formal parameter is a local variable of the function body.)
- The function body is executed.
- When `return` is reached, control passes to the point immediately after the function call, and the return value becomes the value of the function call.

Key point: *actual parameters are evaluated to values (int, float etc.) before the function is executed, and the function sees only the values.*

Changing variables by function calls

The function only sees the *value* of parameters.
So how can we write a function to swap the values of two variables?

```
void swap(int a, int b) {
  int temp;
  temp = b;
  b = a;
  a = temp;
}

int main(void) {
  int x = 3, y = 5;
  swap(x,y);
  printf("x is now %d and y is now %d\n",x,y);
  return EXIT_SUCCESS;
}
```

does NOT work!

The magic of & and *

C has a way to use the *address* of a variable (the numbered label of the box for that variable) as a *value*.

If `x` is a variable, `&x` is its address.

If `a` is an *address*, `*a` means "what is stored at" that address.

And we can store addresses in variables (of type `int *`).

```
int x =5;    /* x is an int  */
int * a;     /* a is the address of an int */
a = &x;      /* Let a have the value of x's address */
```

This defines and assigns an int called `x`, defines a "pointer" called `a`, and assigns the *value of* `a` to be the address of `x`.

The magic of & and *

```
int x =5;    /* x is an int  */
int * a;     /* a is the address of an int */
a = &x;      /* Let a have the value of x's address */
```

After executing the above lines, then assigning to `*a` is the same as assigning to `x` and evaluating `*a` is the same as evaluating `x`.

A sane language would say type `&int` instead of type `int *`.
C programmers usually write `int *a;` rather than `int * a;`

Variables of type `int *` are called *pointers* to integers. Other pointer variables might be `float *` etc.

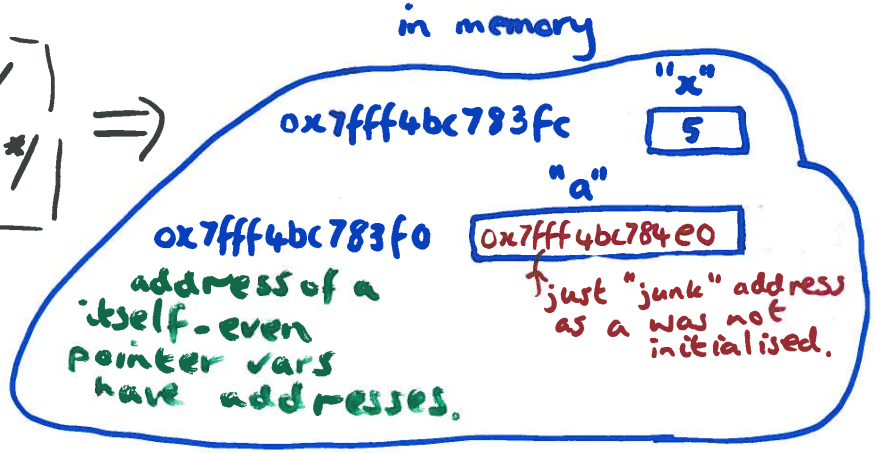
The magic of & and * - Environment

* specific addresses will be different for different runs

Declarations of Variables/Pointers [for slide 13]
(and addresses where they are stored)

```
int   x = 5;   /*int variable */
int   * a;     /*'pointer' to int*/
```

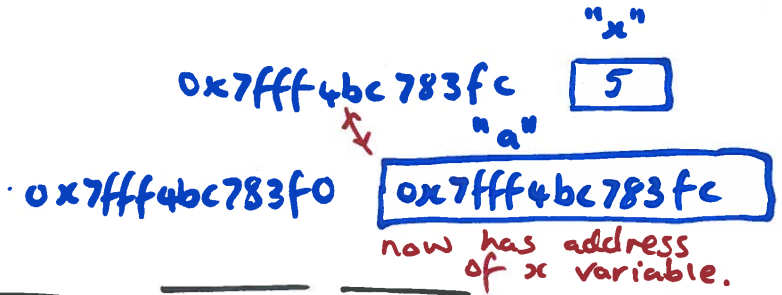
⇒




```
a = &x;
```

"assign to a, the specific address of variable x"

⇒




```
printf("a has value %p, points to value %d.\n", a, *a);
```

⇒ a has value 0x7fff4bc783fc, points to value 5.

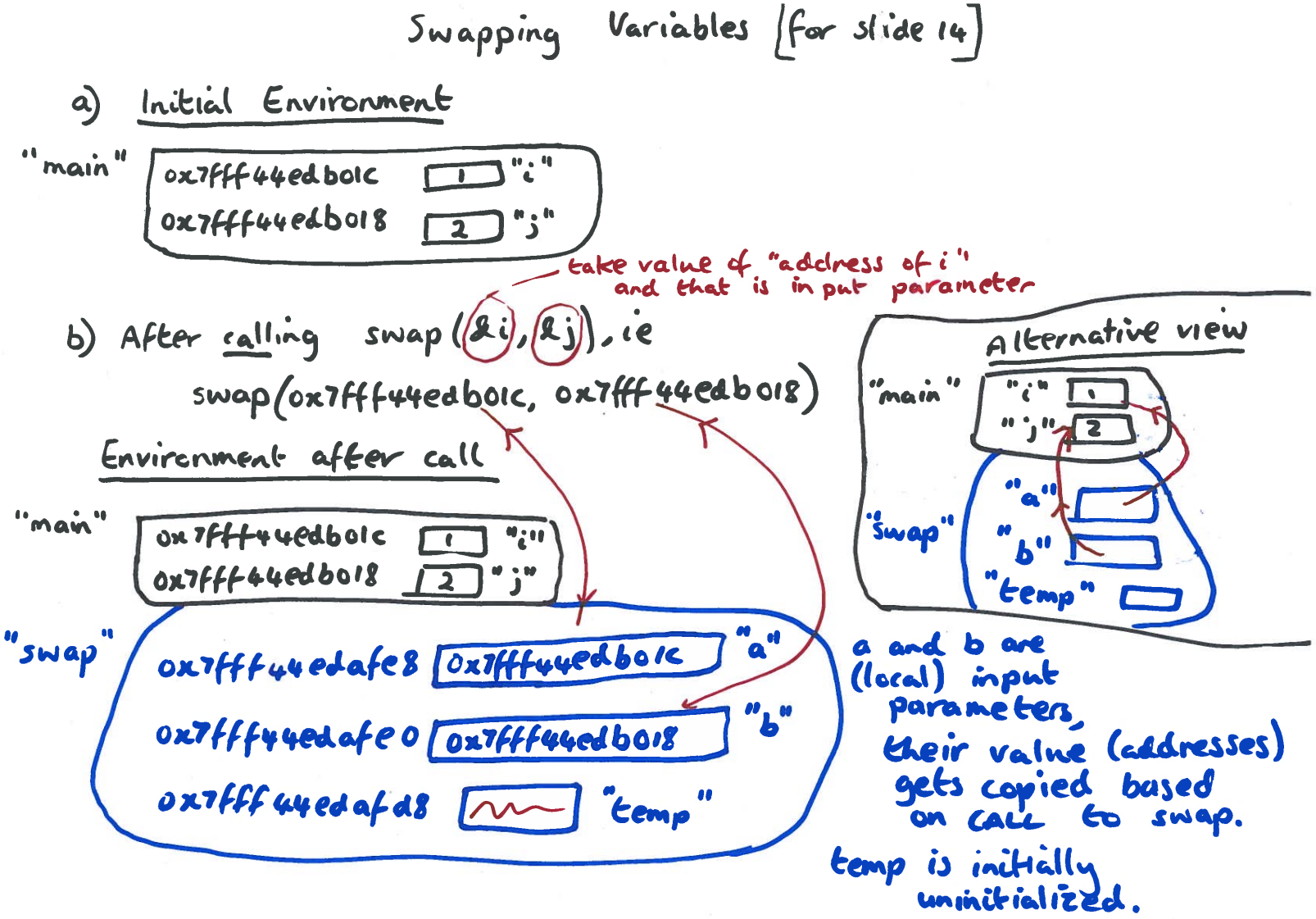
Swapping variables with & and *

```
void swap(int *a, int *b) {
  int temp = *a;
  *a = *b;
  *b = temp;
}

int main(void) {
  int i = 1, j = 2;
  printf("Checkpoint A:  i = %d and j = %d.\n", i, j);
  swap(&i, &j);
  printf("Checkpoint B:  i = %d and j = %d.\n", i, j);
  return EXIT_SUCCESS;
}
```

Using the combination of & and * we achieve the effect of *call by reference* – allowing the function to get at the variable itself, not just its value.

Swapping with & and * - Environment



Overview: Uses of & and *

```
int *p;
```

Definition of a pointer variable

```
p = &a;
```

Take the address of `a` and store in the pointer variable `p`

```
int b = *p;
```

Dereference `p`: Store in `b` the value of the variable that pointer variable `p` points to.

Following Up

For Functions in general:
"A Book on C", Sections 5.1-5.6
(please ignore the comments on "traditional C" and C++)

For pointers:
"A Book on C", Sections 6.1-6.3