Ch.12 Characters and Strings

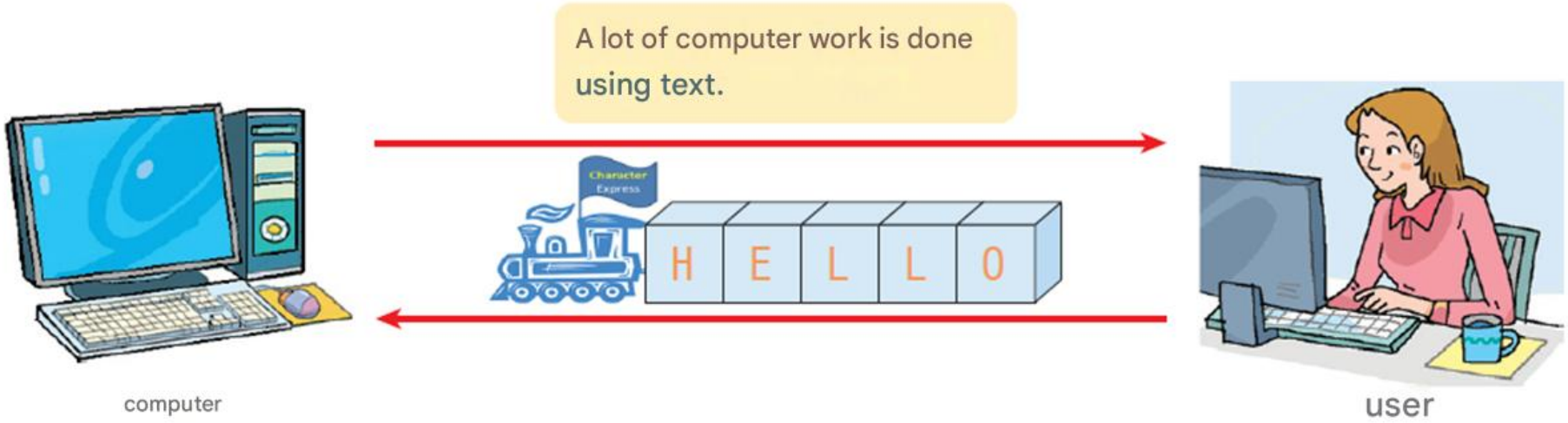
What you will learn in this chapter

- How to express characters
- How to represent strings
- What is a string ?
- Input/output of strings
- Character processing library functions
- Standard Input/Output Library Functions

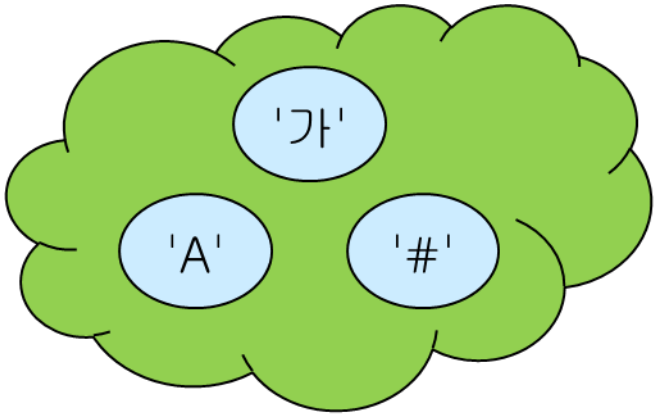
Since humans use characters to express information, strings occupy an important position in programs . In this chapter, we will take a closer look at string handling methods in C.

The importance of letters

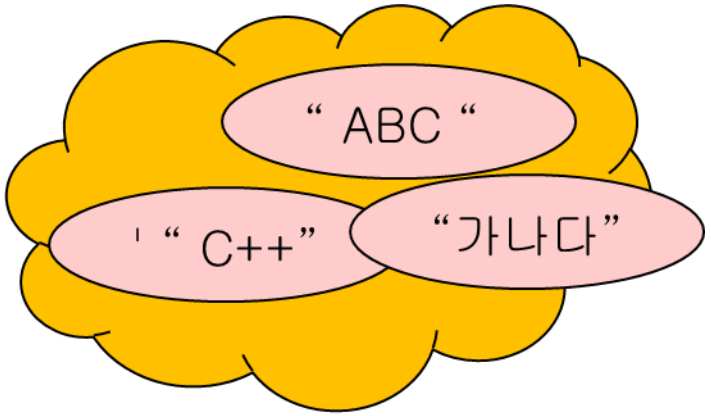
- Text is of utmost importance to humans .



Characters and strings



Characters



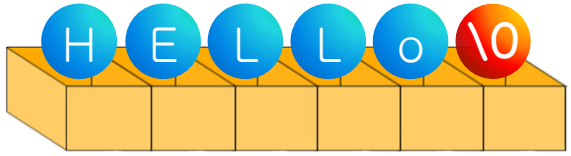
Strings

How to represent strings

- *string :* A collection of several characters
  - "A "
  - "Hello World!"
  - " The value of variable score is %d "

- *String variable*
  - A variable that can store a mutable string.

One character is stored in a char type variable.

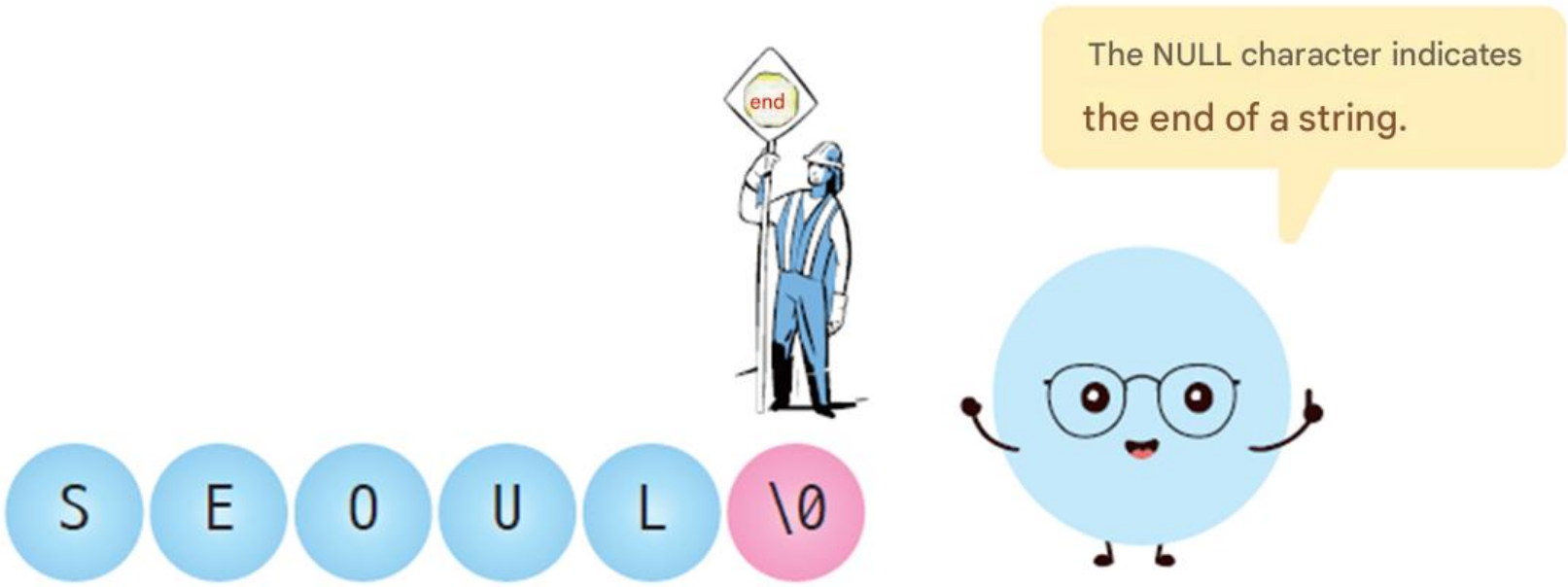


Strings are stored as char type arrays

Storage Type	Syntax	Mutable	Auto cleanup	Use when...
Stack	char str[] = "hi";	☑	☑	Short-lived, fast
Static (literal)	char* str = "hi";	✗	☑	Constant strings
Heap	malloc/free	☑	✗	Dynamic/larger strings

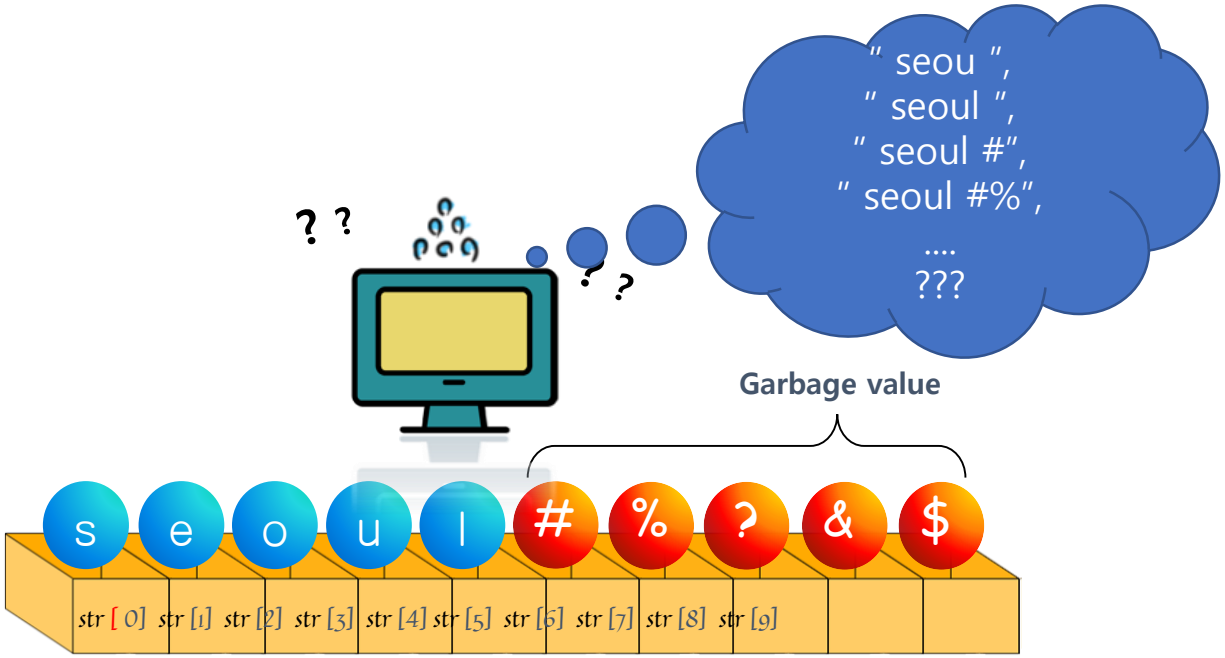
NULL character

- NULL character : Indicates the end of a string .



Why do we need to mark the end of a string ?

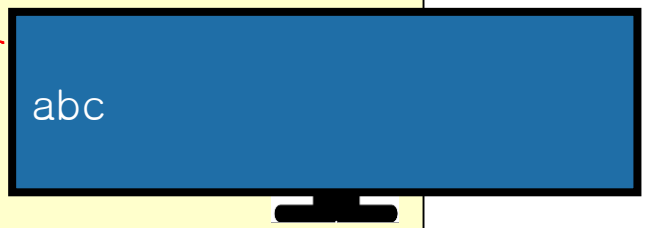
- Since we don't know where the string ends, we need to mark it .



Example #1

```
#include < stdio.h >

int main( void )
{
      int i ;
      char str [4];
      str [0] = 'a';
      str [1] = 'b';
      str [2] = 'c';
      str [3] = '\0';

      i = 0;
      while ( str [ i ] != '\0' ) {
          printf ( "%c" , str [ i ]);
          i ++;
      }
      return 0;
}
```

Let's print out the characters in the character array one by one . When printing a string stored in a character array, you can use %s , but here, in order to experience the basic method of string processing, we print out the characters in the character array one by one on the screen and stop the repetition when a NULL character is encountered .



reference

Note

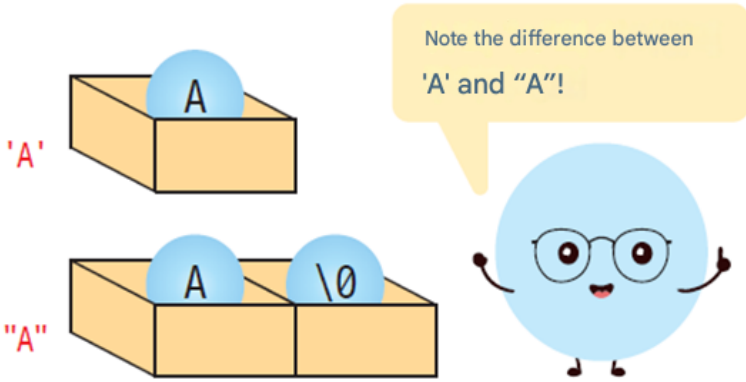
Let's take a quick C language quiz here. C language code

Let's think about the difference between A, 'A', and "A".

A: The compiler considers A as the name of a variable.

'A': Represents the letter A.

"A": Represents a string consisting only of the letter A. This is different from 'A'.

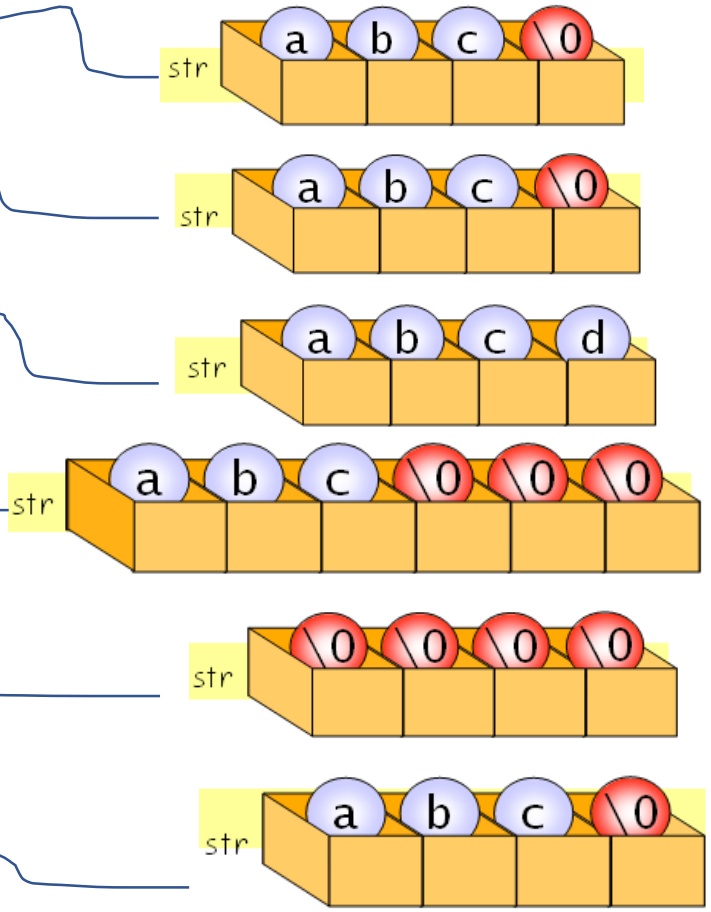


The thing to note here is the difference between 'A' and "A". 'A' represents a single character and is the same as the ASCII code for the character A.

A. "A" is a string, and the NULL character is added to the ASCII code of A to indicate the end of the string.

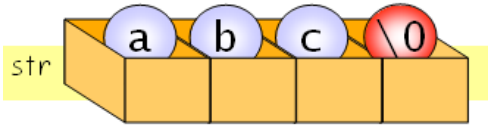
Initializing a character array

- char str [4] = { 'a', 'b', 'c', '\0' };
- char str [4] = "abc";
- char str [4] = "abcdef";
- char str [6] = "abc";
- char str [4] = "";
- char str [] = "abc";



char str[]; Error ☐ The compiler doesn't know how much memory to allocate

Output of string



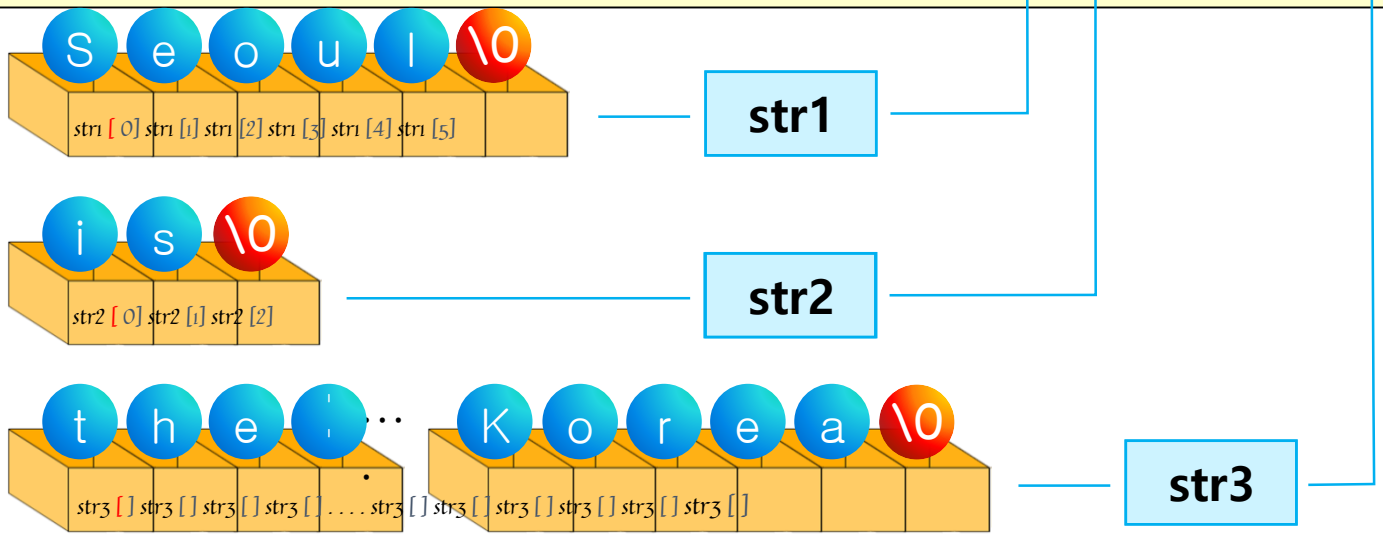

```
char str [] = “abc”;
printf (“%s”, str );
```

```
char str [] = “abc”;
printf ( str );
```

Example #2

```
#include < stdio.h >

int main( void )
{
    char str1[6] = "Seoul" ;
    char str2[3] = { ' i ' , 's' , '\0' };
    char str3[] = "the capital city of Korea." ;
    printf ( "%s %s %s\n" , str1, str2, str3);
    return 0;
}
```

Seoul is the capital city of Korea.



Example #3 (string copy)

```
#include < stdio.h >

int main( void )
{
        char src [] = "Action speaks louder than words" ;
        char dst [100];

        int i ;
        printf ( " Original string =%s\n" , src );
        for (i = 0; src[i] != '\0' ; i++)
            dst [ i ] = src [ i ];
        dst [ i ] = '\0' ;
        printf ( " Copied string =%s\n" , dst );

        return 0;
}
```

NULL and '₩0' are the same .

```
Original string =Action speaks louder than words
Copied string =Action speaks louder than words
```

Example of calculating string length

```
// Program to find the length of a string
#include < stdio.h >

int main( void )
{
        char str [30] = "C language is easy";
        int i = 0;

        while ( str [ i ] != 0)
              i ++;

        printf ( " The length of the string \"%s\" is %d .\n" , str , i );
        return 0;
}
```

String "C language is The length of "easy" is 18.

How to change the character array

1. The first method is to individually assign the desired character to each array element. This is a surefire way, but very inconvenient .

```
char str[10]=“Hello”;
str[0] = 'W';
str[1] = 'o';
str[2] = 'r';
str[3] = 'l';
str[4] = 'd';
str[5] = '\0';
```

2. You can copy a string to a character array using the library function strcpy () .

```
char str[10]=“Hello”;
strcpy (str, "World");
```

Wrong way

3. The following method , which seems to be the most convenient , cannot be used . Please be careful .

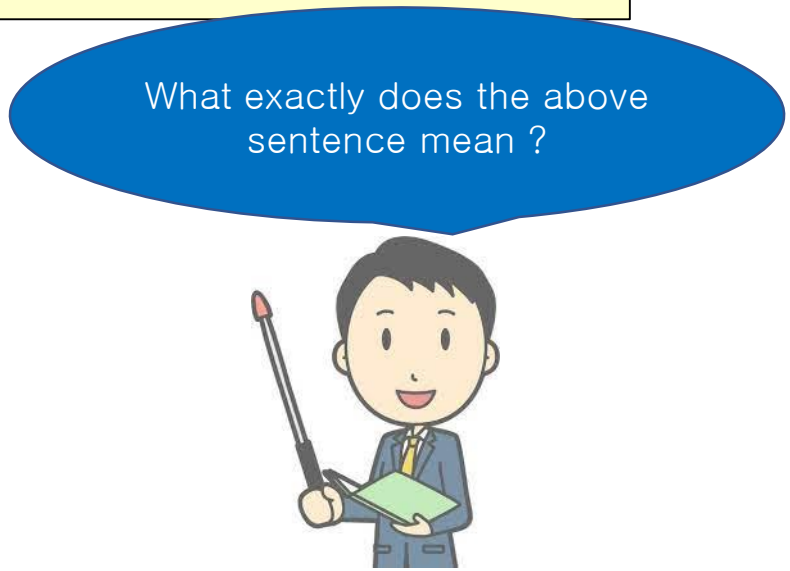
```
char str[10] = "Hello";
str = "World"; // Grammatical error !
```

As we learned in arrays, the name of an array is a pointer constant that points to the array. It cannot be changed.

String constant

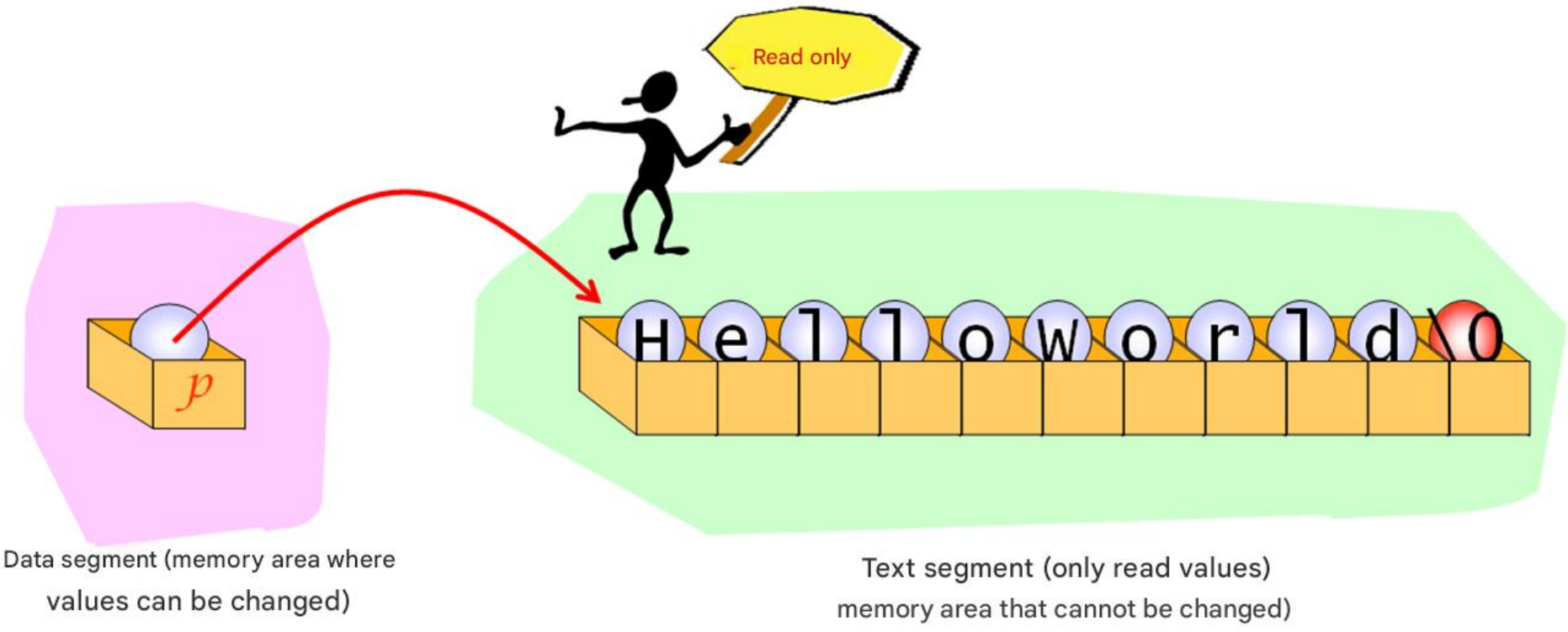
- String constant : Strings included in the program source code such as “HelloWorld”.
- String Constants are stored in **text segment** among the memory areas.

```
char *p = " HelloWorld ";
```



String constant

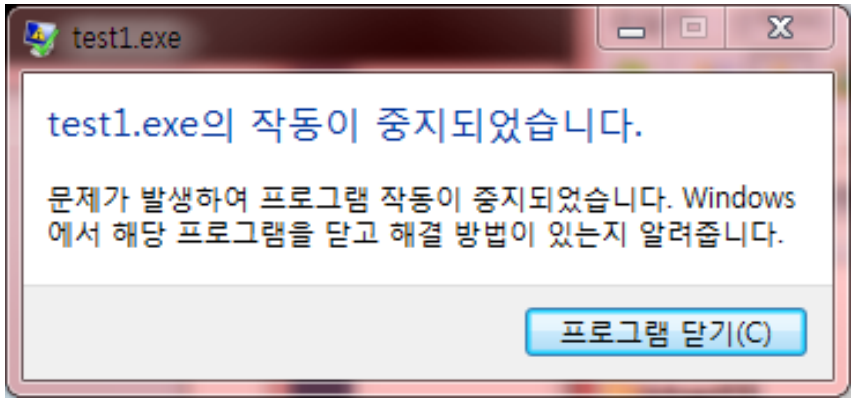
```
char *p = " HelloWorld ";
```

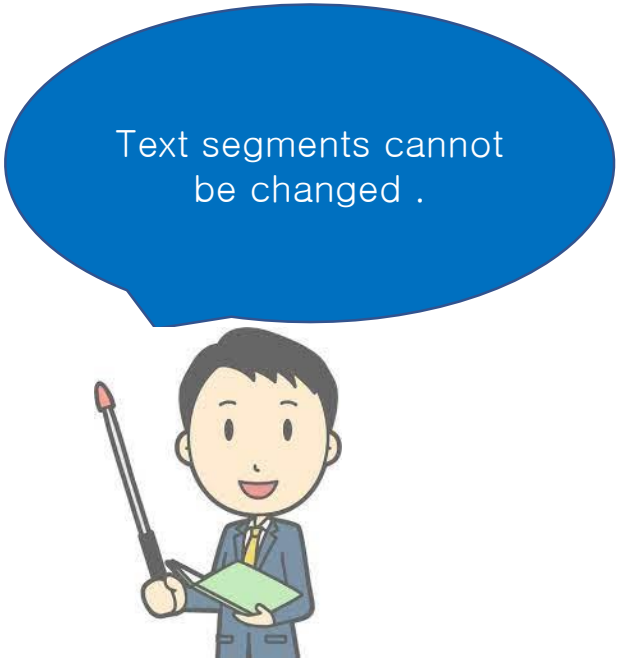


String constant

```
char *p = "HelloWorld";
strcpy (p, “Goodbye”);
```

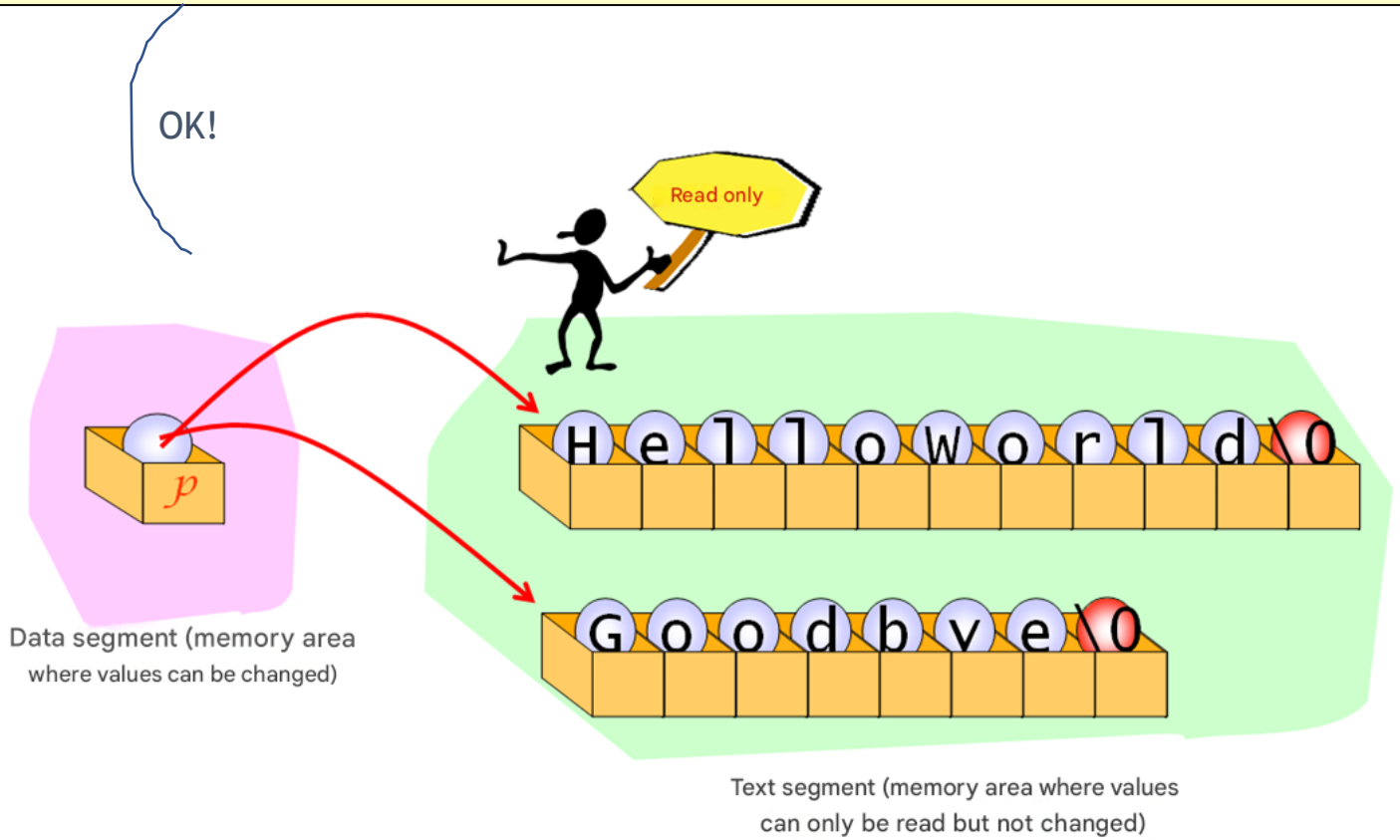
An error occurs when trying to store characters in a text segment via p .





String constant

```
char *p = " HelloWorld ";
p = "Goodbye";
```



Example

```c
#include < stdio.h >

int main( void )
{
    char * p = "HelloWorld" ;
    printf ( "%s \n" , p);

    p = "Welcome to C World!" ; // possible
    printf ( "%s \n" , p);

    p = "Goodbye" ; // possible
    printf ( "%s \n" , p);
    // p[0] = 'a'; // An error occurs .

    return 0;
}
```

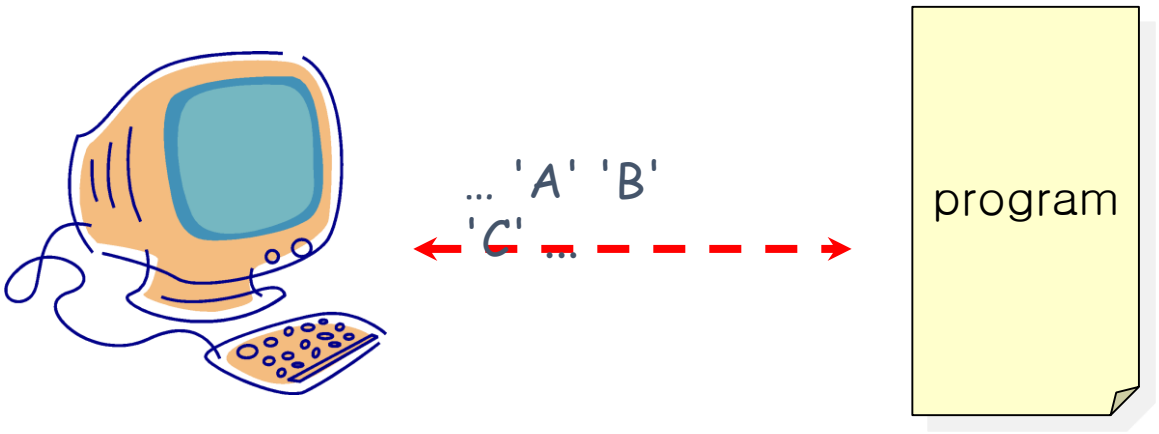
```
HelloWorld
Welcome to C World!
Goodbye
```

Check points

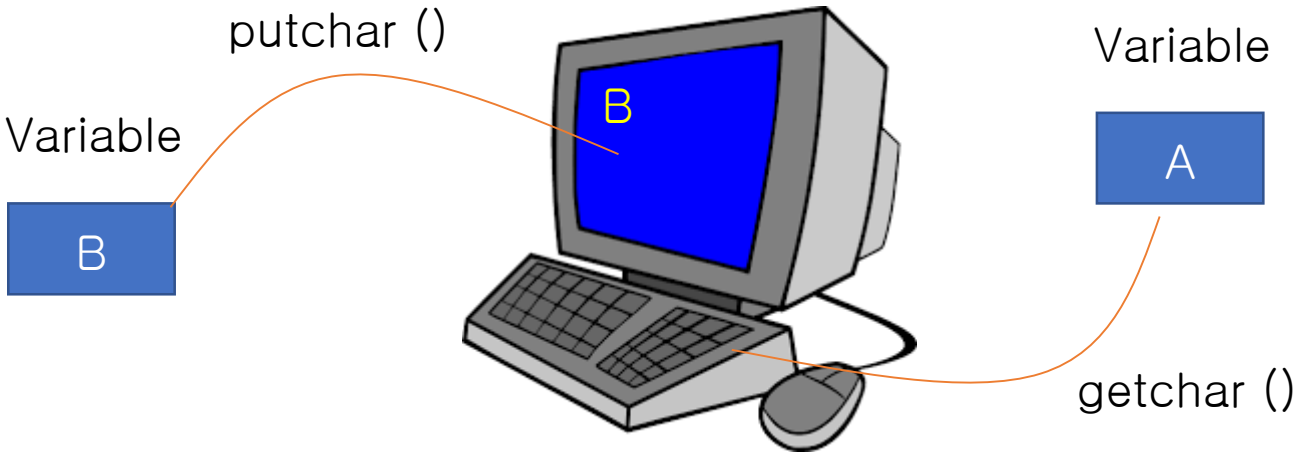
1. How are strings defined in C ?
2. What is the role of the NULL character in a string ?
3. What is the ASCII code value of the NULL character ?
4. What happens if I print a string that doesn't end with a NULL character ?
5. Explain the difference between 'B', and "B" .
6. Where are mutable strings stored ?
7. Why is the size of the character array one larger than the size of the string ?
8. How to initialize a character array to a string.

Character input/output library

Input/output functions	explanation
int getchar(void)	Reads and returns a single character.
void putchar(int c)	Prints the character stored in variable c.
int _getch(void)	Reads and returns a single character (without using a buffer).
void _putch(int c)	Prints the character stored in variable c (without using a buffer).
scanf("%c", &c)	Read one character and store it in variable c.
printf("%c", c);	Prints the character stored in variable c.



getchar (), putchar ()



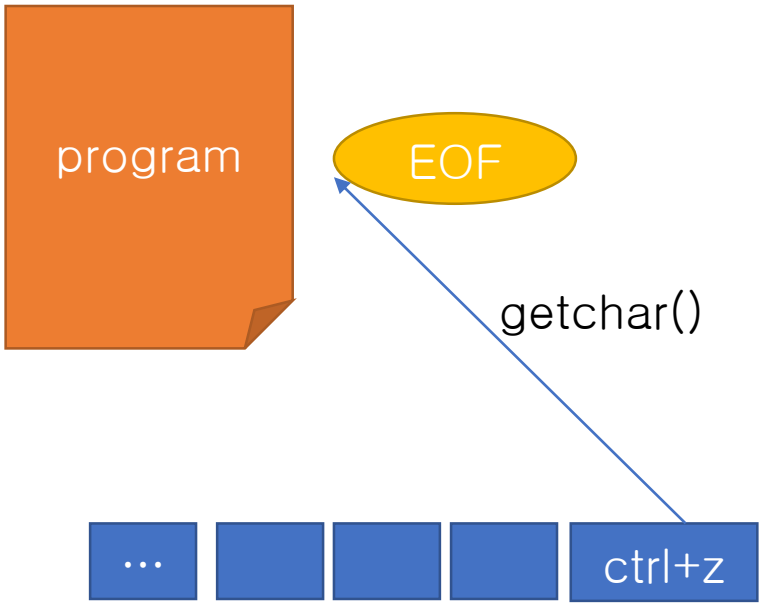
getchar(), putchar()

```
// Usage of
#include < stdio.h >
int main( void )
{
      int ch ;  // Note the use of integers
      while ( ( ch = getchar ()) != EOF )
          putchar ( ch );
      return 0;
}
```

Character indicating
End Of File ,
EOF is an integer -1 .

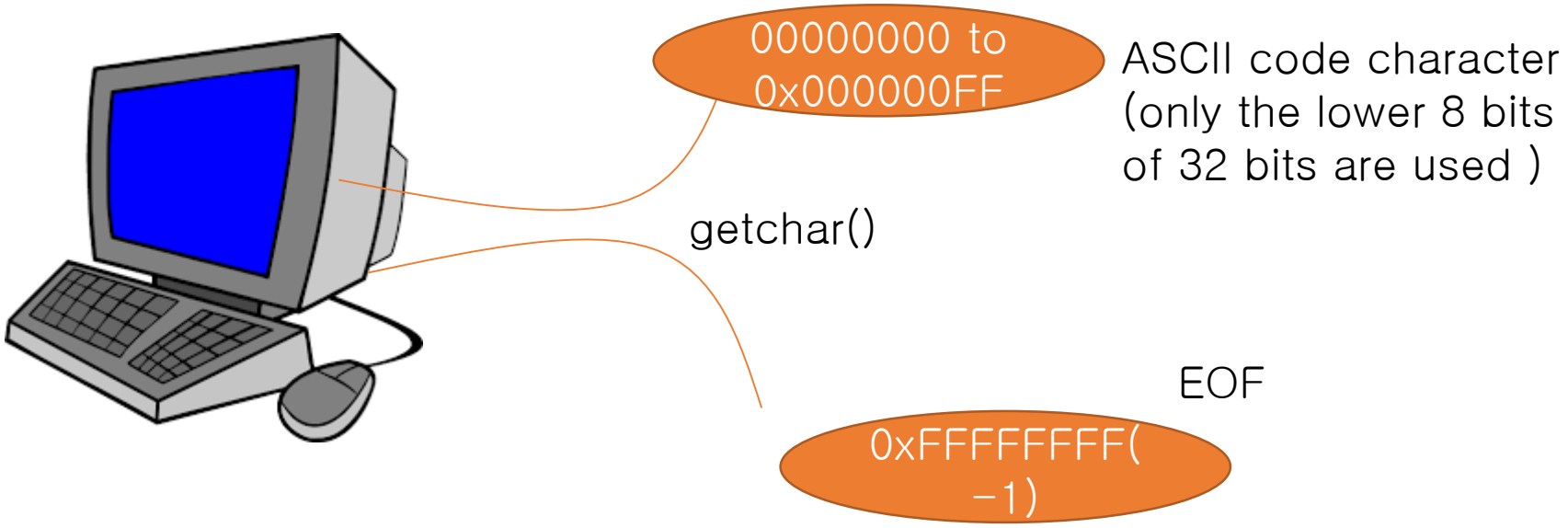
EOF

- EOF(End Of File): A special symbol indicating the end of input.



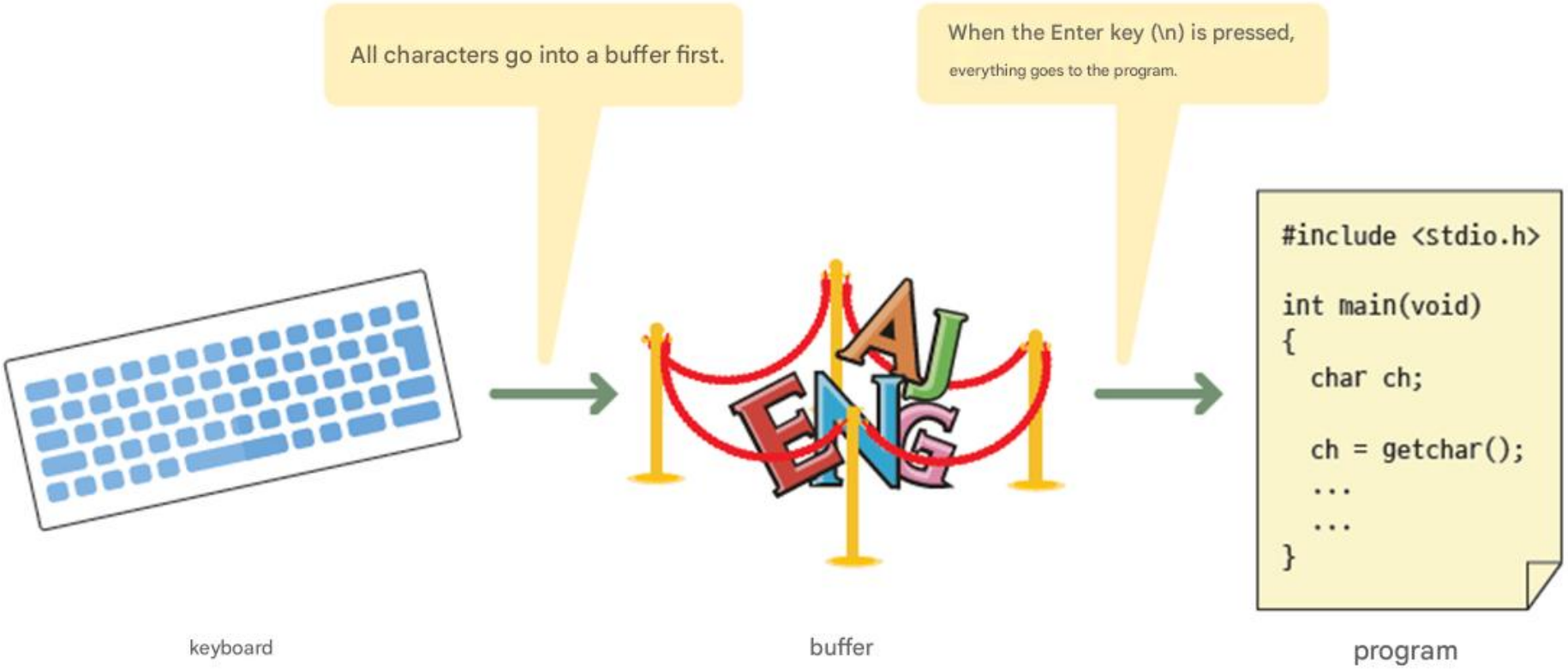
The return value of getchar() Why it's an integer

- The return type of getchar() is “int” to distinguish the ASCII code from EOF.
- If you use a 32 -bit int type, you can clearly distinguish between the ASCII code (0x000000000 to 0x000000FF) and EOF (0xFFFFFFFF), which is a 32- bit int type -1. (It's impossible to do with 8 bits).



Buffering

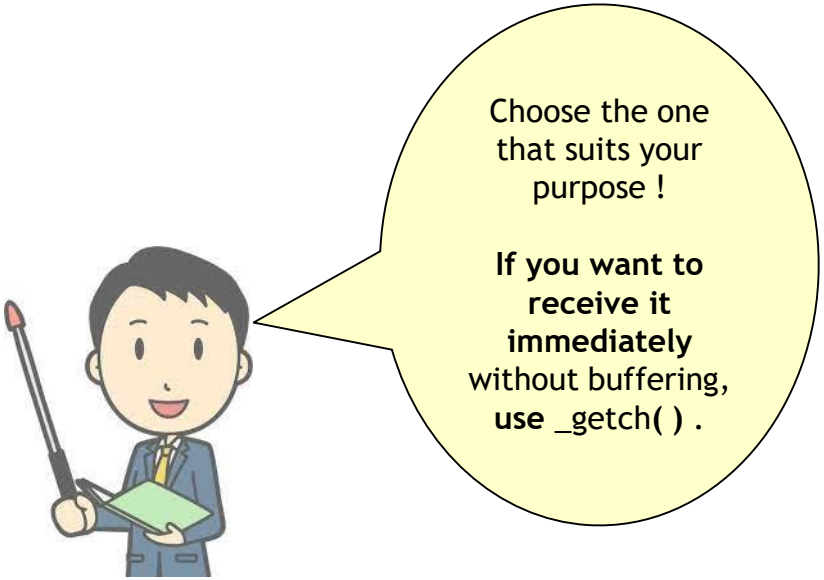
- press Enter to get input?



OS Kernel memory space

_getch (), _getche ( ), getchar ( )

	header file	Whether to use buffer	Eco or not	Responsiveness	Whether to modify text
getchar()	<stdio.h>	used (Entered by pressing Enter)	echo	line unit	possible
_getch()	<conio.h>	Not used	Does not echo	character unit	impossibility
_getche()	<conio.h>	Not used	echo	character unit	impossibility



_ getch(), _ putch()

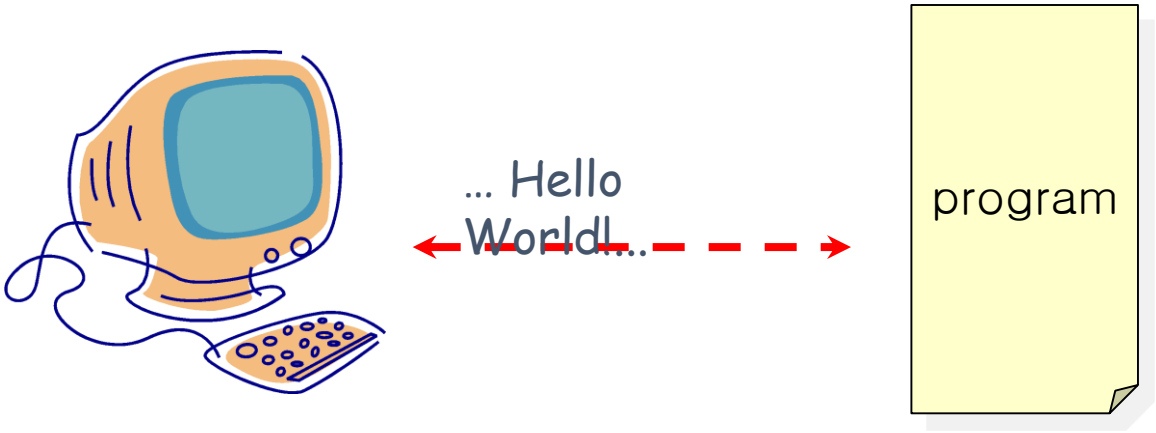
Useful for editing programs!

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

int main( void )
{
        int ch ;
        while (( ch = _ getch ()) != 'q' )
            _ putch( ch );
        return 0;
}
```

Do not use buffers
,
No echo !

String input/output library functions

	Input/output functions	explanation
	int scanf("%s", s)	Read a string and store it in a character array
	int printf("%s", s)	Prints the string stored in array s[].
Windows	char * gets_s(char *s, int size)	Read a line of string and store it in the character array s[] .
	int puts(const char *s)	Prints a single line of string stored in array s[].



Example

```
#include < stdio.h >

int main( void )
{
        char name[100];
        char address[100];

        printf ( "Enter your name : " );
        scanf ( "%s" , name);
        printf ( "Enter your current address : " );
        scanf ( "%s" , address);

        printf ( "Hello , Mr. % s who lives in %s .\n" , address, name);
        return 0;
}
```

```
Enter your name : Hong
Enter your current address : Seoul Jongno -gu 1st room 303

Hello . I am Hong living in Seoul.
```

The address is not fully saved.

gets_s () and puts() string input/output

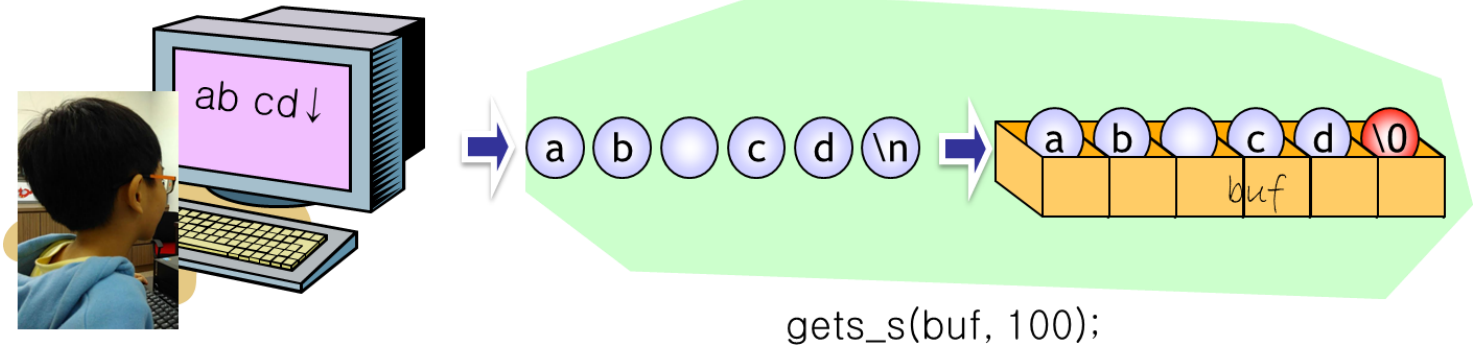
Syntax gets_s()

yes

```
char buf[100];
gets_s(buf, 100);
puts(buf);
```

Takes one line of input from the user.

Prints one line.



gets_s(buf, 100);

Example

```
#include < stdio.h >
int main( void )
{
        char name[100];
        char address[100];

        printf ( “Enter your name : “ );
        gets_s (name, sizeof (name));
        printf ( “Enter your current address : “ );
        gets_s (address, sizeof (address));

        printf ( “Hello , Mr. % s who lives in %s .\n” , address, name);
        return 0;
}
```

Used when entering more than one word

.

```
Enter your name : Hong Gil-dong
Enter your current address : 1 Jongno -gu, Seoul

Hello ? I am Hong Gil-dong, living at 1 Jongno-gu, Seoul .
```

Character processing library functions

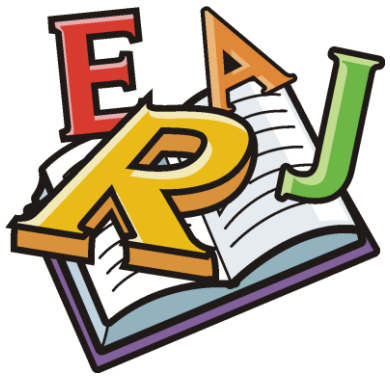
- Check or convert characters .

Function	explanation
isalpha (c)	Is c an English letter ? (az, AZ)
isupper (c)	Is c uppercase ? (AZ)
islower(c)	c lowercase ? (az)
isdigit (c)	Is c a number ? (0-9)
isalnum(c)	c a letter or a number ? (az, AZ, 0-9)
isxdigit(c)	Is c a hexadecimal number ? (0-9, AF, af)
isspace(c)	Is c a space character ? (' ', '\n', '\t', '\v', '\r')
ispunct(c)	Is c a punctuation character ?
isprint(c)	C a printable character ?
iscntrl(c)	Is c a control character ?
isascii(c)	c an ascii code ?

Character processing library functions

- Check or convert characters .

Function	explanation
toupper(c)	c to uppercase .
tolower(c)	c to lowercase .
toascii(c)	c to ASCII code .



Example

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

int main( void )
{
      int c;

      while ((c = getchar ()) != EOF)
      {
          if ( islower (c) )
                c = toupper (c);
          putchar (c);
      }
      return 0;
}
```

Check if it is lowercase

Convert to uppercase

```
abcdef
ABCDEF
^ Z
```

To input EOF from your keyboard, type ^Z

Lab: Words century

- Let's write a program that counts the number of words in a string. If the string is “the c book…” , the output will be as follows :

Example

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

int count_word ( char * s );
int main( void )
{
    int wc = count_word ( "the c book..." );
    printf ( " Number of words : %d \n" , wc );

    return 0;

}
```

Example

```
int count_word ( char * s )
{
    int i , wc = 0, waiting = 1;

    for ( i = 0; s [ i ] != NULL ; ++ i ) // Examine each letter of
        if ( isalpha ( s [ i ])) // If the letter of
        {
            if (waiting) // If you are waiting for a word
            {
                wc ++; // increment the counter
                waiting = 0; // Processing words
             }
         }
          else // if it is not an alphabet
               waiting = 1; // Wait for a word .

   return wc ;
}
```

Lab: Check valid password

- A valid password must be at least 7 characters long , contain at least one lowercase letter, at least one uppercase letter, and at least one number .

Solution

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

int main( void )
{
        int lower_case_count = 0; // Number of lowercase letters
        int upper_case_count = 0; // Number of uppercase letters
        int digit_count = 0; // number of digits
        char pass[100];
        int len ;

        printf ( " Enter your password : " );
        gets_s (pass, sizeof (pass));
```

Solution

```
        len = strlen (pass); // length of the string
        if ( len < 7) {
                printf ( " Not a valid password .\n" );
                exit(1);
        }
        for ( int i = 0; i < len ; i ++) {
                if ( islower (pass[ i ])) ++ lower_case_count ;
                if ( isupper (pass[ i ])) ++ upper_case_count ;
                if ( isdigit (pass[ i ])) ++ digit_count ;
        }
        if ( lower_case_count > 0 && upper_case_count > 0 && digit_count > 0)
                printf ( " This is a strong password . \n" );
        else
                printf ( " Not a valid password \n" );
        return 0;
}
```

Check points

1. What header files must I include to use the character processing library functions ?
2. What is the difference between getchar() and getch() ?
3. What is the return value of ispunct('.') ?
4. What is the return value of toupper('a') ?

String processing library

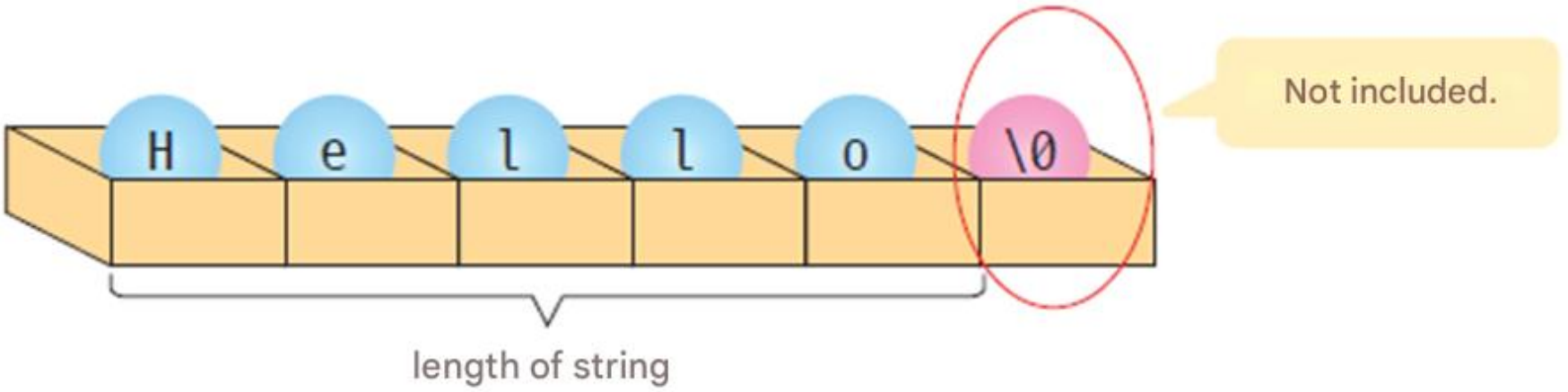
- String functions are declared in string.h. Therefore, to use these functions, you must include string.h at the beginning of your program.

Function	explanation
strlen(s)	Finds the length of string s .
strcpy(s1, s2)	Copy s2 to s1 .
strcat(s1, s2)	Paste s2 to the end of s1 .
strcmp(s1, s2)	Compare s1 and s2 .
strncpy(s1, s2, n)	Copy at most n characters from s2 to s1 .
strncat(s1, s2, n)	Paste at most n characters from s2 to the end of s1 .
strncmp(s1, s2, n)	Compares s1 and s2 up to n characters .
strchr(s, c)	Finds the character c in string s .
strstr(s1, s2)	Find string s2 in string s1 .

Length of string

- The function to calculate the length of a string is strlen (const char *str) .

```
int size = strlen ("Hello"); // size becomes 5

char a[6] = “Hello”;
Int size = strlen(a);          // size becomes 5
```

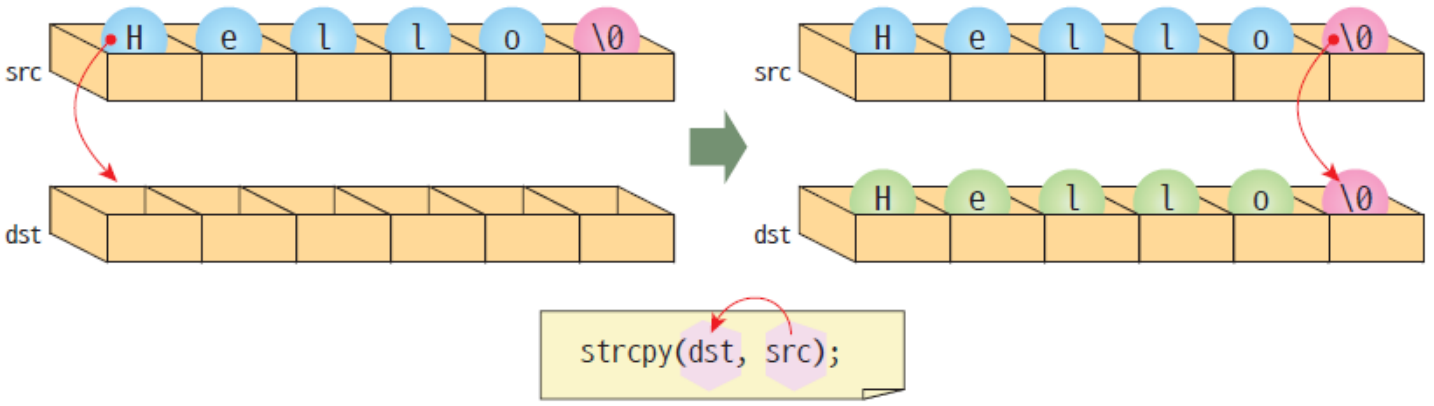


Copy string

Syntax strcpy()

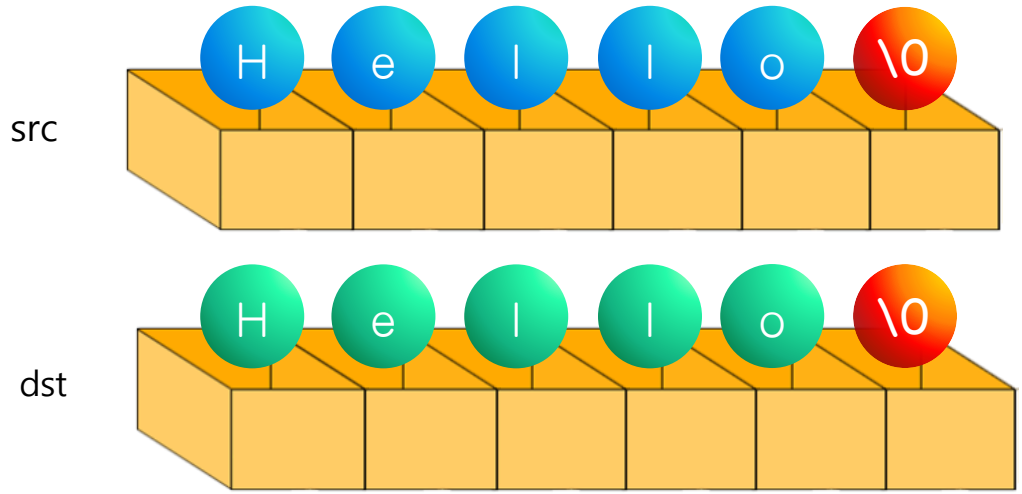
yes

```
char dst[6];
char src[6]="Hello";
strcpy(dst, src);                    // Copy src to dst.
```



String copy animation

```
char dst [6];
char src [6] = “Hello";
strcpy ( dst , src );
```

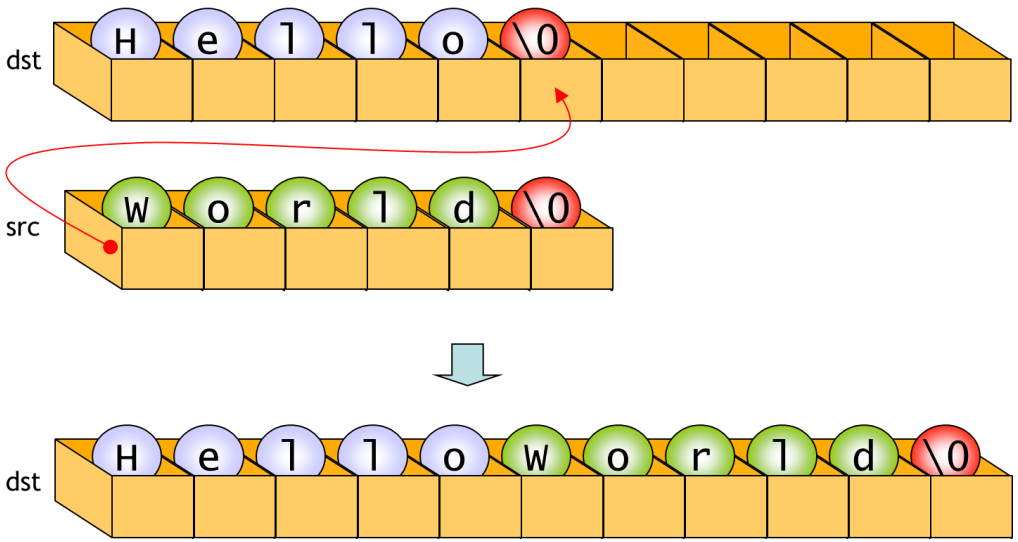


String concatenation

Syntax strcat()

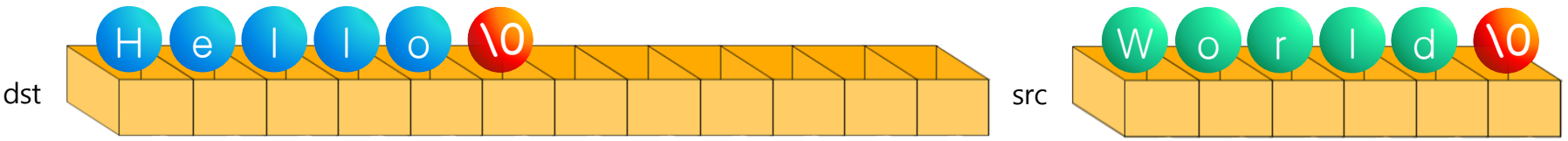
yes

```
char dst[12]= "Hello";
char src[6] = "World";
strcat(dst, src);                    // dst becomes "HelloWorld".
```



String concatenation animation

```
char dst [12] = "Hello";
char src [6] = "World";
strcat ( dst , src );
```



Example

```
// strcpy and strcat
#include < string.h >
#include < stdio.h >

int main( void )
{
        char string[80];

        strcpy ( string, "Hello world from " );
        strcat (string, " strcpy " );
        strcat ( string, "and " );
        strcat ( string, " strcat !" );
        printf ( "string = %s\n" , string );
        return 0;
}
```

```
string = Hello world from strcpy and strcat !
```

String comparison

Syntax `strcmp()`

strcmp() compares strings s1 and 2 lexicographically.

If s1 comes first in the (lexicographic) order, the negative number is

If it is returned, 0 is returned if it is equal, and a positive number is returned if it is later.

yes

```
int result = strcmp("dog", "dog"); // 0 is returned.
```

return value	Relationship between s1 and 2
〈 0	s1 comes before s2.
0	s1 == s2
〉0	s1 comes after s2.

The string If they are equal,
strcmp ( ) returns

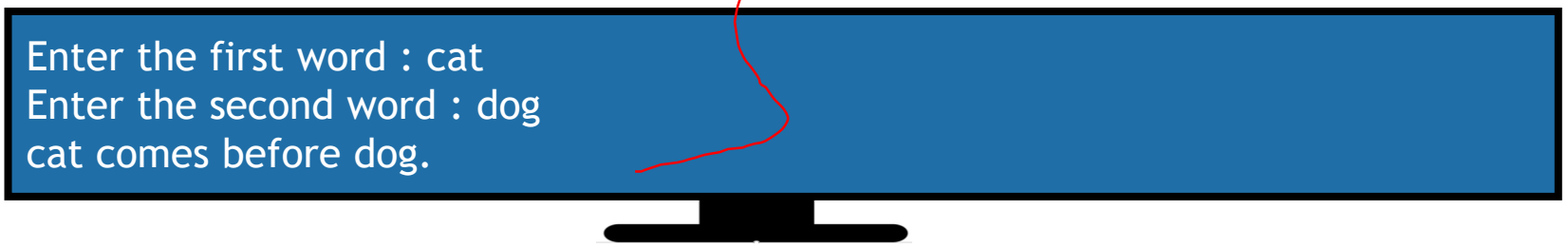
Example

```
// strcmp () function
#include < string.h >
#include < stdio.h >

int main( void )
{
        char s1[80]; // first The word To save Character array
        char s2[80]; // second The word To save Character array
        int result;

        printf ( " first The word Enter :" );
        scanf ( "%s" , s1);
        printf ( " second The word Enter :" );
        scanf ( "%s" , s2);
```

Example

```
    result = strcmp (s1, s2);
    if ( result < 0 )
        printf ( "% s is greater than % s" in front There are .\n" , s1, s2);
    else if ( result == 0 )
        printf ( "% s is % s and are the same .\n" , s1, s2);
    else
        printf ( "% s is greater than % s" behind are .\n" , s1, s2);
     return 0;
}
```

Alphabetically, meaning it is at the front in the dictionary



Text search

- To check whether a given string contains a specific character, use strchr() .

Syntax strchr()

예

```
char *p = strchr("dog", 'g');
```

Return the address of character ‘g’

Text search

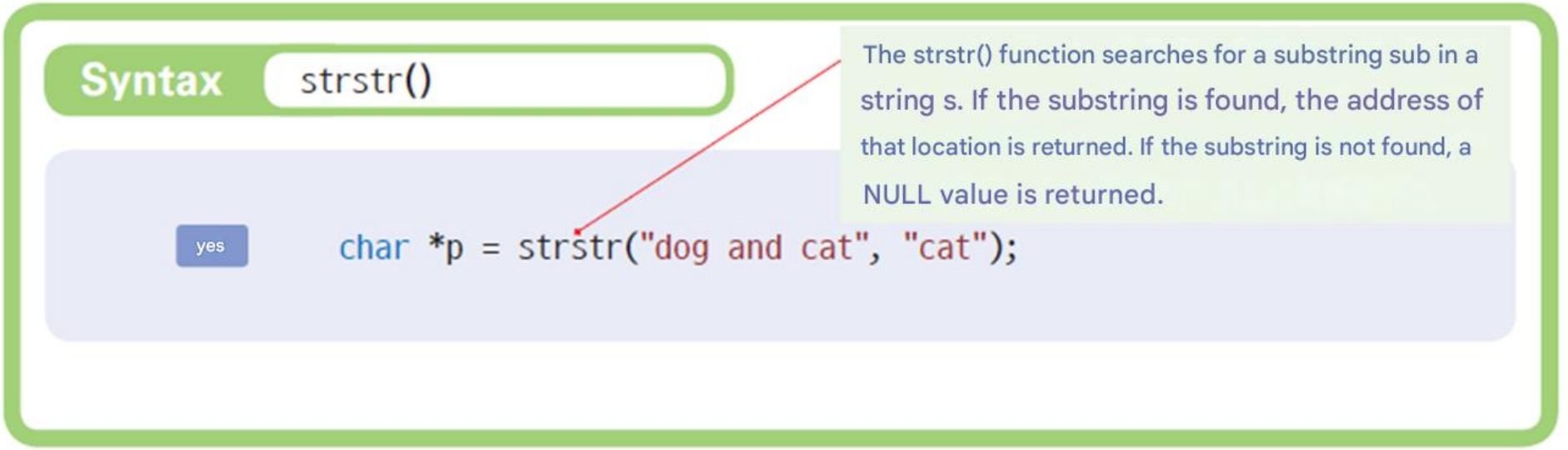
```
#include < string.h >
#include < stdio.h >

int main( void )
{
        char s[] = "language";
        char c = 'g';
        char *p;
        int loc;

        p = strchr (s, c);
        if ( p == NULL )
             printf ( "%c not found \n" , c );
        else {
             loc = ( int )(p - s);
             printf ( " First %c in %s found in %d \n" , c, s, loc);
         }
        return 0;
}
```

Search the letter c in string s

First g in language was found in 3

String search

- To search for a specific string within a given string, use strstr ().



String search

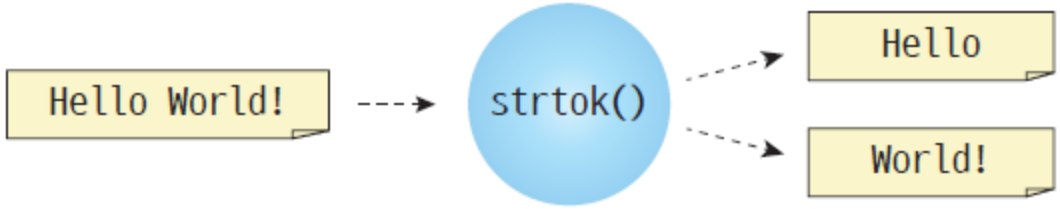
```
#include < string.h >
#include < stdio.h >

int main( void )
{
        char s[] = "A bird in hand is worth two in the bush";
        char sub[] = "bird";
        char *p;
        int loc;

        p = strstr (s, sub);
        if ( p == NULL )
              printf ( "%s not found \n" , sub );
        else {
              loc = ( int )(p - s);
              printf ( " First %s in % s found in %d\n" , sub , s, loc );
         }
        return 0;
}
```

Search sub string in string s

First bird in A bird in hand is worth two in the bush was found in 2

String tokenization

- The strtok () function makes it easy to separate words from a sentence.



String tokenization

- The strtok () function makes it easy to separate words from a sentence.
- The reason to put NULL from 2nd calling function is because strtok internally remembers the state of the previous string and continues to search for the next token from that saved location.

```
char[] s = “Man is immortal, because he has a soul” ;
t1 = strtok (s, “ “ ); // first th token : Man
t2 = strtok (NULL, " " ); // Second token : is
t3 = strtok (NULL, “ “ ); // Third token : immortal,
t4 = strtok (NULL, " " ); // fourth token : because
```

String tokenization

```
// strtok Example of using a function
#include < string.h >
#include < stdio.h >

char s[] = "Man is immortal, because he has a soul";
char seps [] = " ,\t\n";
char *token;

int main( void )
{
      // string And pass it on next Token Get .
      token = strtok ( s, seps );
      while ( token != NULL )
      {
            // string In s The token present during Repeat .
            printf ( " Token : %s\n" , token );
            // next Token Get .
            token = strtok (NULL, seps ); //
      }
}
```

separa
tor

```
Token : Man
Token : is
Token : immortal
Token : because
Token : he
Token : has
Token : a
Token : soul
```

Check points

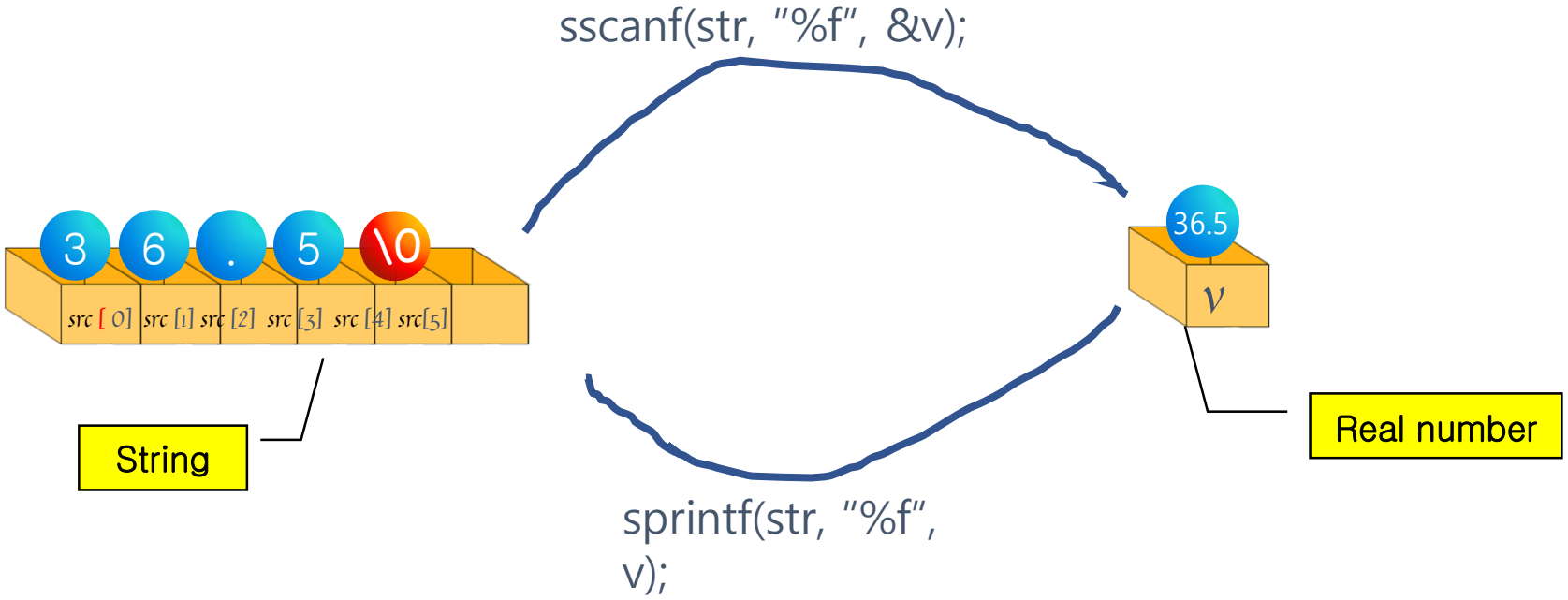
1. Write a statement that copies string s1 to string s2.
2. What is the minimum size of a character array required to store a "String" ?
3. What is the function to compare strings ?
4. What is the difference between strcpy() and strncpy() ?
5. s2[] to the end of the string stored in s1[], what library function should I use and how ?
6. What is the return value of strcmp ("dog", "dog") ?

String to number conversion

- String “36.5” and numeric value 36.5
- They are stored quite differently within a computer.

String conversion : sprintf() and sscanf()

- in front the attached s means string .



Example

```
#include < stdio.h >

int main( void )
{
        char instring []="file 12";
        char name[10];
        int number;

        sscanf ( instring , "%s %d", name, &number);

        printf ("name = %s \n", name);
        printf ("number = %d \n", number);
        return 0;
}
```

Example

```
#include < stdio.h >

int main( void )
{
        char buffer[50];
        int x=10, y=20, result;

        result = x + y;
        sprintf (buffer, "Integer %d plus integer %d is %d .", x, y, result);


        printf ("%s \n", buffer);
        return 0;
}
```

Lab: Automatically generate video file names

- Let's write a program that automatically generates file names .

```
image0.jpg
image1.jpg
image2.jpg
image3.jpg
image4.jpg
image5.jpg
```

Example

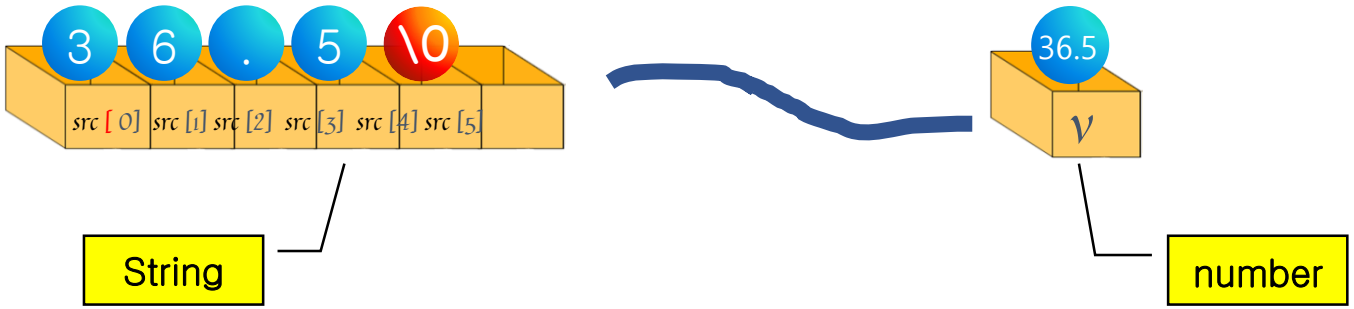
```
#include < stdio.h >
#include < string.h >

int main( void )
{
   char filename[100];
   int i ;

   for (i=0; i < 6; i++){
      sprintf (filename, "image%d.jpg" , i );
      printf ( "%s \n" , filename);
   }
   return 0;
}
```

Create sequential file names .

Functions to convert a string to a number

- The dedicated function is smaller than scanf() .
- Prototype definition in stdlib.h - must be included

Function	explanation
int atoi(const char *str);	Convert string to int type .
double atof(const char * str);	Convert string to double type .



String to number conversion

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

int main( void )
{
        char s1[] = "100" ;
        char s2[] = "12.93" ;
        int i ;
        double d, result;

        i = atoi (s1);
        d = atof (s2);

        result = i + d;
        printf ( " The result of the operation is %.2f .\n" , result);

        return 0;
}
```

The result of the operation is 112.93.

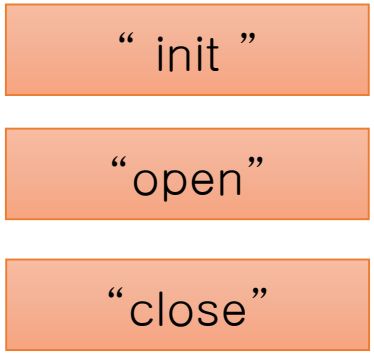
Check points

1. Compare the memory space occupied by number 3.141592 and the string "3.141592".
2. What functions can be used to convert the string " 3.141592" to a real number ?
3. What is the difference between printf() and sprintf() ?

Array of strings

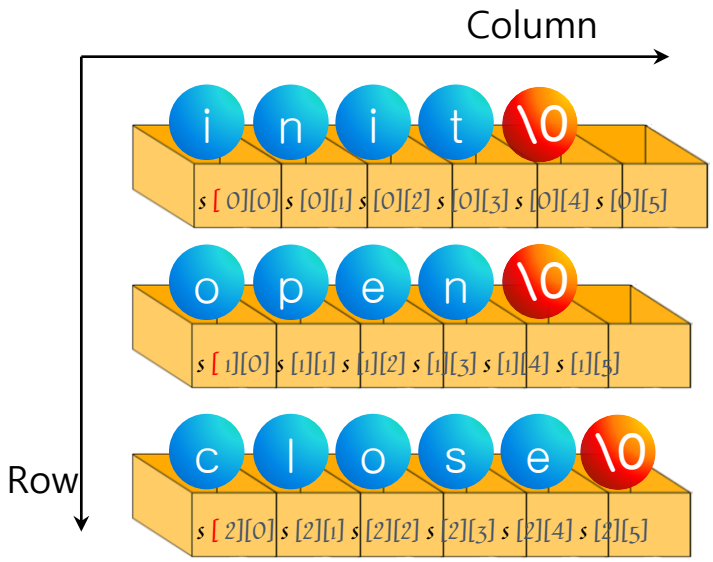
- If I have multiple strings, what is the best structure to store them in ?
  - (Example) " init", "open", "close", ...

- Two ways .
  - String array
  - Array of character pointers



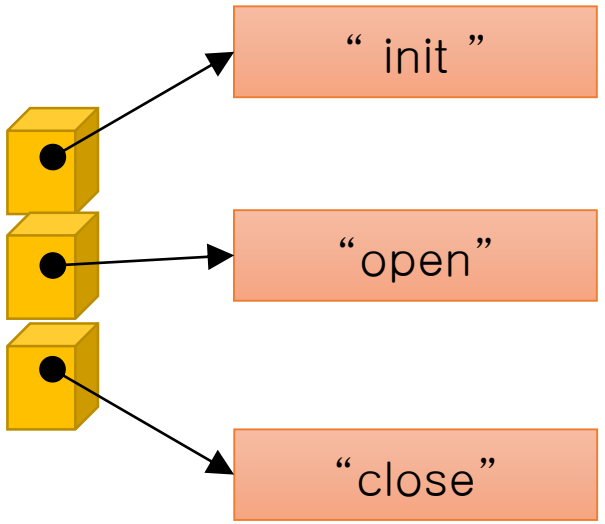
1. String array

```
char s[3][6] = {
        "init",
        "open",
        "close"
};
```



2. Array of character pointers

```
char *s[3] = {
        "init ",
        "open",
        "close"
};
```



Example


```c
#include < stdio.h >

int main( void )
{
    int i ;
    char menu[5][10] = {
        " init " ,
        "open" ,
        "close" ,
        "read" ,
        "write"
    };

    for (i = 0; i < 5; i++)
        printf ( "% menu : %s \n", i+1, menu[i]);

    return 0;
}
```

```
1 menu : init
2 menu : open
3 menu : close
4 menu : read
5 menu : write
```

Input as a two- dimensional array

Practice

```
#include < stdio.h >
int main( void )
{
        int i ;
        char fruits[3][20];
        for ( i = 0; i < 3; i ++) {
              printf ( " Enter the fruit name : " , fruits[ i ]);
              scanf ( "%s" , fruits[ i ]);
        }
        for ( i = 0; i < 3; i ++)
               printf ( "% fruit : %s\n" , i , fruits[ i ]);
        return 0;
}
```

```
Enter the name of the fruit : apple
Enter the name of the fruit : Pear
Enter the name of the fruit : Grape
0 fruit : apple
1 fruit : pear
2 fruit : grapes
```

Lab: Korean-English Implementation of the dictionary

- Let's implement a simple Korean-English dictionary using a three- dimensional string array .

```
Enter the word : boy
boy: boy
```

Implementation of Korean-English dictionary

```
#define ENTRIES 5

int main( void )
{
	int i , index;
	char dic [ENTRIES][2][30] = {
		{"book", "책"},
		{"boy", "소년"},
		{"computer", "컴퓨터"},
		{"lanuguage", "언어"},
		{"rain", "비"},
	};
	char word[30];
```

Implementation of Korean-English dictionary

```
printf ( "Enter a word:" );
scanf ( "%s" , word);

index = 0;
for ( i = 0; i < ENTRIES; i ++)
{
      if ( strcmp ( dic [index][0], word) == 0 )
      {
            printf ( "%s: %s\n" , word, dic [index][1]);
            return 0;
       }
       index++;
  }
  printf ( " from dictionary Not found did not .\n" );

}
```

```
Enter a word : book
book: 책
```

Q & A