Arrays
Chapter 7

Problem Solving & Program Design in C

Eighth Edition

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Chapter Objectives

- To learn how to declare and use arrays for storing collections of values of the same type
- To understand how to use a subscript to reference the individual values in an array
- To learn how to process the elements of an array in sequential order using loops

Chapter Objectives

- To understand how to pass individual array elements and entire arrays through function arguments
- To learn a method for searching an array
- To learn a method for sorting an array
- To learn how to use multidimensional arrays for storing tables of data
- To understand the concept of parallel arrays
- To learn how to declare and use your own data types

Basic Terminology

- data structure
  - a composite of related data items stored under the same name

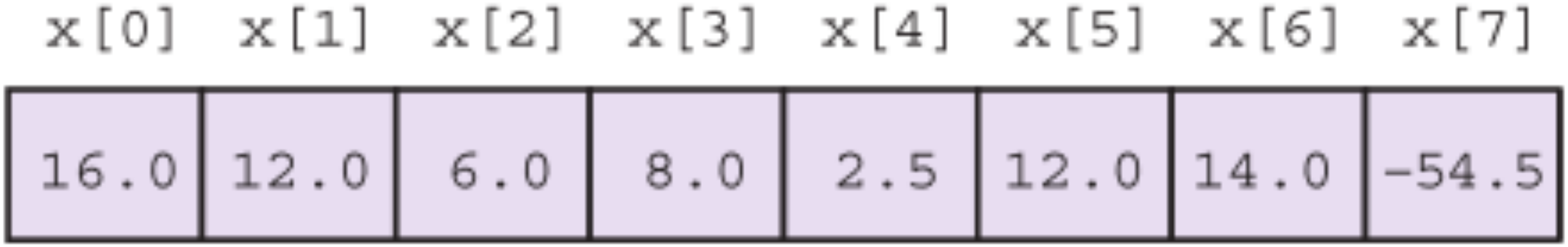
- array
  - a collection of data items of the same type

Declaring and Referencing Arrays

- array element
  - a data item that is part of an array
- subscripted variable
  - a variable followed by a subscript in brackets, designating an array element
- array subscript
  - a value or expression enclosed in brackets after the array name, specifying which array element to access

```
double x[8];
```

Array x



x[0]	x[1]	x[2]	x[3]	x[4]	x[5]	x[6]	x[7]
16.0	12.0	6.0	8.0	2.5	12.0	14.0	-54.5

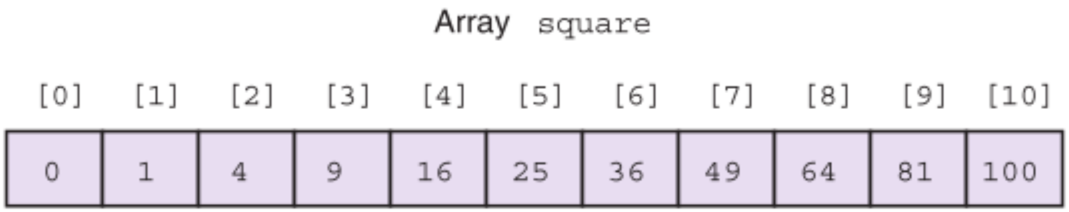
Array Initialization

```
int prime_lt_100[] = {2, 3, 5, 7, 11, 13, 17, 19,
                23, 29, 31, 37, 41, 43, 47, 53, 59, 61,
                67, 71, 73, 79, 83, 89, 97}
```

```
char vowels[] = {‘a’, ‘e’, ‘i’, ‘o’, ‘u’, ‘y’}
```

Using for Loops for Sequential Access

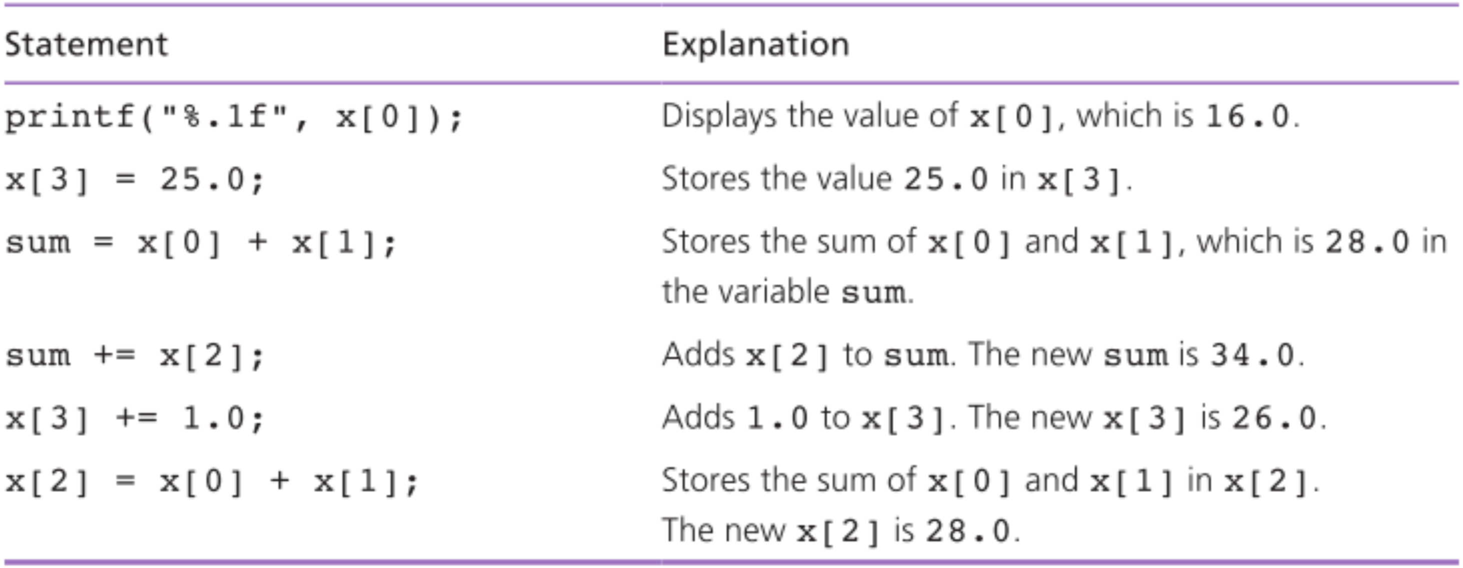
```
for (i = 0; i < SIZE; ++i)
        square[i] = i * i;
```



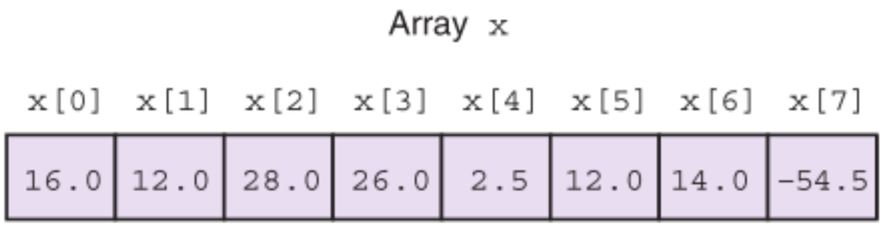
Array square

[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
0	1	4	9	16	25	36	49	64	81	100

TABLE 7.1 Statements That Manipulate Array x



Statement	Explanation
`printf("%.1f", x[0]);`	Displays the value of `x[0]`, which is `16.0`.
`x[3] = 25.0;`	Stores the value `25.0` in `x[3]`.
`sum = x[0] + x[1];`	Stores the sum of `x[0]` and `x[1]`, which is `28.0` in the variable `sum`.
`sum += x[2];`	Adds `x[2]` to `sum`. The new `sum` is `34.0`.
`x[3] += 1.0;`	Adds `1.0` to `x[3]`. The new `x[3]` is `26.0`.
`x[2] = x[0] + x[1];`	Stores the sum of `x[0]` and `x[1]` in `x[2]`. The new `x[2]` is `28.0`.



Array x

x[0]	x[1]	x[2]	x[3]	x[4]	x[5]	x[6]	x[7]
16.0	12.0	28.0	26.0	2.5	12.0	14.0	-54.5

Array Subscripts

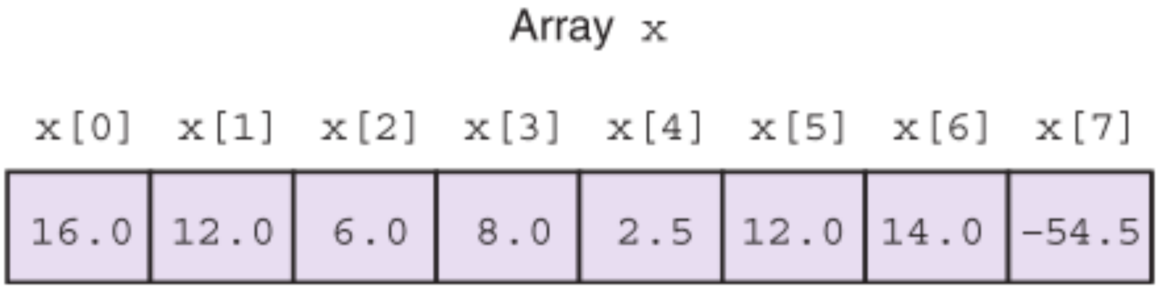
- Syntax:

  aname [subscript]

- Examples:

  x[3]

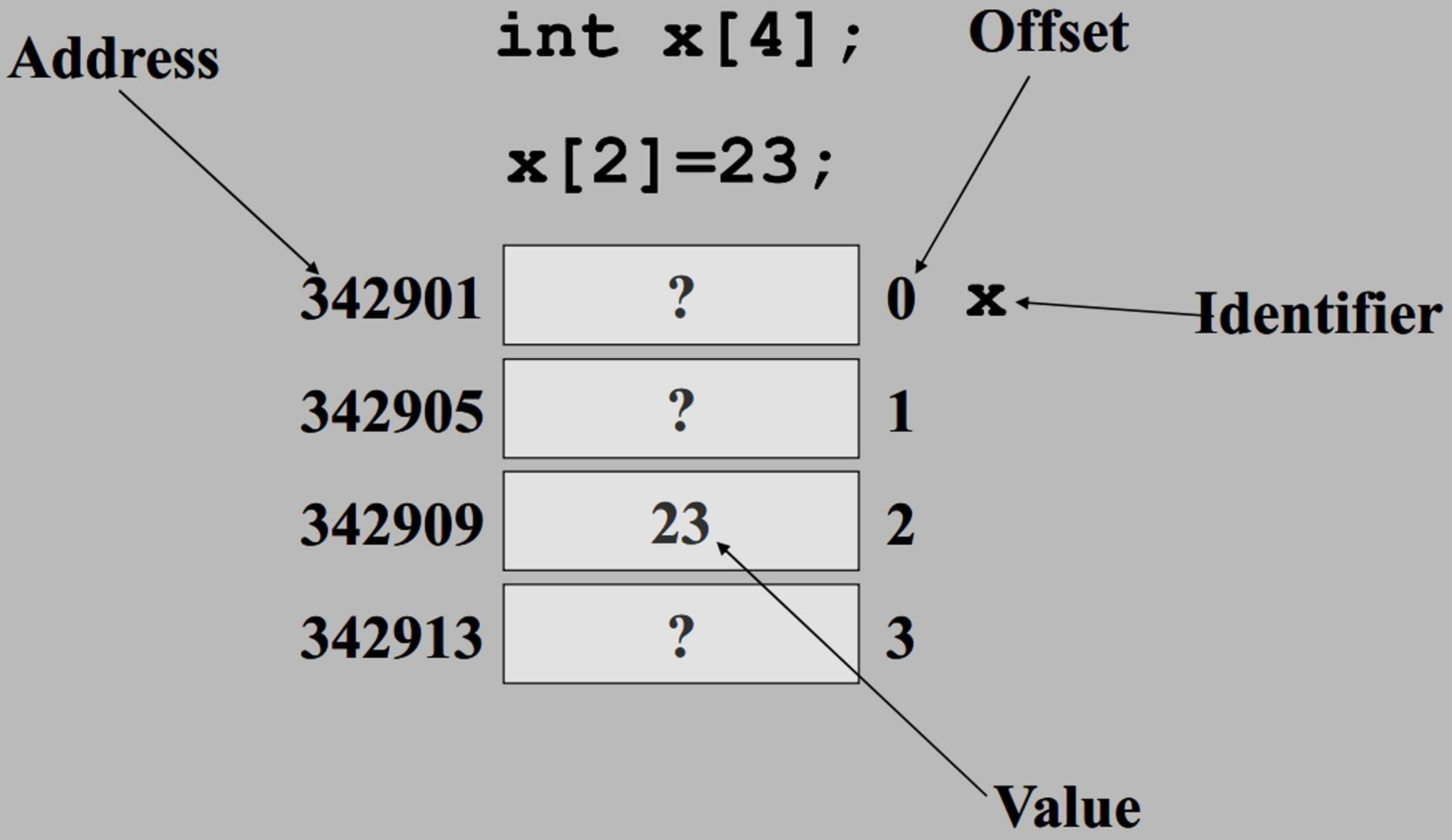
  x[i + 1]



Array x

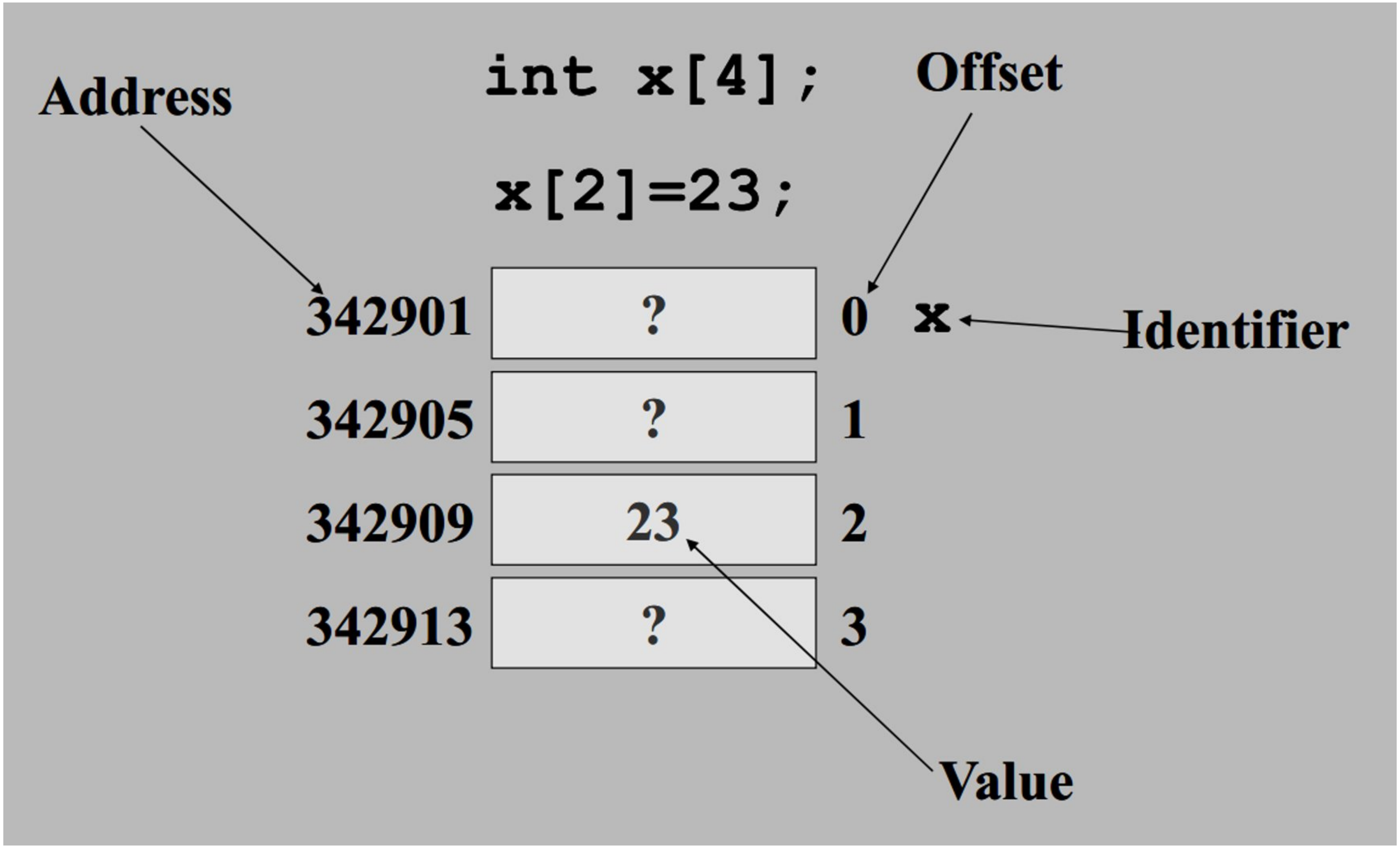
x[0]	x[1]	x[2]	x[3]	x[4]	x[5]	x[6]	x[7]
16.0	12.0	6.0	8.0	2.5	12.0	14.0	-54.5

```
int x[4];

x[2]=23;
```



342901	?	0	x
342905	?	1	
342909	23	2	
342913	?	3	

What’s at x[5]?



```
int x[4];

x[2]=23;
```

Partially Filled Arrays

- A program may need to process many lists of similar data but the lists may not all be the same length.
- In order to reuse an array for processing more than one data set, you can declare an array large enough to hold the largest data set anticipated.
- Then your program should keep track of how many array elements are actually in use.

Multidimensional Arrays

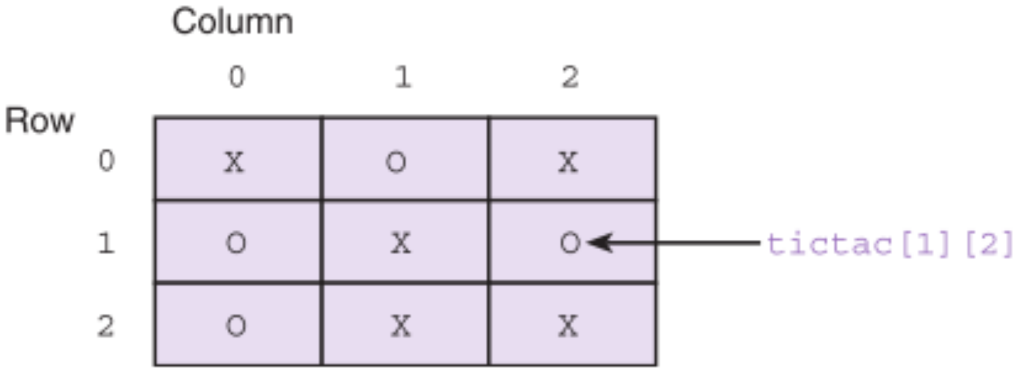
- multidimensional array

type arr_name[dim1val][dim2val]

tictac[3][3]

FIGURE 7.20

A Tic-tac-toe Board Stored as Array tictac



	Column		
Row	0	1	2
0	X	O	X
1	O	X	O
2	O	X	X

Using Array Elements as Function Arguments

```
scanf(“%lf”,  &x[i]);
```

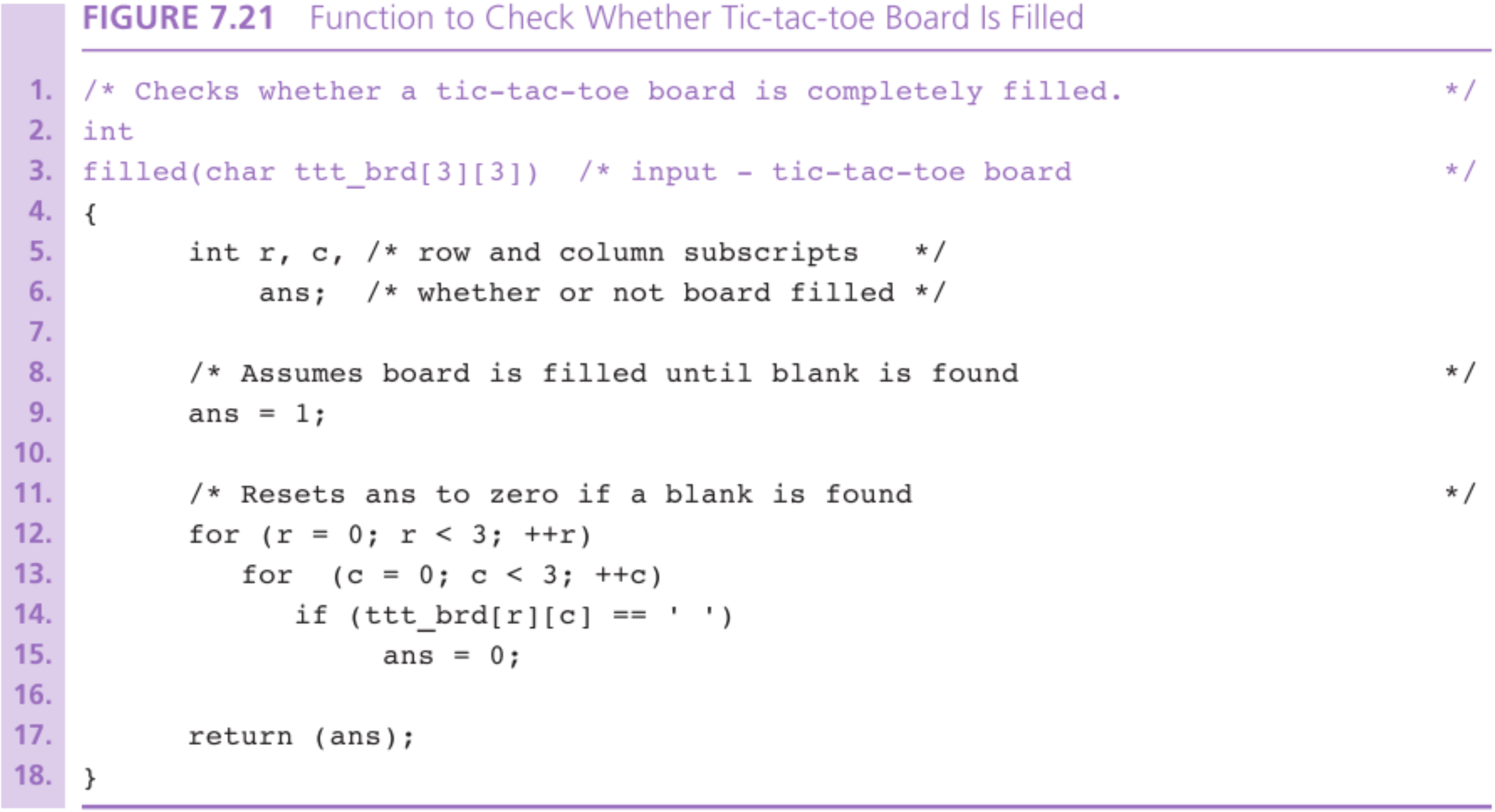
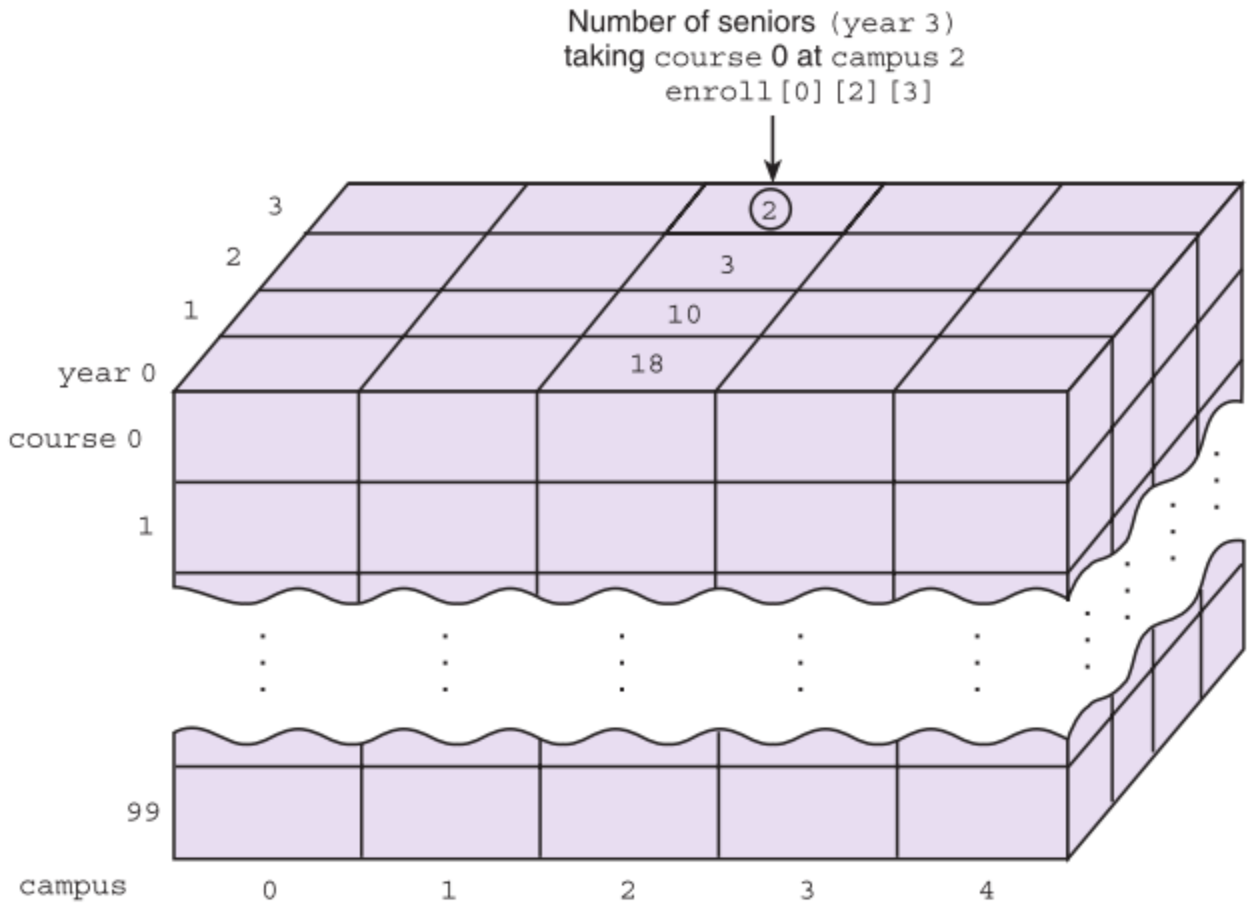


FIGURE 7.21 Function to Check Whether Tic-tac-toe Board Is Filled

```
/* Checks whether a tic-tac-toe board is completely filled.                  */
int
filled(char ttt_brd[3][3])  /* input - tic-tac-toe board                     */
{
      int r, c, /* row and column subscripts   */
          ans;  /* whether or not board filled */

      /* Assumes board is filled until blank is found                        */
      ans = 1;

      /* Resets ans to zero if a blank is found                              */
      for (r = 0; r < 3; ++r)
         for  (c = 0; c < 3; ++c)
            if (ttt_brd[r][c] == ' ')
                 ans = 0;

      return (ans);
}
```

FIGURE 7.22

Three-Dimensional Array enroll



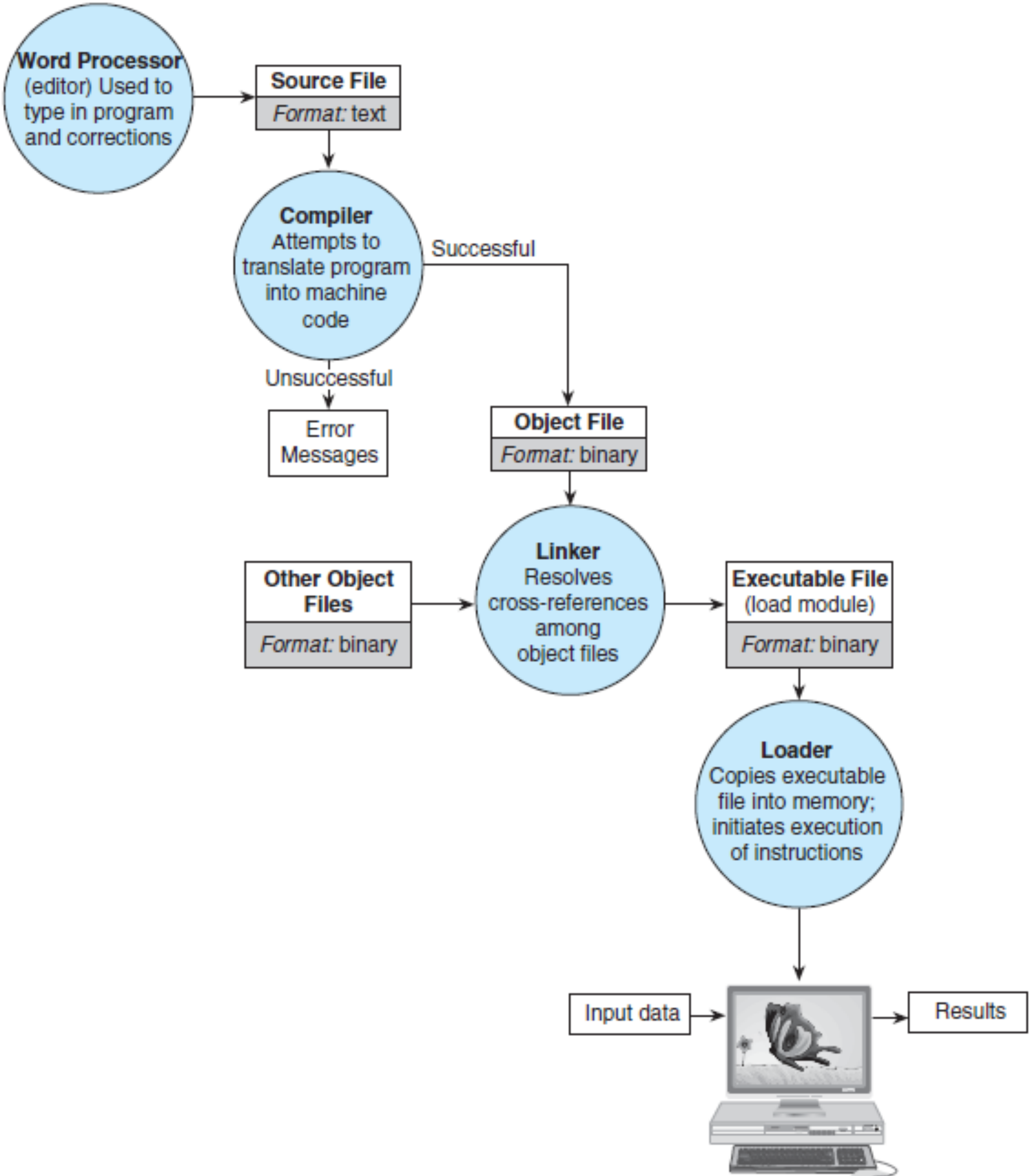
Array Arguments

- We can write functions that have arrays as arguments.

- Such functions can manipulate some, or all, of the elements corresponding to an actual array argument.

Variable scope

- Part of a program where a variable is accessible
- Lifetime of a variable



Word Processor (editor) Used to type in program and corrections

Source File
Format: text

Compiler Attempts to translate program into machine code

Successful

Unsuccessful

Error Messages

Object File
Format: binary

Other Object Files
Format: binary

Linker Resolves cross-references among object files

Executable File (load module)
Format: binary

Loader Copies executable file into memory; initiates execution of instructions

Input data

Results

What happens when we run our executable file?

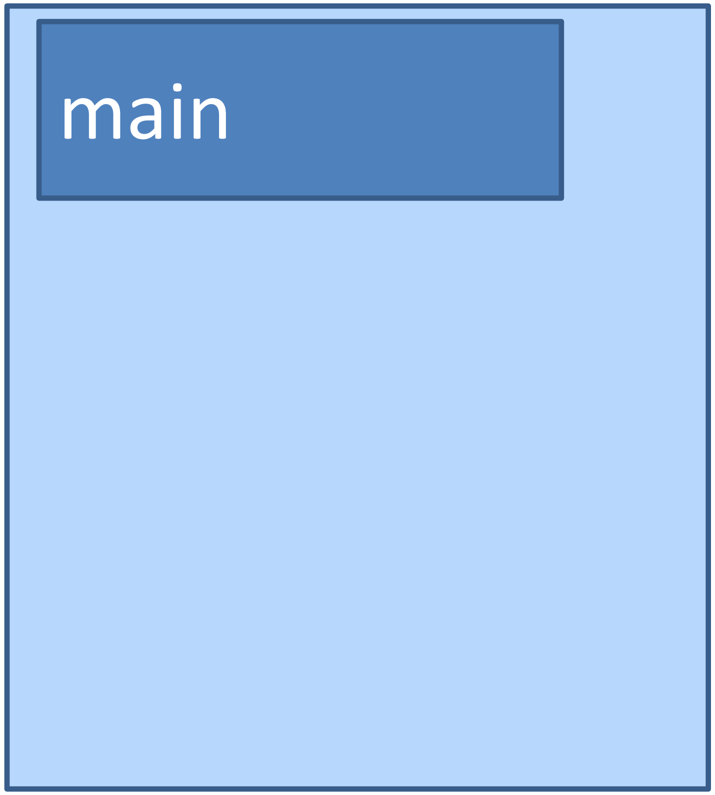
```
func2() {
   printf(“%d\n”, x);
}
func1() {
   int x = 1;
   func2();
}
int main(void) {
   char letter=’c’
   func1();
}
```

Memory

What happens when we run our executable file?

```
func2() {
    printf(“%d\n”, x);
}
func1() {
    int x = 1;
    func2();
}
int main(void) {
    char letter=’c’
    func1();
}
```

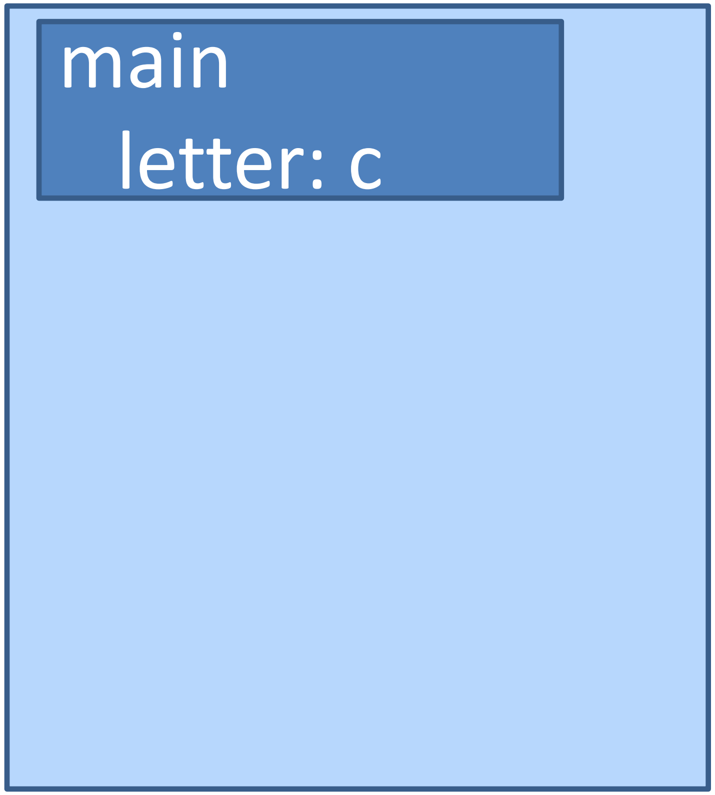
Memory



What happens when we run our executable file?

```
func2() {
    printf(“%d\n”, x);
}
func1() {
    int x = 1;
    func2();
}
int main(void) {
    char letter=’c’
    func1();
}
```

Memory



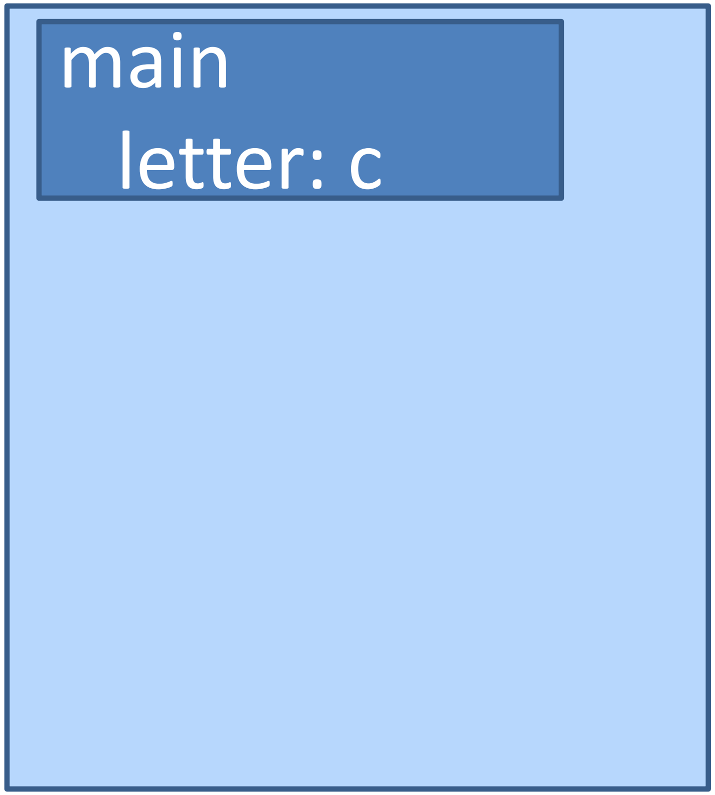
main

letter: c

What happens when we run our executable file?

```
func2() {
    printf(“%d\n”, x);
}
func1() {
    int x = 1;
    func2();
}
int main(void) {
    char letter=’c’
    func1();
}
```

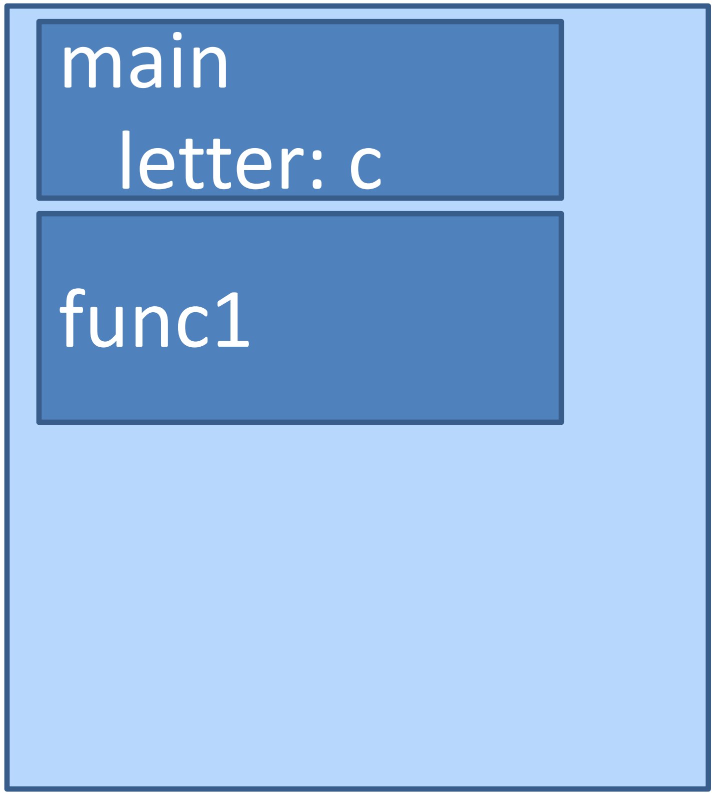
Memory


main
letter: c

What happens when we run our executable file?

```
func2() {
    printf("%d\n", x);
}
func1() {
    int x = 1;
    func2();
}
int main(void) {
    char letter='c'
    func1();
}
```

Memory



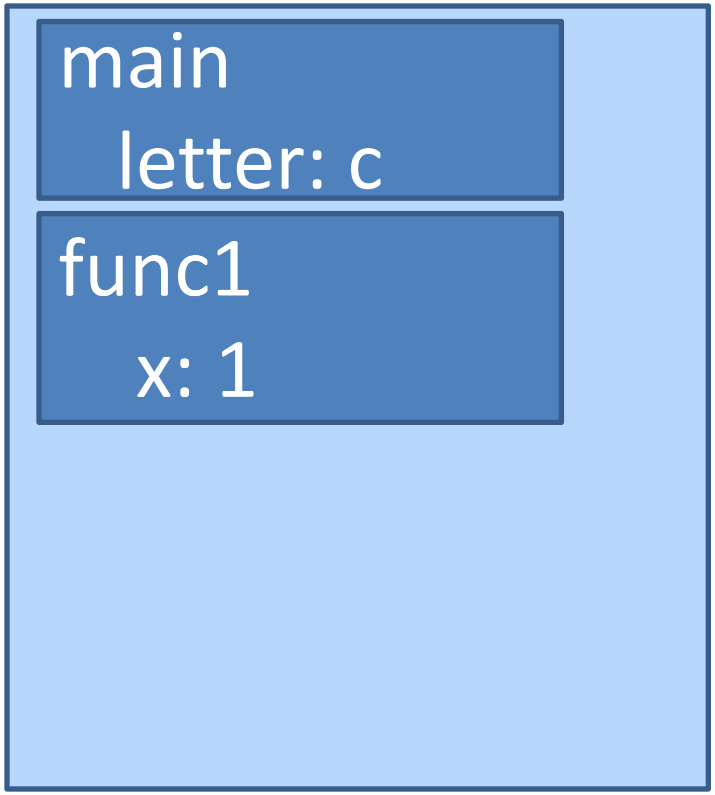
main
letter: c

func1

What happens when we run our executable file?

```
func2() {
    printf("%d\n", x);
}
func1() {
    int x = 1;
    func2();
}
int main(void) {
    char letter='c'
    func1();
}
```

Memory



main

letter: c

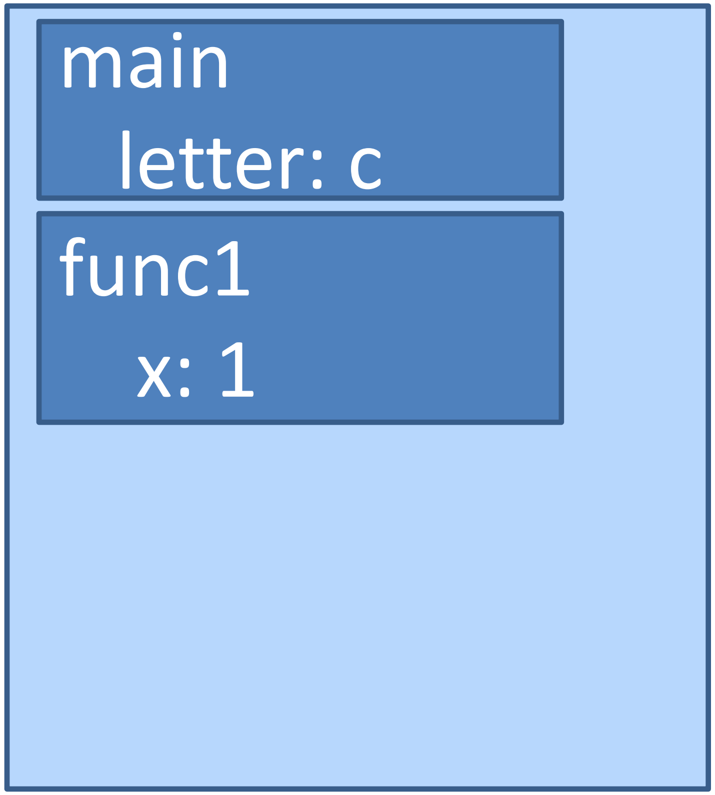
func1

x: 1

What happens when we run our executable file?

```
func2() {
   printf(“%d\n”, x);
}
func1() {
   int x = 1;
   func2();
}
int main(void) {
   char letter=’c’
   func1();
}
```

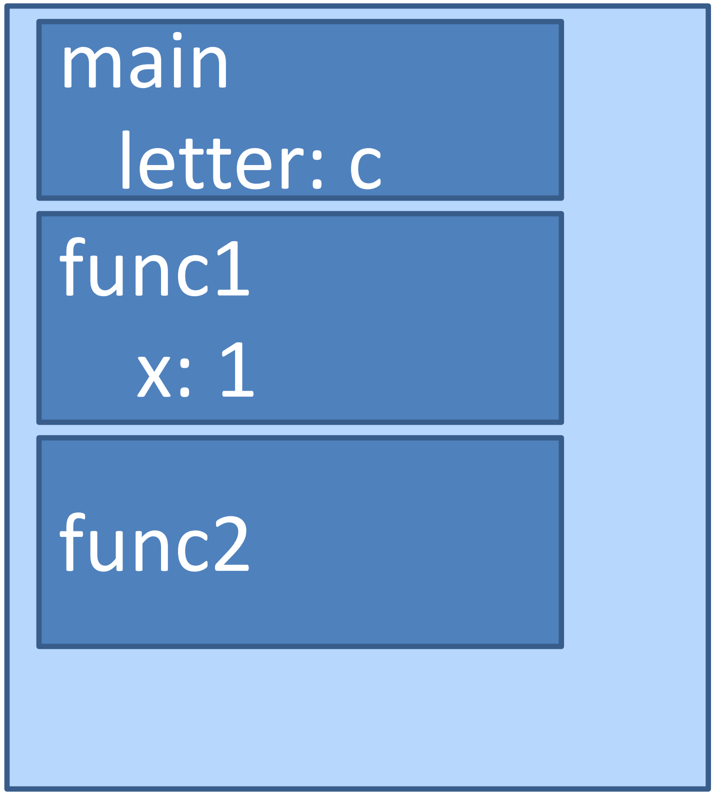
Memory



What happens when we run our executable file?

```
func2() {
    printf("%d\n", x);
}
func1() {
    int x = 1;
    func2();
}
int main(void) {
    char letter='c'
    func1();
}
```

Memory



main
letter: c

func1
x: 1

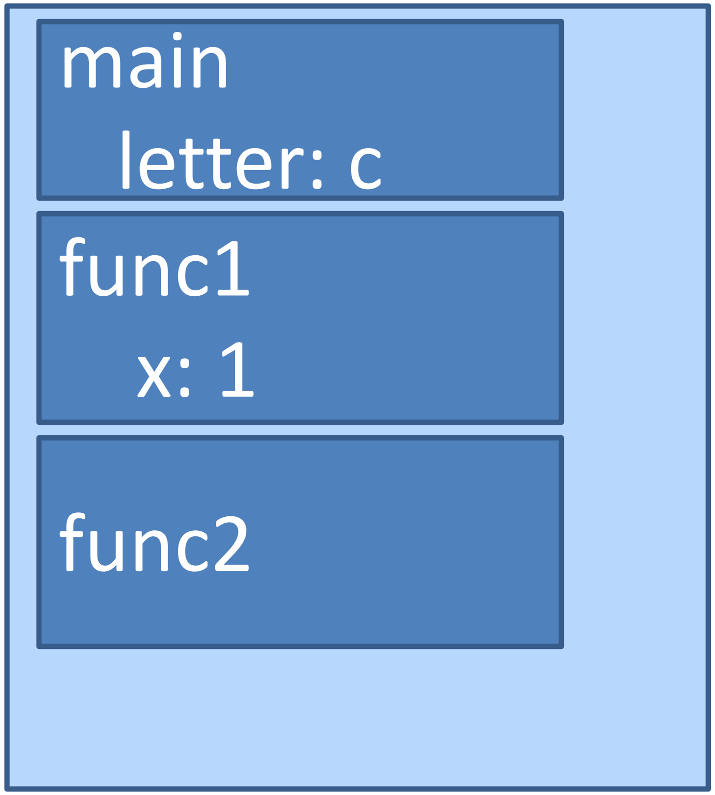
func2

What happens when we run our executable file?

```
func2() {
   printf(“%d\n”, x);
}
func1() {
   int x = 1;
   func2();
}
int main(void) {
   char letter=’c’
   func1();
}
```

out of scope!

Memory



main
letter: c

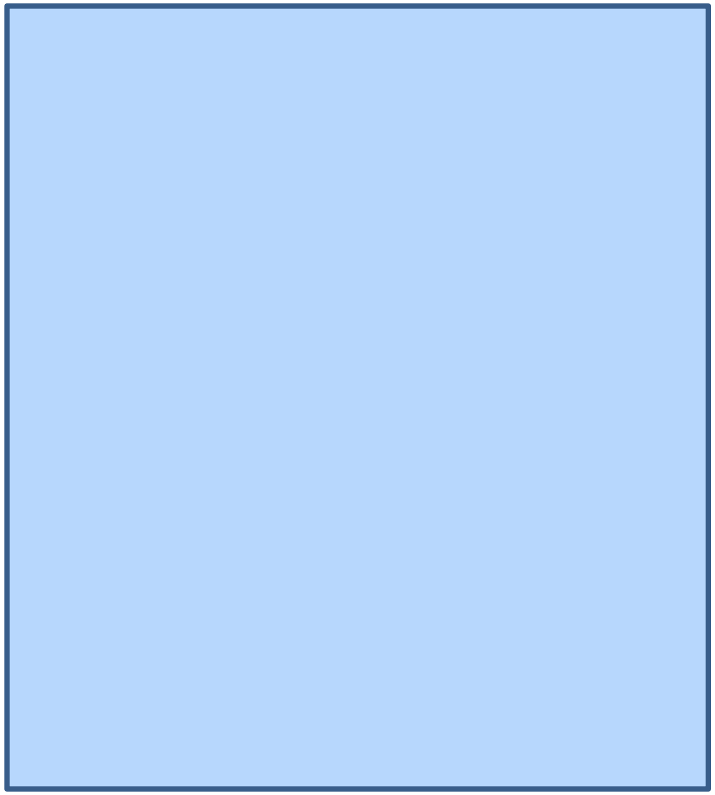
func1
x: 1

func2

What happens when we run our executable file?

```
void fill_array(
      int list[],
      int n,
      int in_value) {
    int i;
    for (i = 0;
         i < n; ++i) {
        list[i] = in_value;
    }
}
int main(void) {
    int arr[10];
    fill_array(arr, 5, 1);
}
```

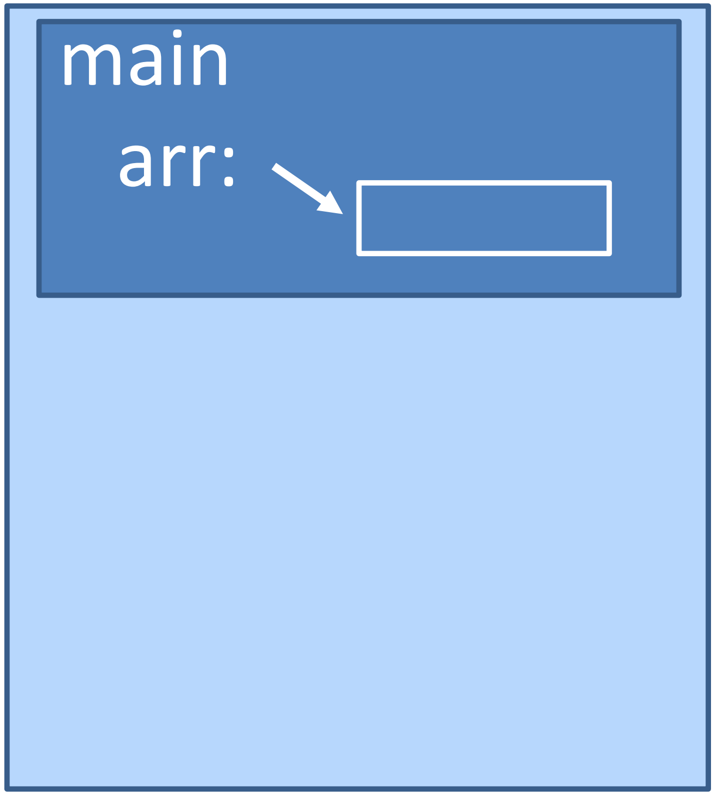
Memory



What happens when we run our executable file?

```
void fill_array(
      int list[],
      int n,
      int in_value) {
    int i;
    for (i = 0;
         i < n; ++i) {
        list[i] = in_value;
    }
}
int main(void) {
    int arr[10];
    fill_array(arr, 5, 1);
}
```

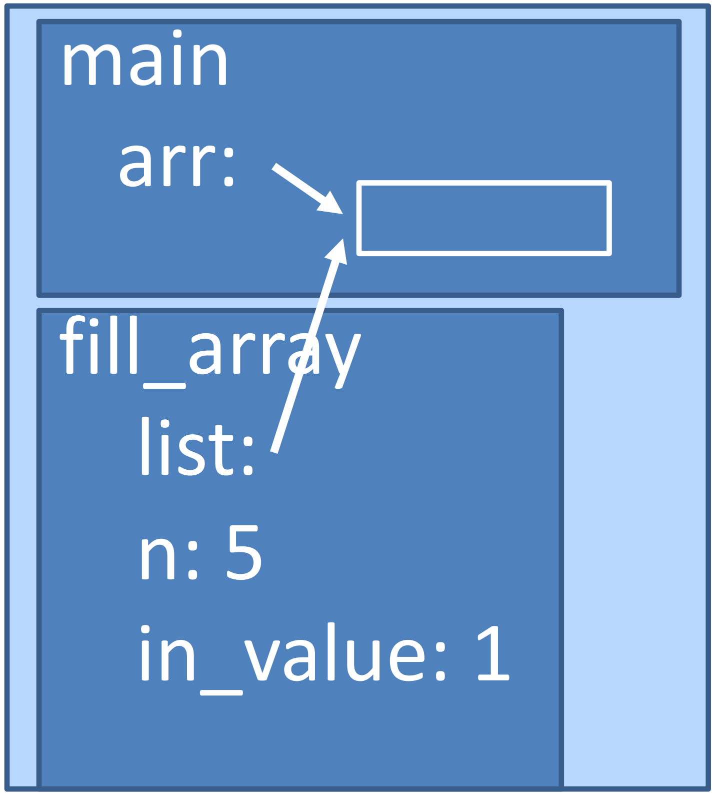
Memory



What happens when we run our executable file?

```
void fill_array(
      int list[],
      int n,
      int in_value) {
    int i;
    for (i = 0;
         i < n; ++i) {
        list[i] = in_value;
    }
}
int main(void) {
    int arr[10];
    fill_array(arr, 5, 1);
}
```

Memory



main

arr:

fill_array

list:

n: 5

in_value: 1

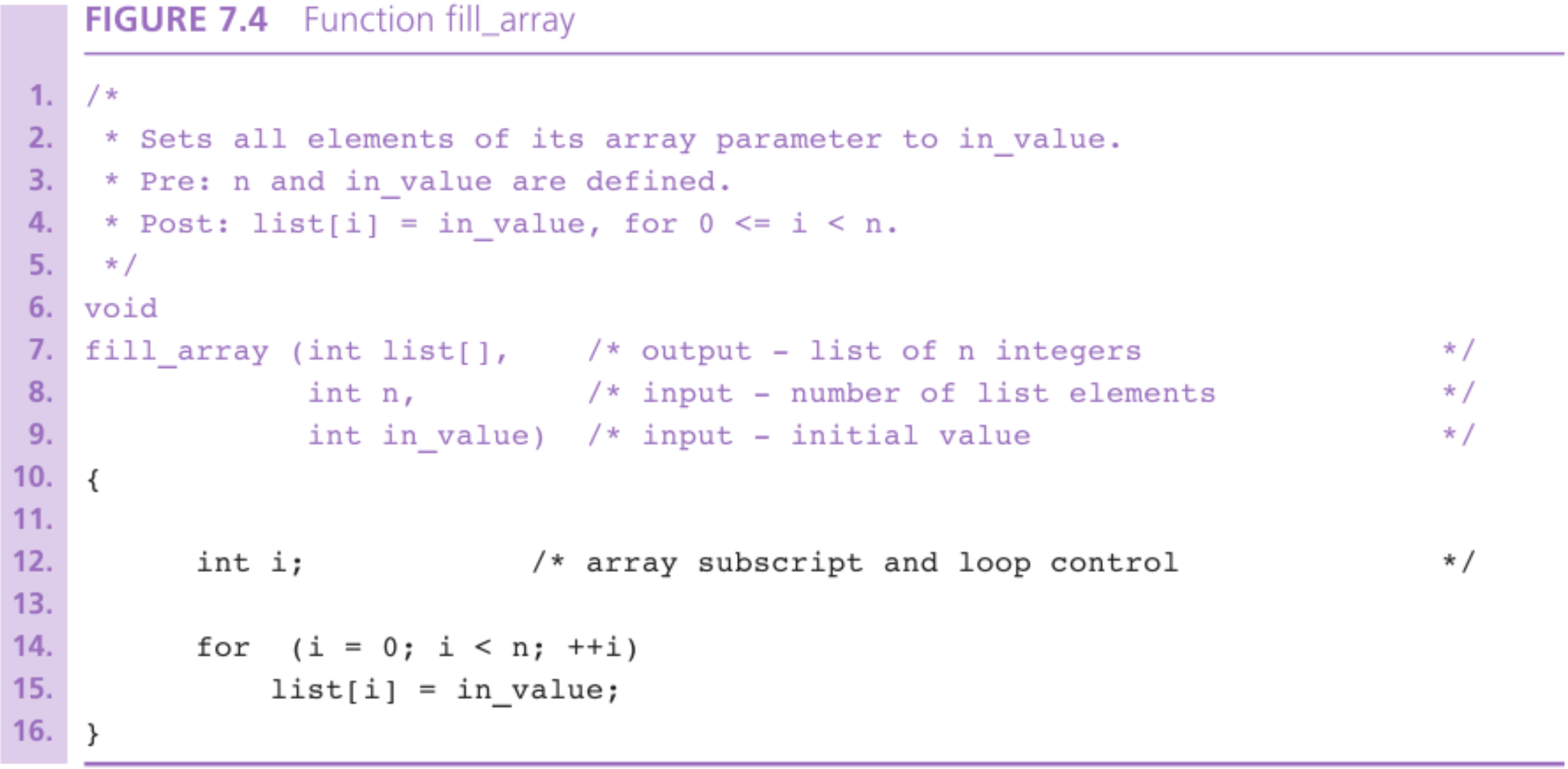
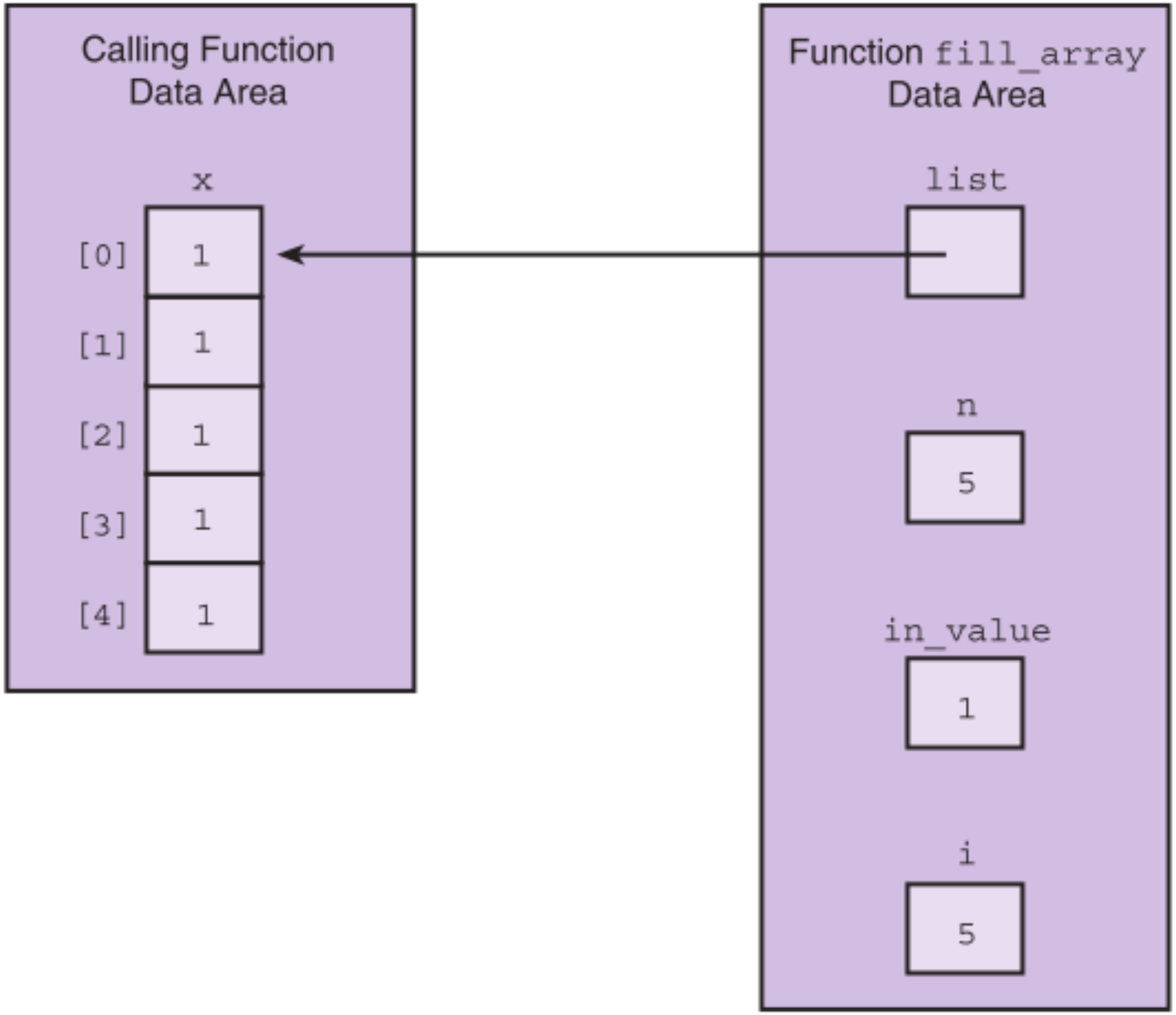


FIGURE 7.4 Function fill_array

```
/*
 * Sets all elements of its array parameter to in_value.
 * Pre: n and in_value are defined.
 * Post: list[i] = in_value, for 0 <= i < n.
 */
void
fill_array (int list[],    /* output - list of n integers                */
            int n,         /* input - number of list elements            */
            int in_value)  /* input - initial value                      */
{

      int i;            /* array subscript and loop control              */

      for  (i = 0; i < n; ++i)
          list[i] = in_value;
}
```

FIGURE 7.5

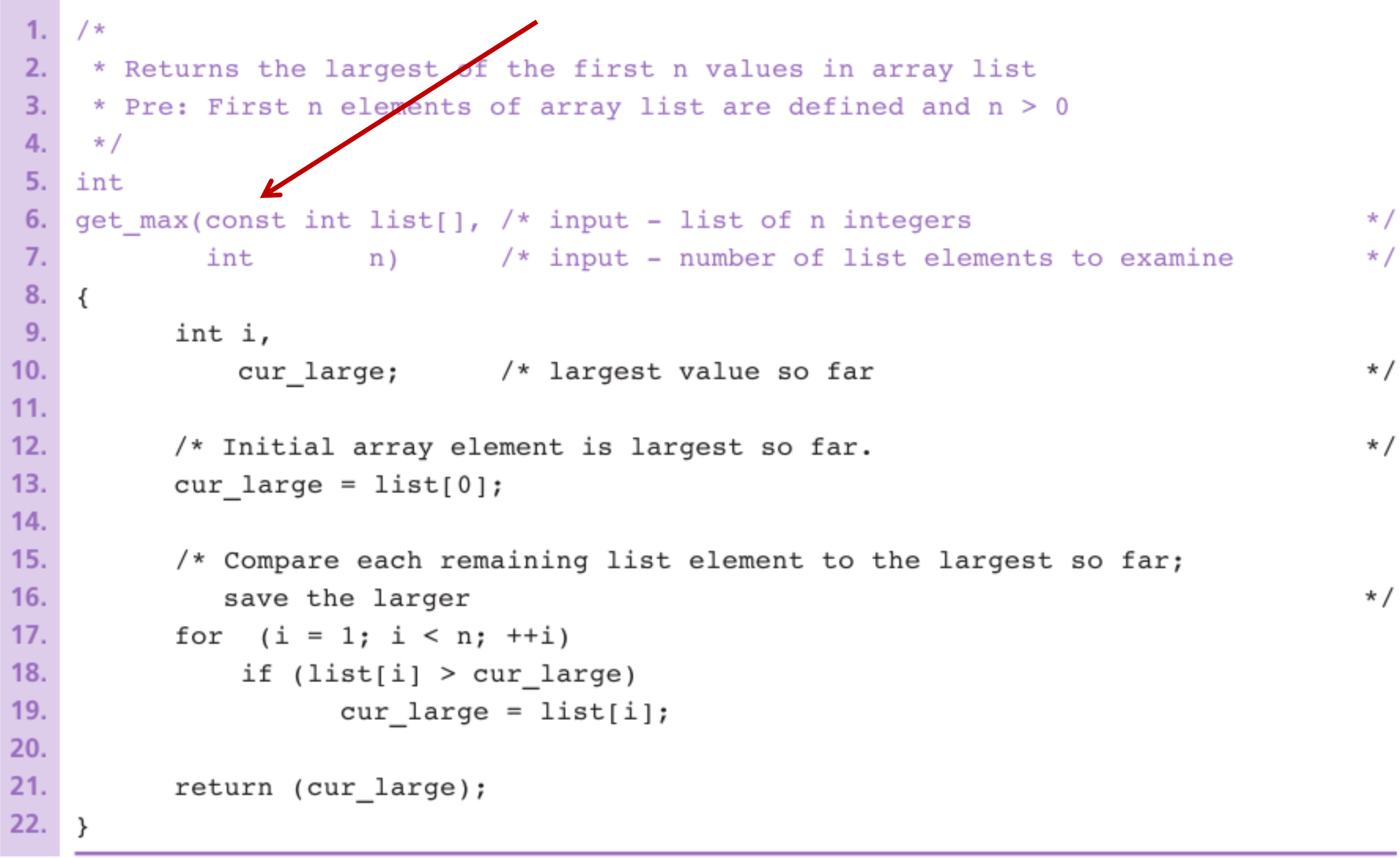
Data Areas Before Return from `fill_array (x, 5, 1);`



Arrays as Input Arguments

- The qualifier const allows the compiler to mark as an error any attempt to change an array element within the function.

FIGURE 7.6 Function to Find the Largest Element in an Array



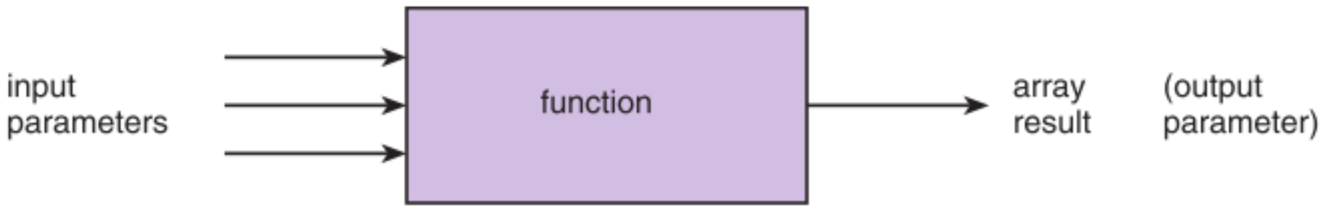
```
/*
 * Returns the largest of the first n values in array list
 * Pre: First n elements of array list are defined and n > 0
 */
int
get_max(const int list[], /* input - list of n integers                       */
        int       n)      /* input - number of list elements to examine       */
{
      int i,
          cur_large;      /* largest value so far                             */

      /* Initial array element is largest so far.                             */
      cur_large = list[0];

      /* Compare each remaining list element to the largest so far;
         save the larger                                                       */
      for  (i = 1; i < n; ++i)
          if (list[i] > cur_large)
                cur_large = list[i];

      return (cur_large);
}
```

Returning an Array Result

- In C, it is not legal for a function's return type to be an array.
- You need to use an output parameter to send your array back to the calling module.

FIGURE 7.7

Diagram of a Function That Computes an Array Result



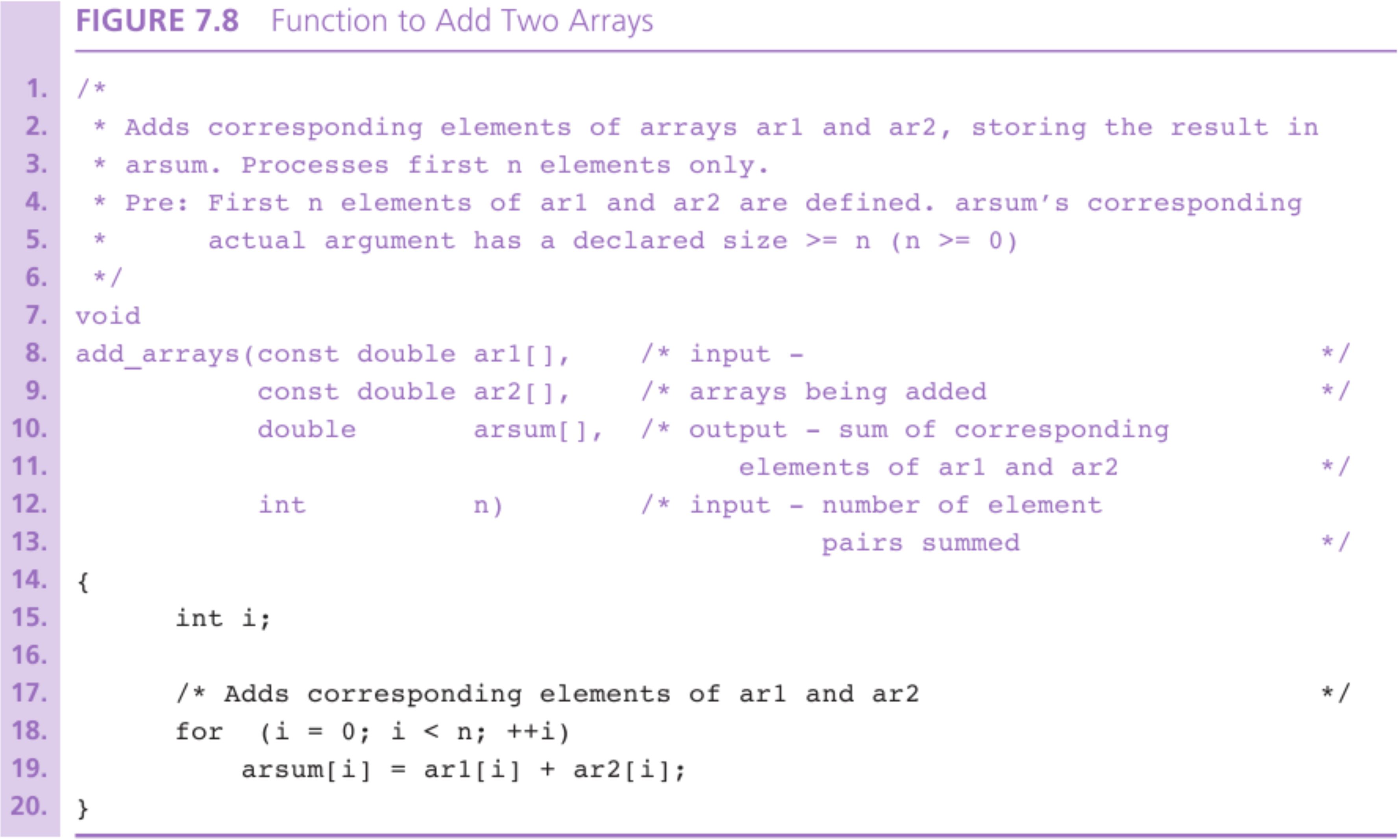
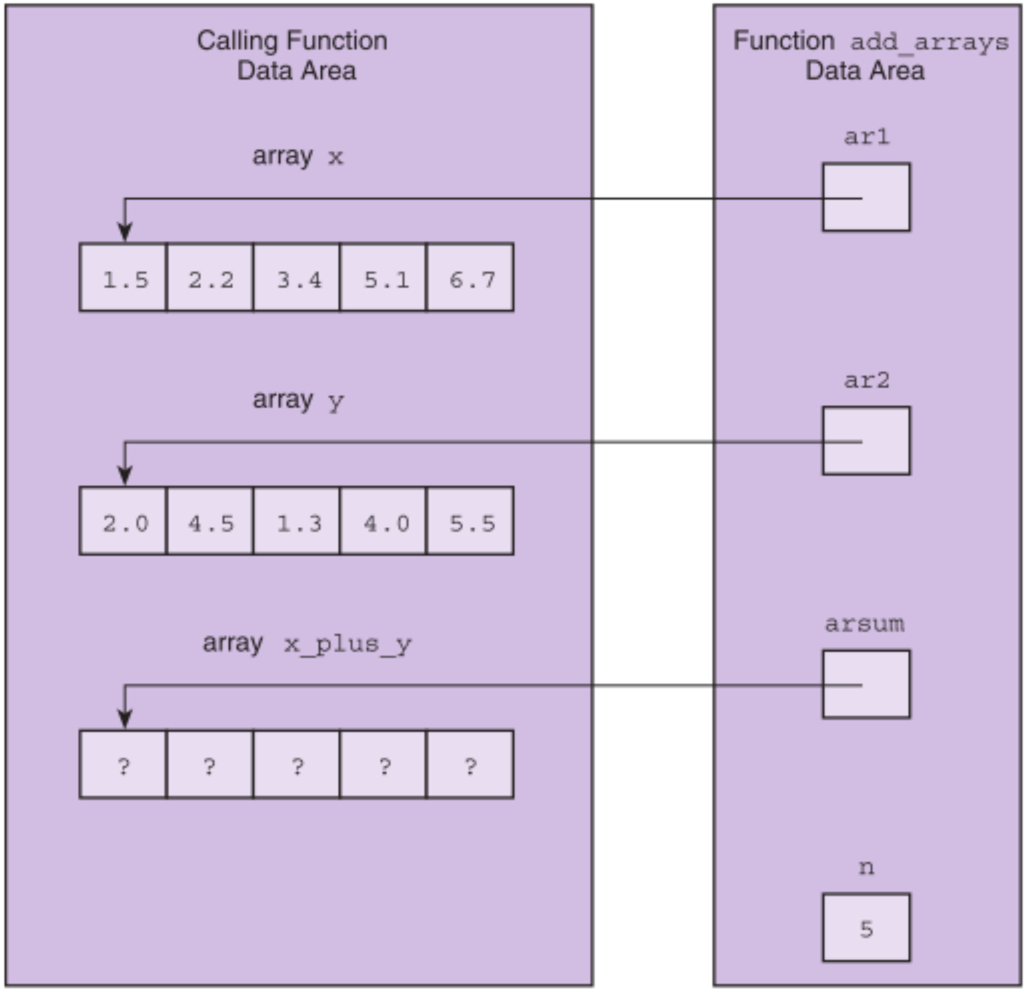


FIGURE 7.8 Function to Add Two Arrays

```
/*
 * Adds corresponding elements of arrays ar1 and ar2, storing the result in
 * arsum. Processes first n elements only.
 * Pre: First n elements of ar1 and ar2 are defined. arsum's corresponding
 *      actual argument has a declared size >= n (n >= 0)
 */
void
add_arrays(const double ar1[],    /* input -                               */
           const double ar2[],    /* arrays being added                    */
           double       arsum[],  /* output - sum of corresponding
                                        elements of ar1 and ar2            */
           int          n)        /* input - number of element
                                             pairs summed                  */
{
      int i;

      /* Adds corresponding elements of ar1 and ar2                        */
      for  (i = 0; i < n; ++i)
          arsum[i] = ar1[i] + ar2[i];
}
```

FIGURE 7.9

Function Data Areas for `add_arrays(x, y, x_plus_y, 5);`



Array Search

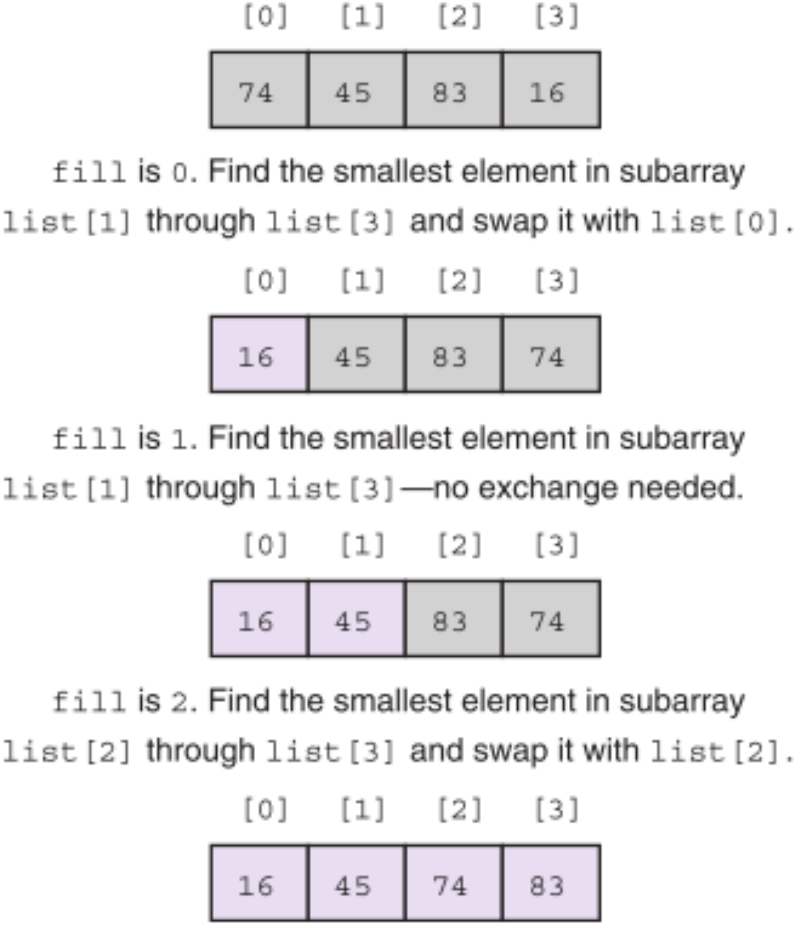
```
1.  Assume the target has not been found.
2.  Start with the initial array element.
3.  repeat while the target is not found and there
    are more array elements
    4.  if the current element matches the target
        5.  Set a flag to indicate that the target has been found
        else
        6.  Advance to the next array element.
7.  if the target was found
    8.  Return the target index as the search result
    else
    9.  Return -1 as the search result.
```

Selection Sort

```
1. for each value of fill from 0 to n-2
    2. Find index_of_min, the index of the smallest
       element in the unsorted subarray list[fill]
       through list[n-1]
    3. if fill is not the position of the smallest element
       (index_of_min)
        4. Exchange the smallest element with the one at
           position fill.
```

FIGURE 7.15

Trace of Selection Sort



[0]	[1]	[2]	[3]
74	45	83	16

fill is 0. Find the smallest element in subarray list[1] through list[3] and swap it with list[0].

[0]	[1]	[2]	[3]
16	45	83	74

fill is 1. Find the smallest element in subarray list[1] through list[3]—no exchange needed.

[0]	[1]	[2]	[3]
16	45	83	74

fill is 2. Find the smallest element in subarray list[2] through list[3] and swap it with list[2].

[0]	[1]	[2]	[3]
16	45	74	83

Wrap Up

- A data structure is a grouping of related data items in memory.

- An array is a data structure used to store a collection of data items of the same type.