C++ For C Coders 5

Data Structures
C++ for C Coders

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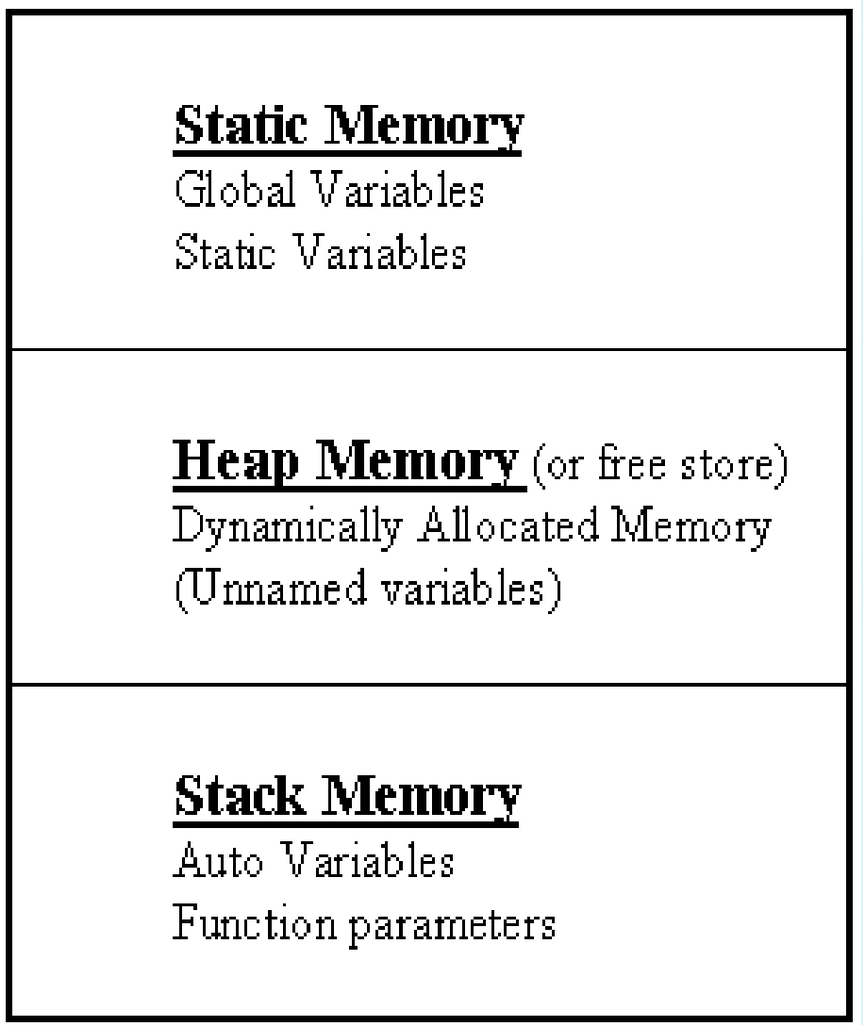
dynamic memory allocation
new & delete operators

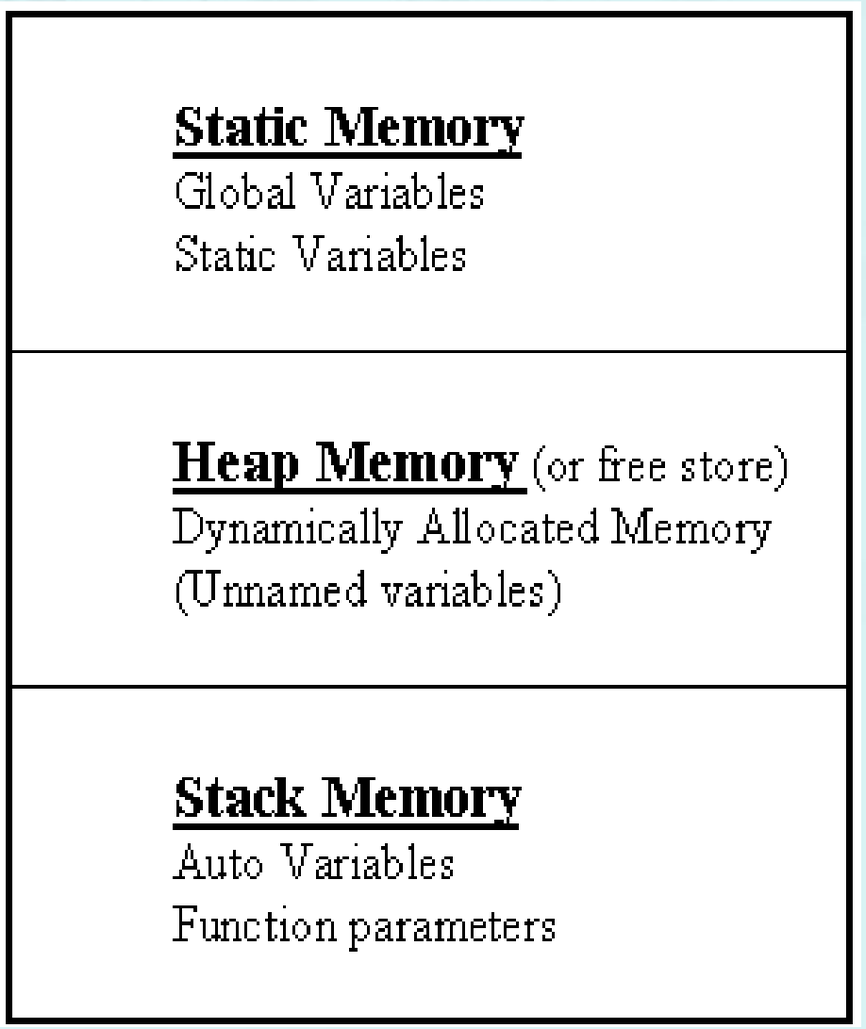
Three kinds of memory (or data)

- **Static memory**
  - where global and static variables live
  - allocated at compile time rather than during runtime when the program is loaded into memory.
  - These variables retain their values throughout the entire execution of the program and have a fixed memory address.



Three kinds of memory (or data)

- **Static memory**
  - where global and static variables live
  - allocated at compile time
- **Heap memory**
  - dynamically allocated at run time
  - "managed" memory accessed using pointers
  - explicitly allocated and deallocated using operators new and delete by programmer



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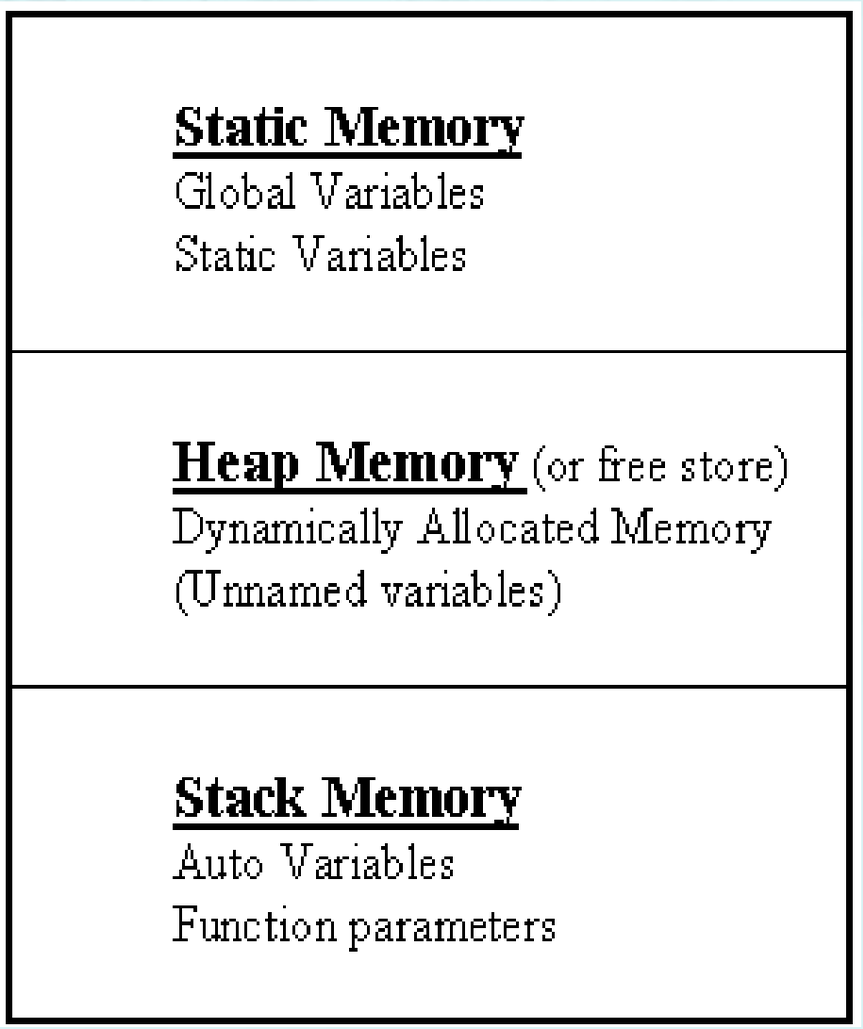
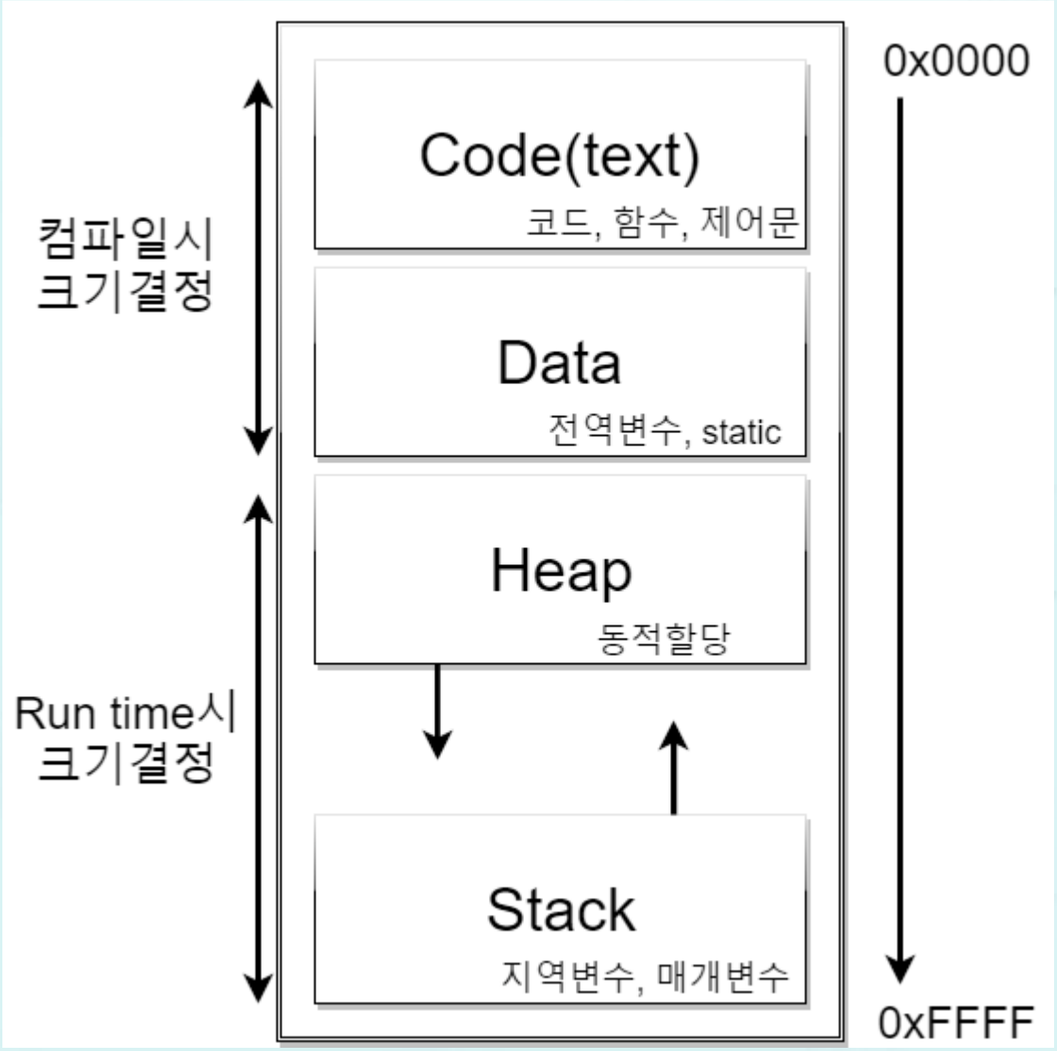
- **Stack memory**
  - used by automatic variables
  - automatically created at function entry, resides in activation frame of the function, and is destroyed when returning from function



Dynamic Memory Allocation Diagram



Dynamic Memory Allocation Diagram


```c

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

const int constval = 30;     // 상수

int uninitial;  // 초기화되지 않은 전역변수
int initial = 30;    // 초기화된 전역변수
static int staticval = 70;  // 정적변수


int function() {     // 함수
    return 20;
}


int main(int argc, const char * argv[]) {

    int localval1 = 30;    // 지역변수 1
    int localval2;       // 지역변수 2

    printf("숫자 입력 : ");
    scanf("%d", &localval2);

    char *arr = malloc(sizeof(char) * 10);  // 동적 할당 변수

    return 0;
}

```

Dynamic Memory Allocation

- *In C*, functions such as **malloc()** are used to dynamically allocate memory from the **Heap**.

- *In C++,* this is accomplished using the **new** and **delete** operators

- **new** is used to allocate memory during execution time
  - returns a pointer to the address where the object is to be stored
  - always returns a pointer to the type that follows the **new**

Operator new Syntax

new DataType

new DataType[IntialExpression]

- If memory is available, in an area called the heap (or free store) **new** allocates the requested object or array, and returns a pointer to (address of) the memory allocated.
- Otherwise, program terminates with error message.
- The dynamically allocated object exists until the **delete** operator destroys it.

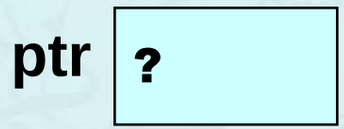
Operator new

```
char  *ptr;
```

```
ptr = new char;

*ptr = 'B';

cout  <<  *ptr;
```



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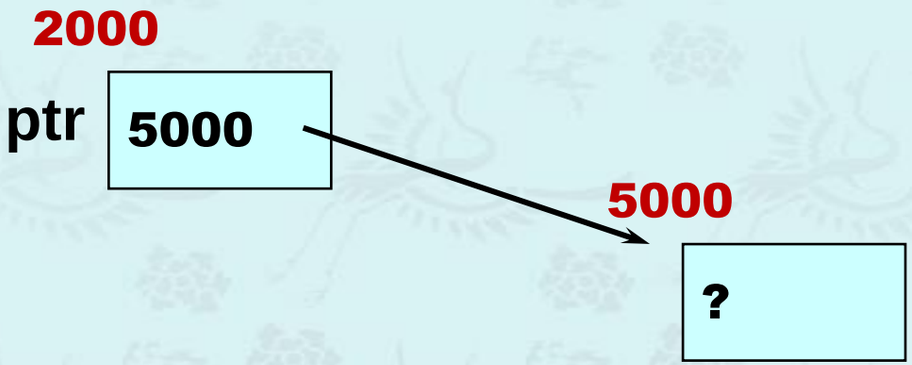

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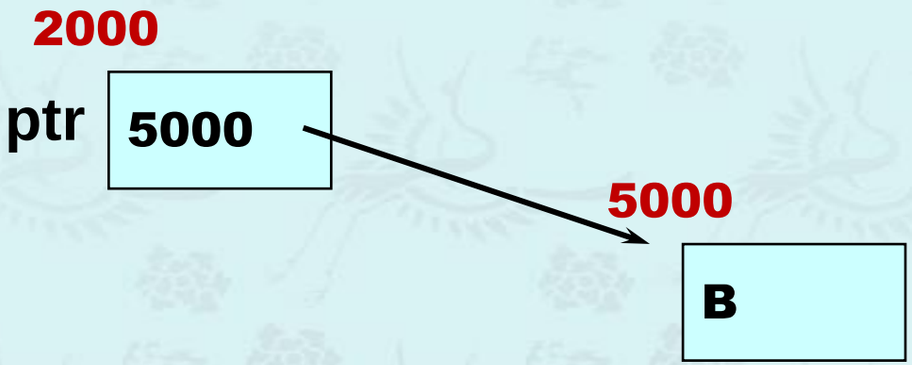

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new vs. malloc()

- new is an operator.
- It calls the constructor.
- It returns exact data type if memory is available.
- It throws bad_alloc exception on failure. Use **nothrow** for **nullptr**.
- It can be overridden.
- In which memory allocated from the heap.
- Size is calculated by the compiler.

- malloc is a library function.
- It does not call the constructor.
- It returns the void * if memory is available.
- It returns `nullptr` on failure.
- It cannot be overridden.
- In which memory allocated from the heap.
- Need to pass the size.

NOTE: Use **malloc()** only if asked. Use **new** and **delete** operators in this course.

The NULL/nullptr Pointer

- There is a pointer constant called the "null pointer" denoted by NULL/nullptr.
- NULL is int type 0 in C/C++, but nullptr is std::nullptr_t type.
- NOTE: It is an error to dereference a pointer whose value is NULL or nullptr. Such an error may cause your program to crash, or behave erratically. It is the programmer's job to check for this.

```
while (ptr != nullptr) {
      . . .
         . . .              // ok to use ptr here
}
```

Operator delete Syntax

```
delete PointerVariable
```

```
delete [] PointerVariable
```

- The object or array currently pointed to by Pointer is deallocated, and the value of Pointer is undefined. The memory is returned to the free store.
- Good idea to set the pointer to the released memory to nullptr.
- Square brackets are used with delete to deallocate a dynamically allocated array.

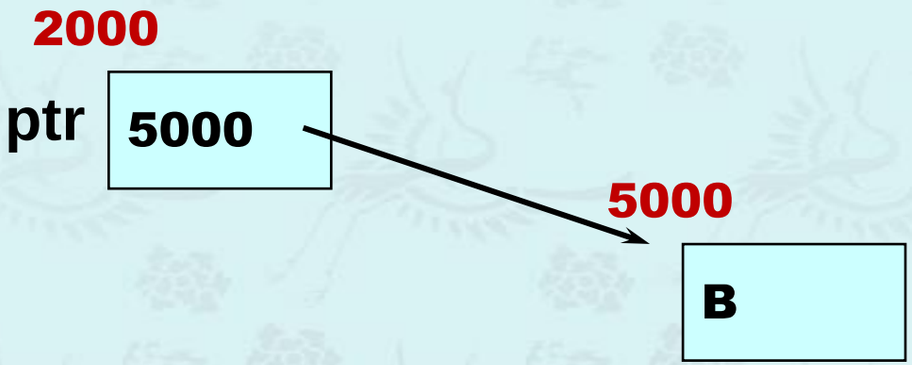
Operator delete

```
char  *ptr;


ptr = new char;

*ptr = 'B';

delete ptr;
```



Question: **After 'delete'** operation, can we use ptr again?

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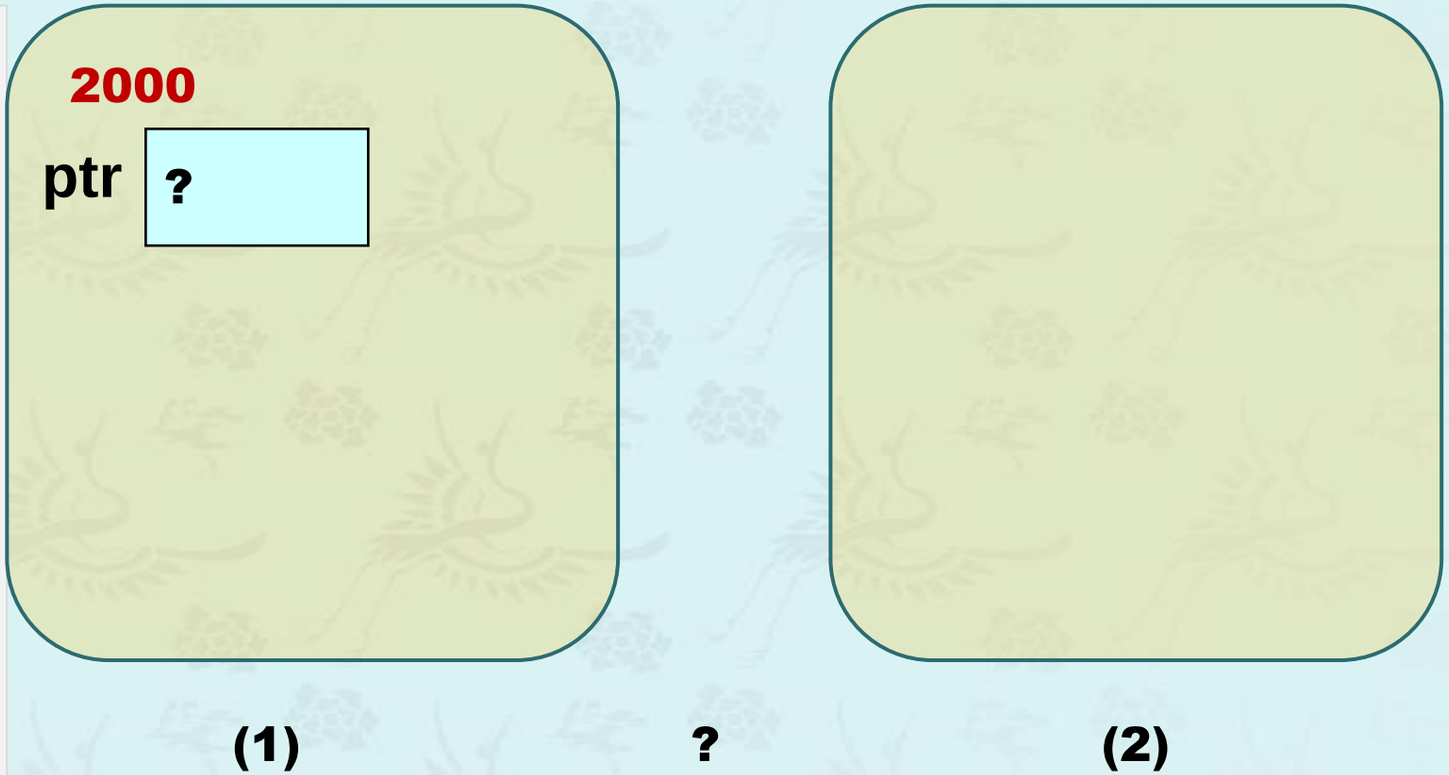

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ptr = new char[10];
delete [] ptr;
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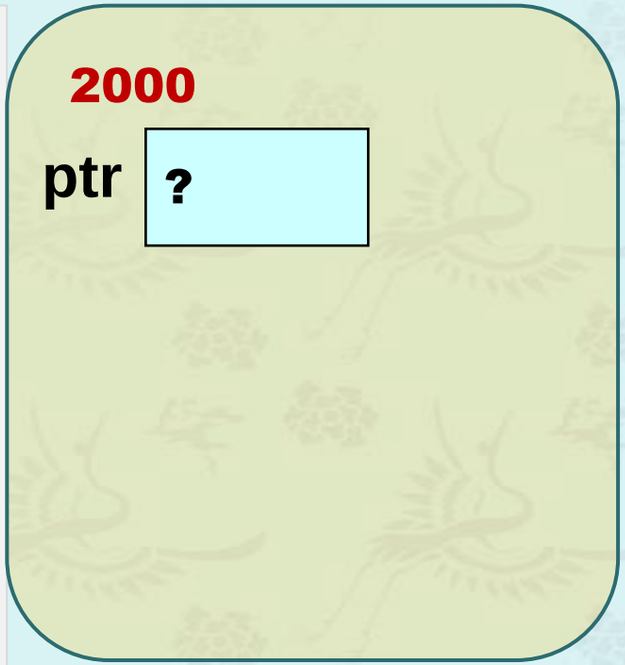


(1)

NOTE: **delete** deallocates the memory pointed to by ptr

Example: Operator delete

```
char  *ptr;

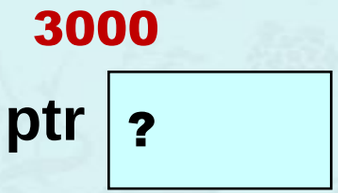
ptr = new char[5];

strcpy(ptr, "Bye");

ptr[0] = 'E';

delete [] ptr;

ptr = nullptr;
```



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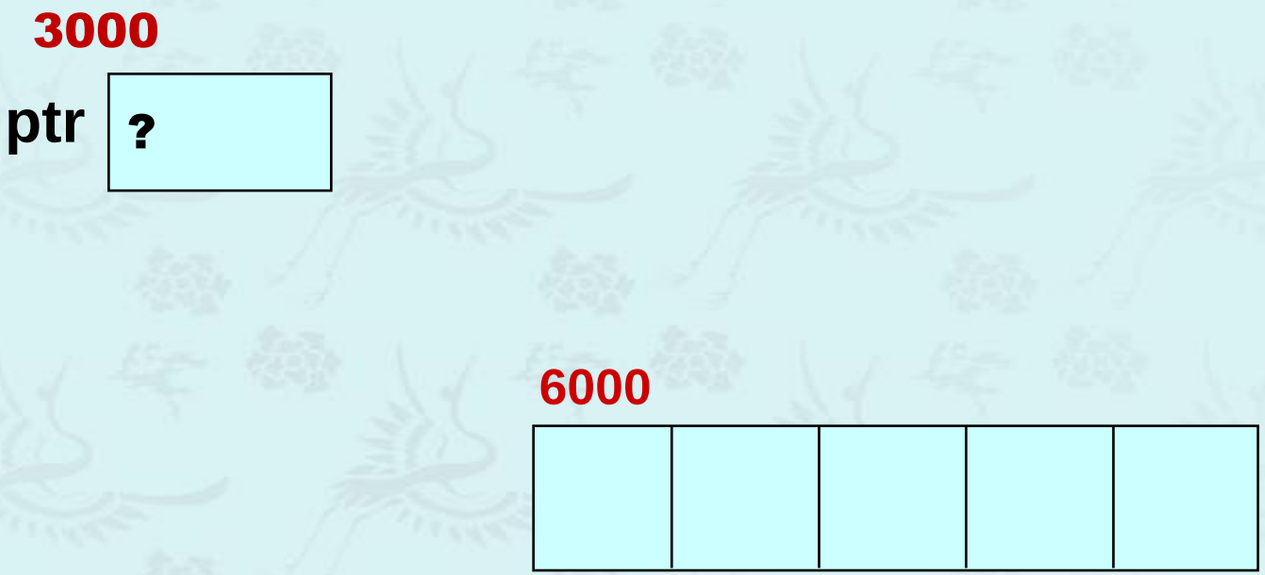

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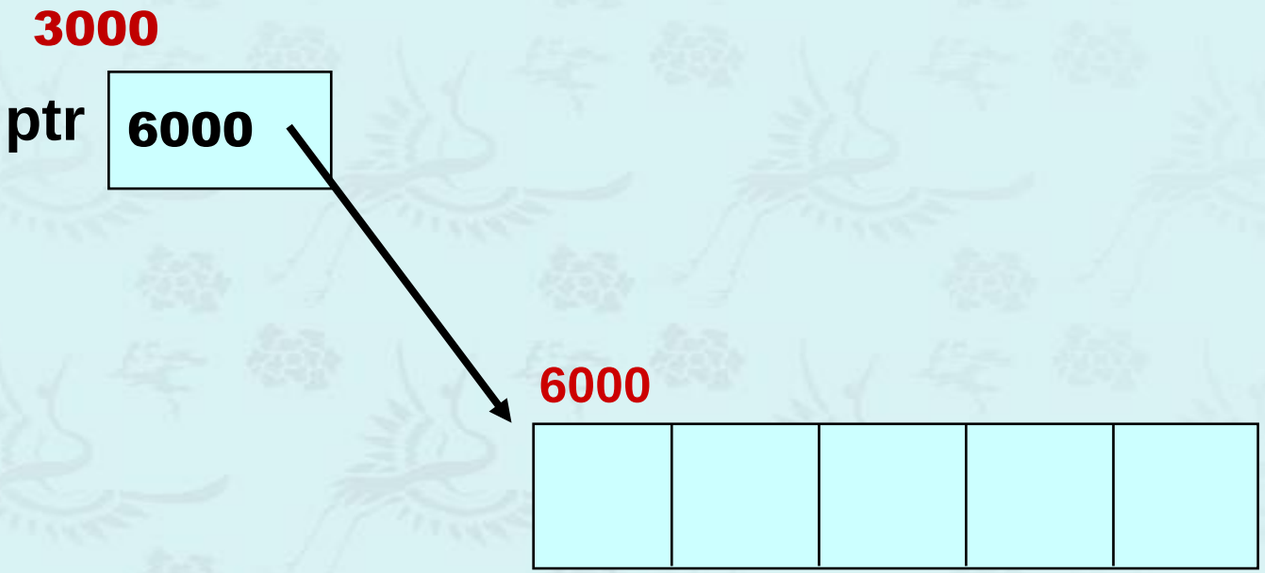

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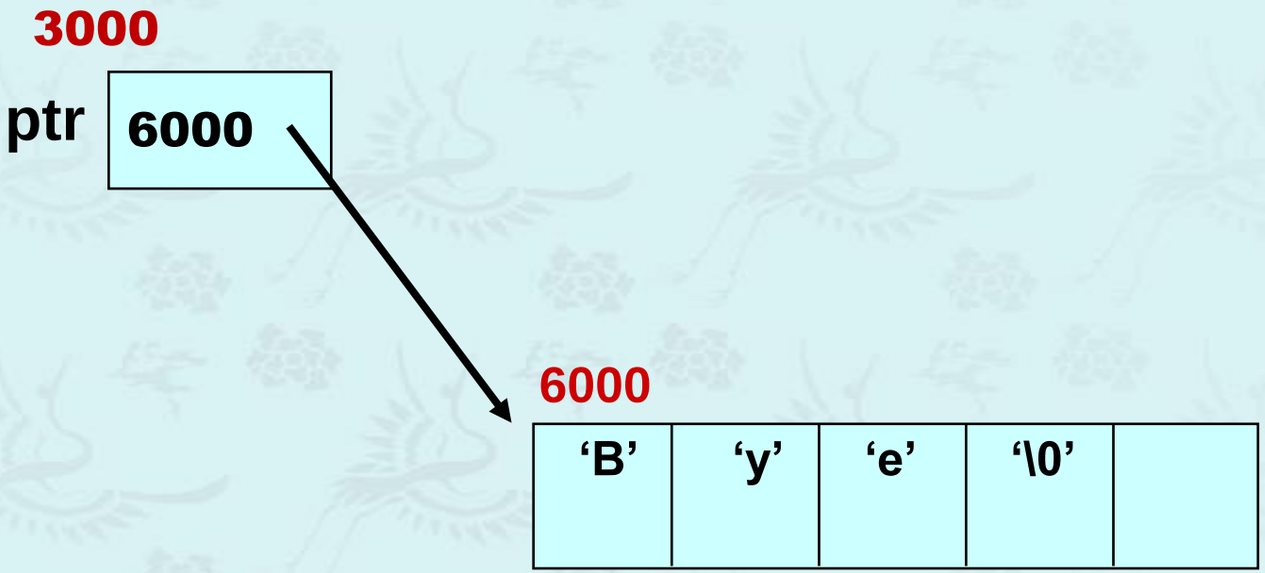

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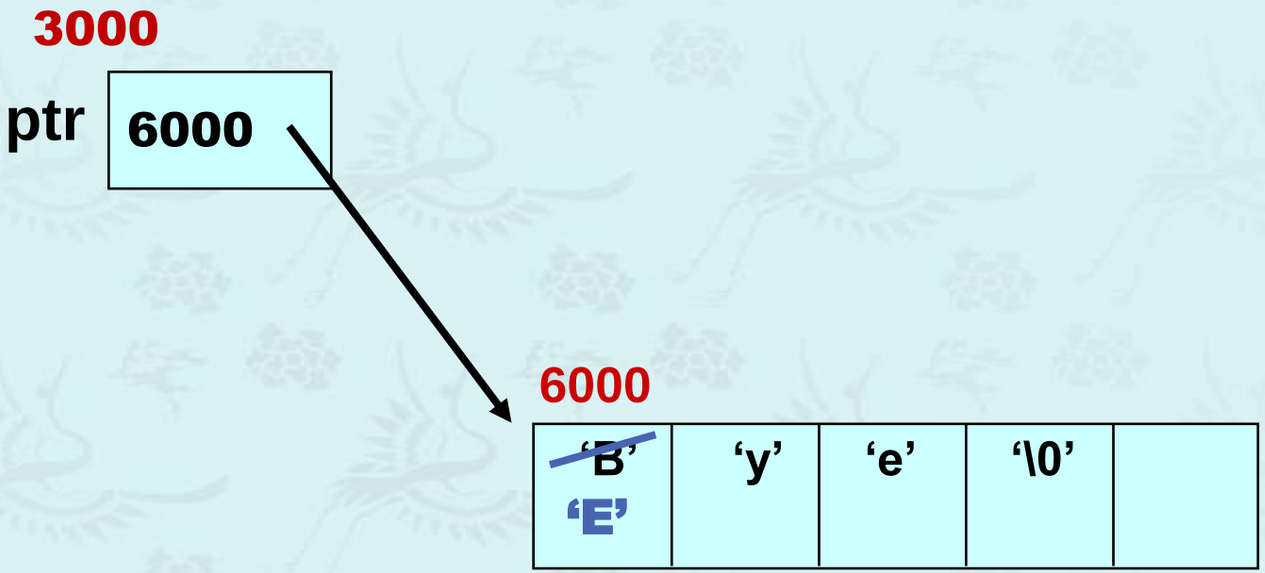

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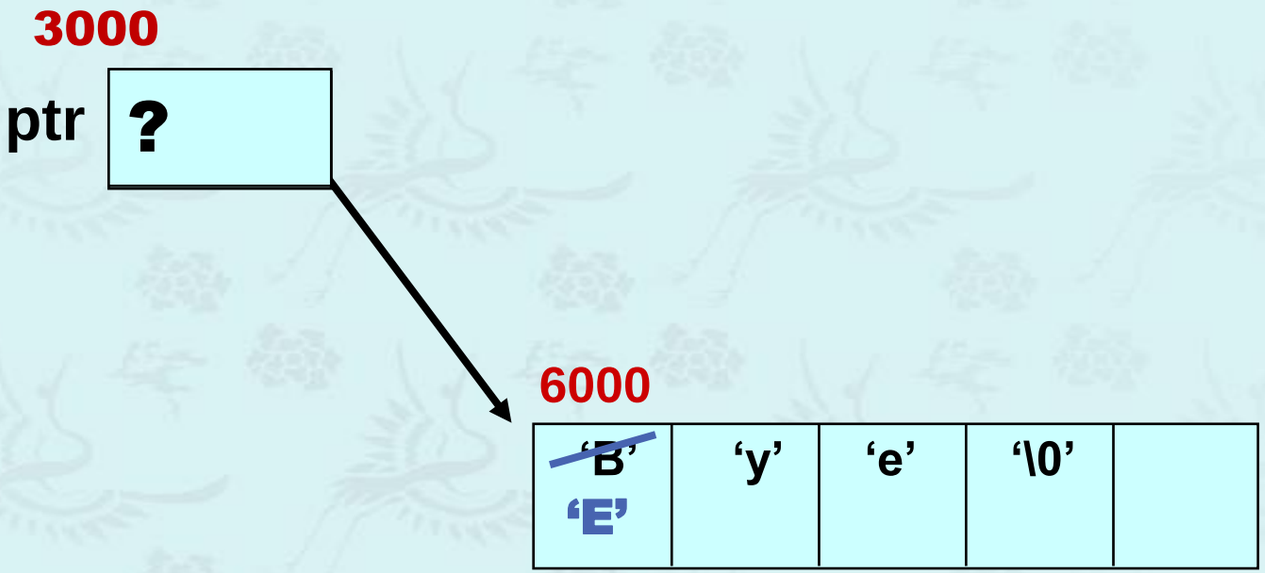

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Take Home Message

- Be aware of where a pointer points to, and what is the size of that space.
- Have the same information in mind when you use reference variables.
- Always check if a pointer points to nullptr before accessing it.
  For example,

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char *ptr = new char[5];
assert(ptr != nullptr);
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- Have the same information in mind when you use reference variables.
- Always check if a pointer points to nullptr before accessing it.
  For example,

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char *ptr = new char[5];
assert(ptr != nullptr);
```

```
char *ptr = new (nothrow) char[5];
assert(ptr != nullptr);
```

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