C++ For C Coders 5

Data Structures
C++ for C Coders

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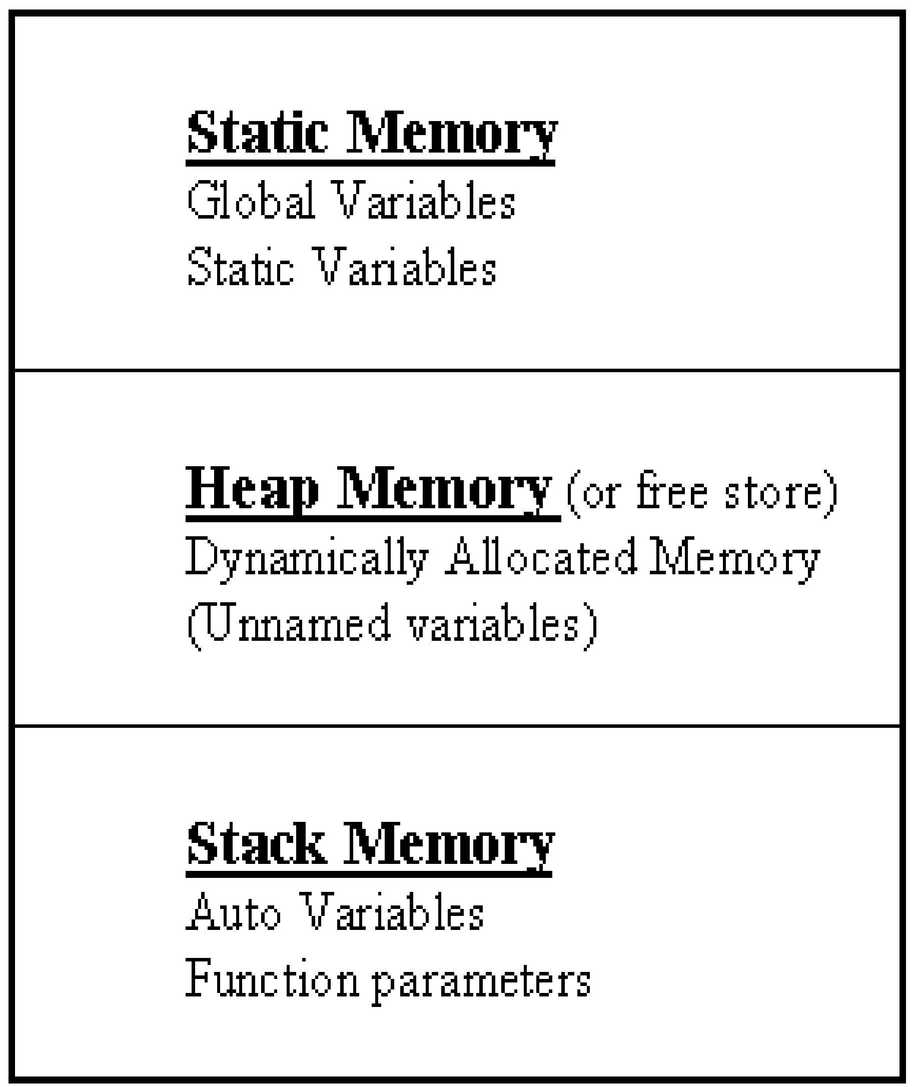
dynamic memory allocation
new & delete operators

Three kinds of memory (or data)

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

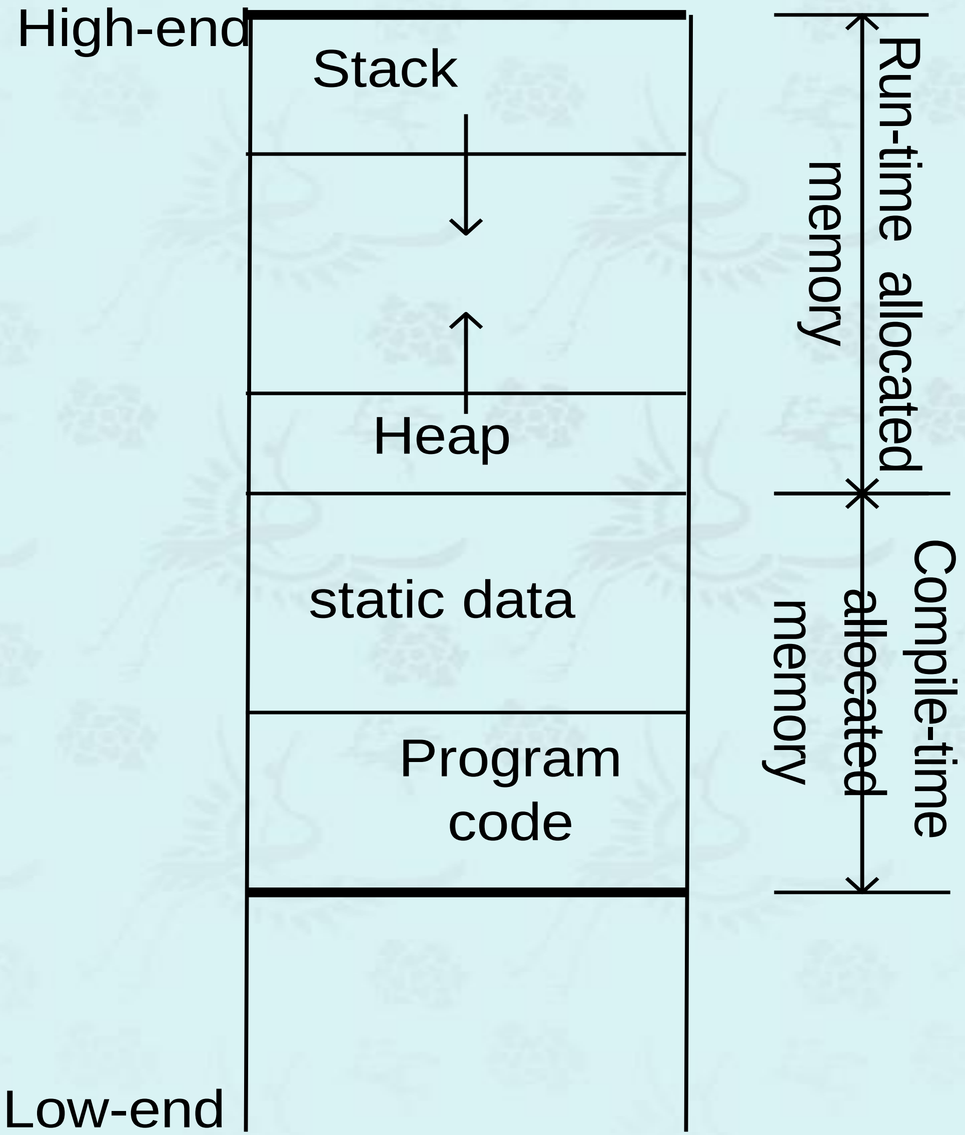


Static Memory
Global Variables
Static Variables

Heap Memory (or free store)
Dynamically Allocated Memory
(Unnamed variables)

Stack Memory
Auto Variables
Function parameters

Dynamic Memory Allocation Diagram



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.

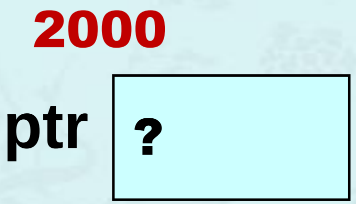
Operator new

```
char  *ptr;


ptr = new char;

*ptr = 'B';

cout  <<  *ptr;
```



NOTE: **Dynamic data has no variable name**

Operator new

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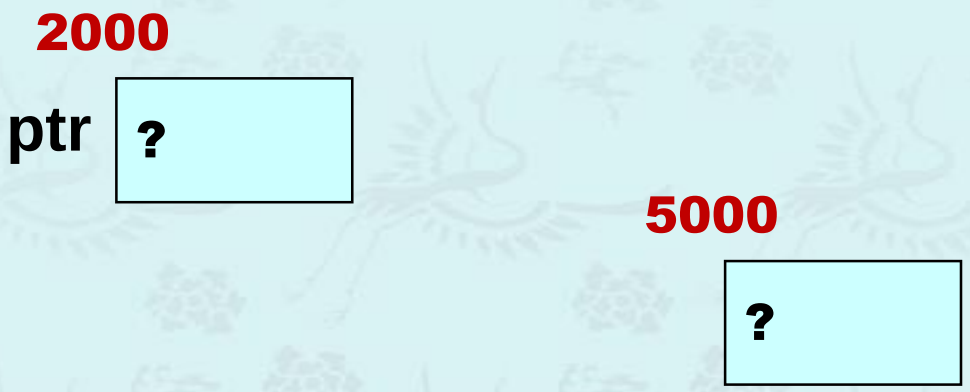

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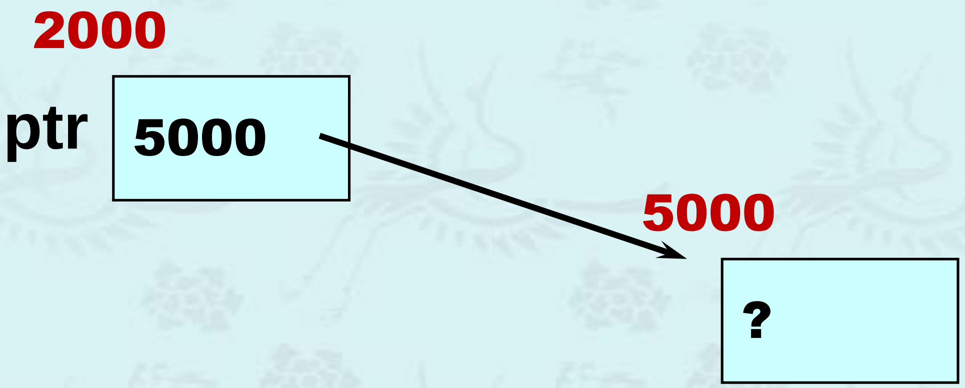

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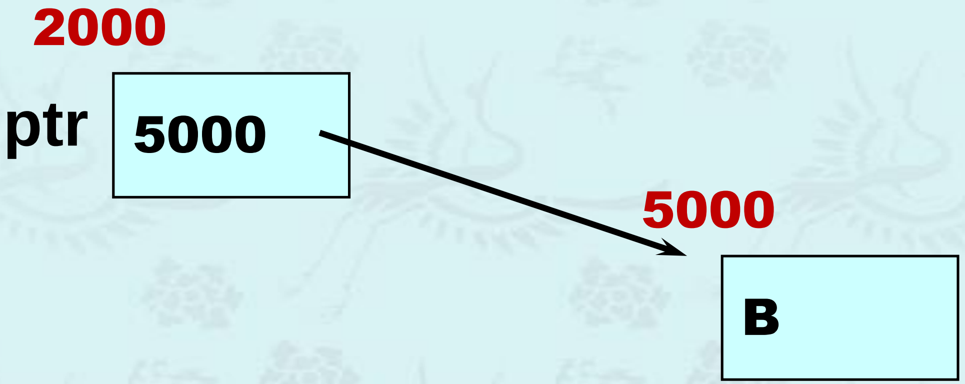

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new vs. malloc()

▪ new is an operator.	▪ malloc is a library function.
▪ It calls the constructor.	▪ It does not call the constructor.
▪ It returns exact data type if memory is available.	▪ It returns the void * if memory is available.
▪ It throws bad_alloc exception on failure. Use **nothrow** for **nullptr**.	▪ It returns **`nullptr`** on failure.
▪ It can be overridden.	▪ It cannot be overridden.
▪ In which memory allocated from the heap.	▪ In which memory allocated from the heap.
▪ Size is calculated by the compiler.	▪ Need to pass the size.

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

Dynamic Memory Allocation

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

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

- **new** is used to allocate memory during execution time
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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

```
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ptr = new char;

*ptr = 'B';

delete ptr;
```

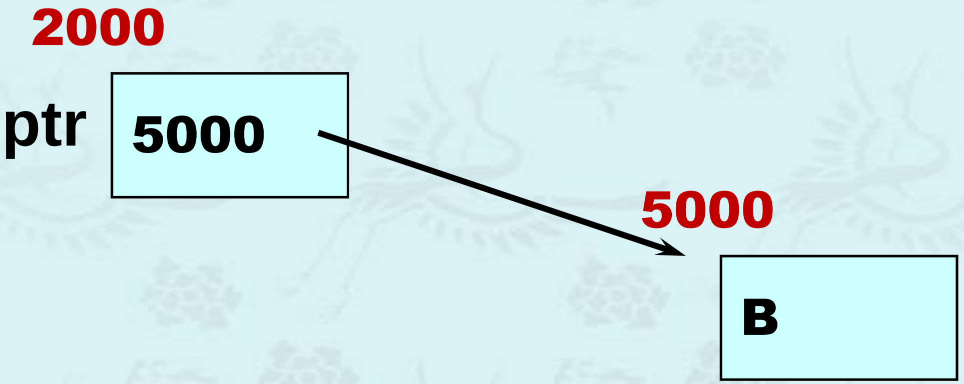

Question: **After 'delete'** operation, can we use ptr again?

Operator delete

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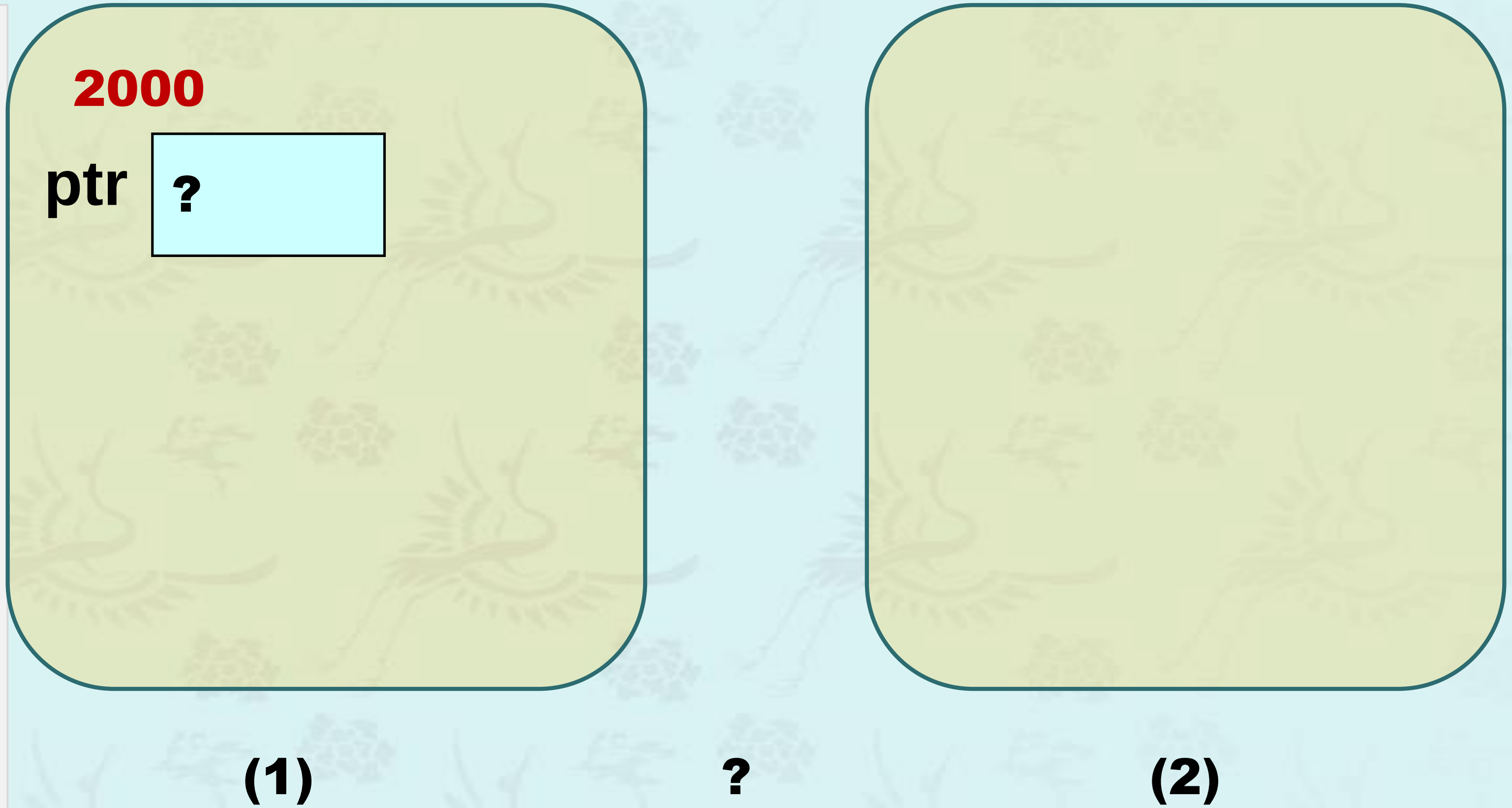
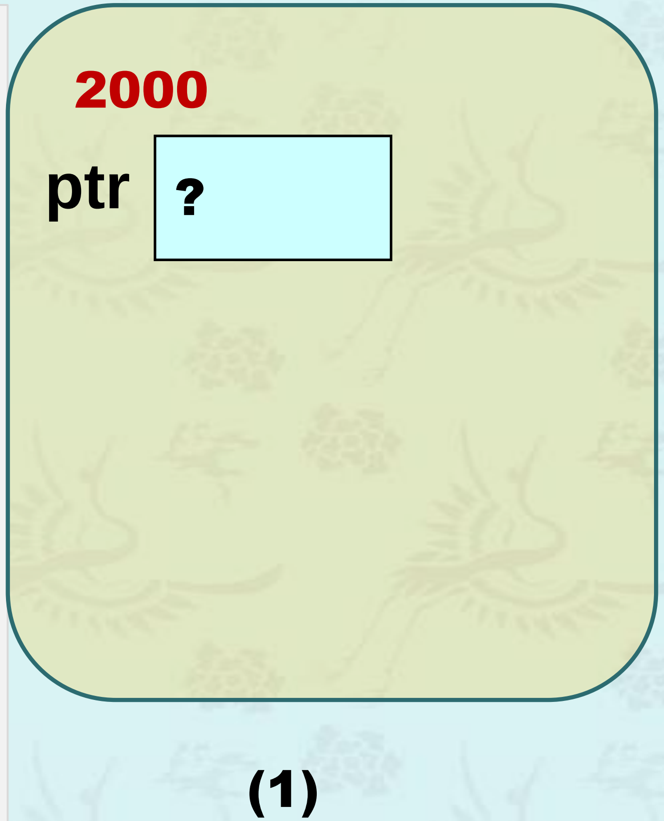


Question: **After 'delete'** operation, can we use ptr again?

Operator delete

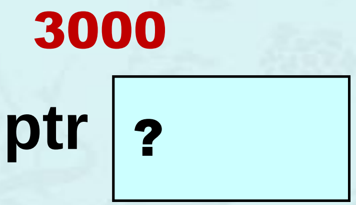
```
char  *ptr;


ptr = new char;

*ptr = 'B';

delete ptr;

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



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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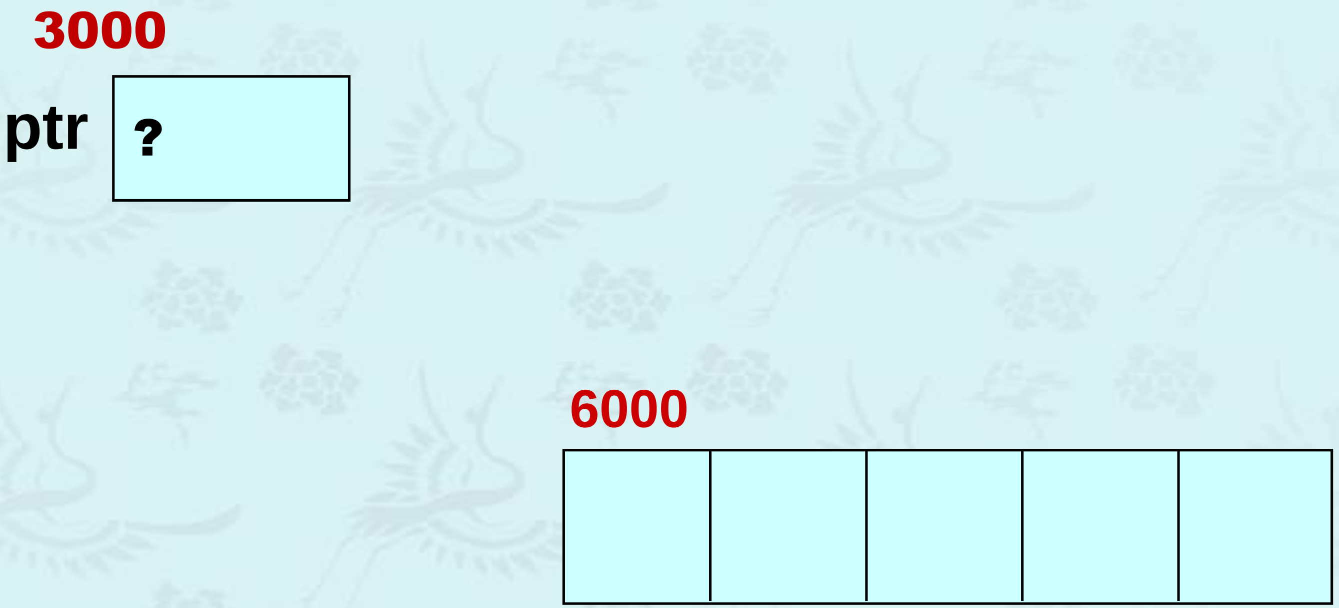

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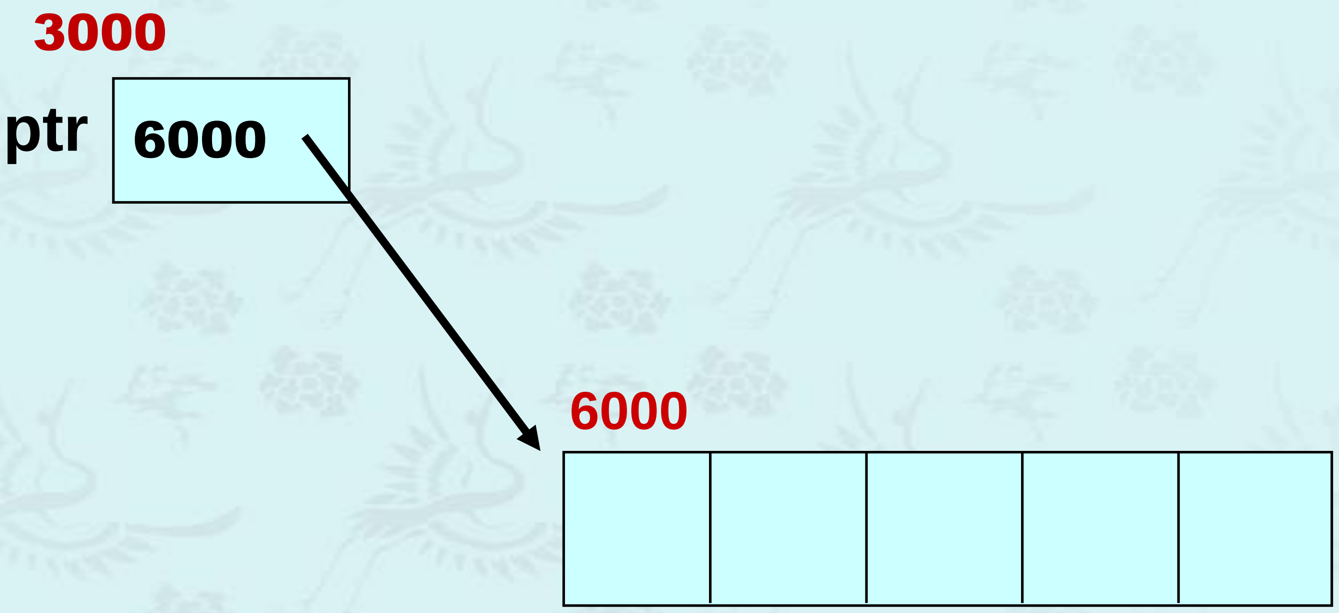

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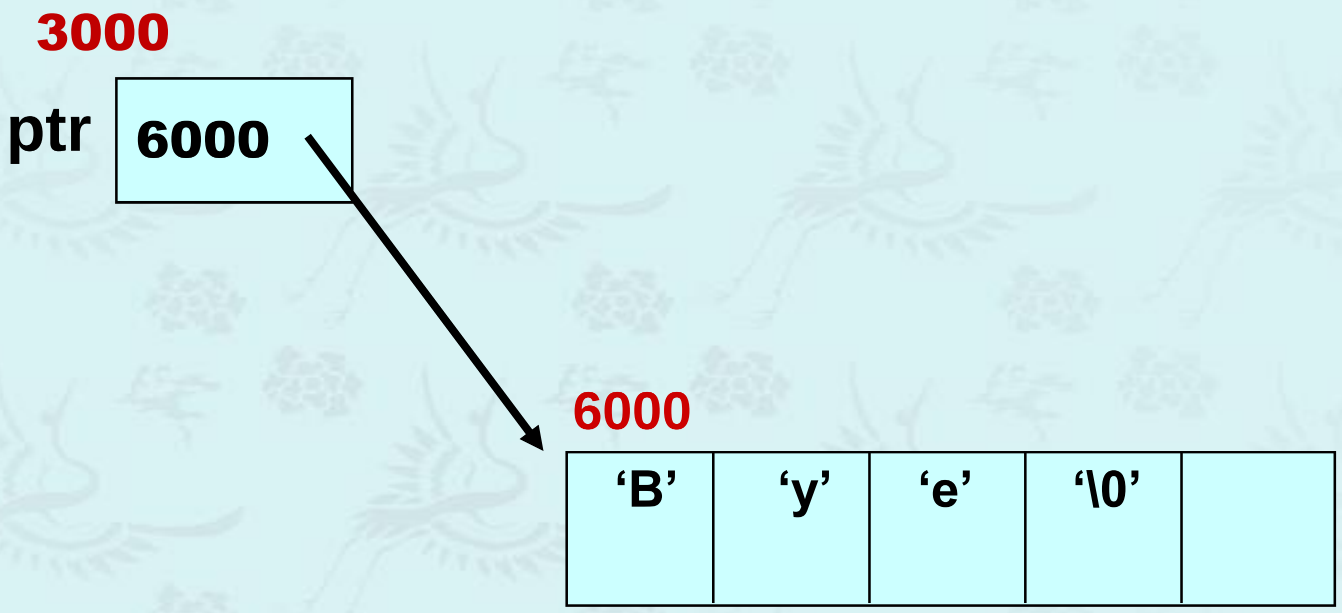

3000

ptr 6000

6000

‘B’ ‘y’ ‘e’ ‘\0’

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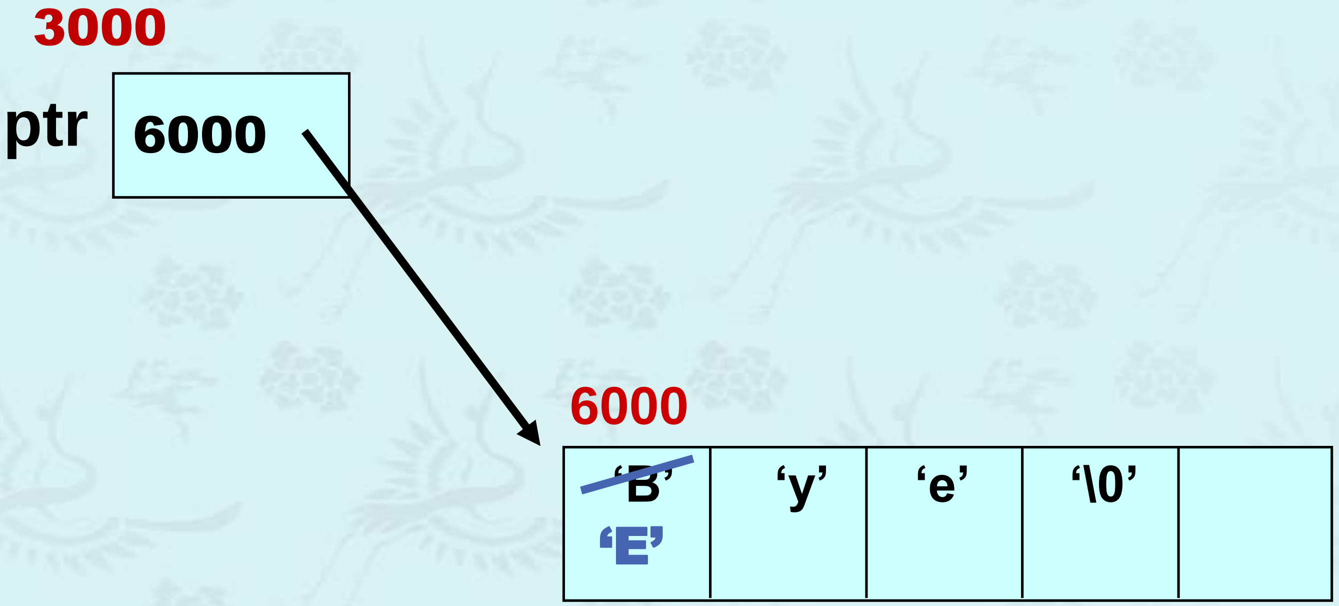

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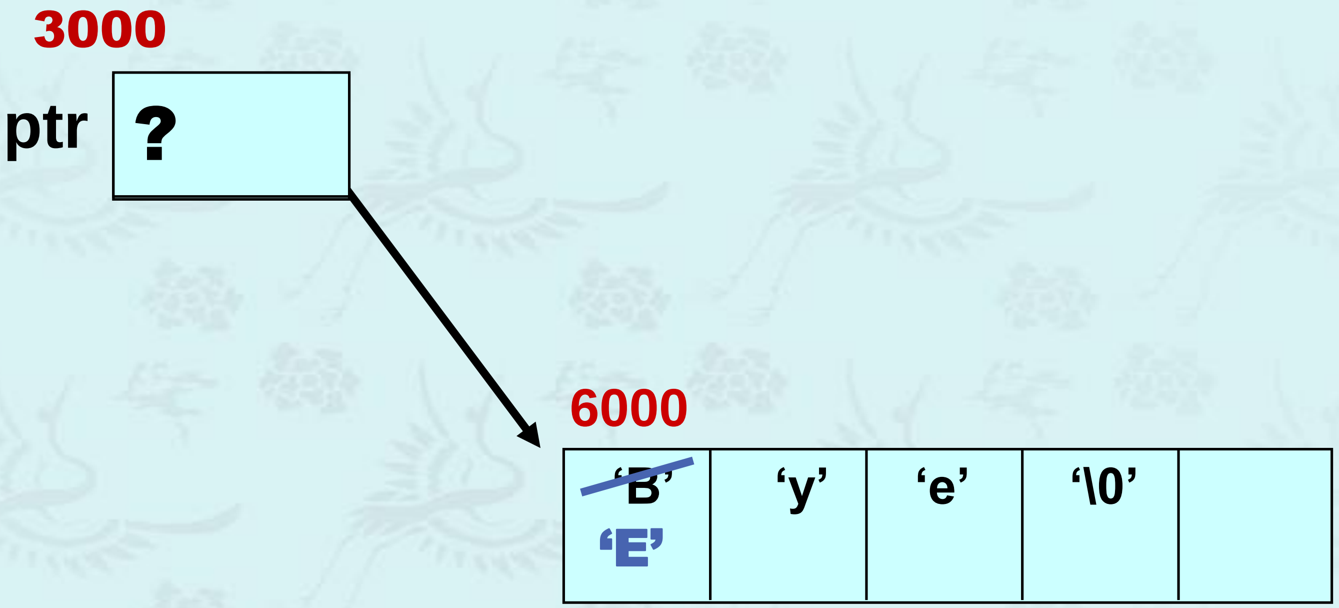

NOTE:

- deallocates the array pointed to by ptr
- ptr itself is not deallocated
- the value of ptr becomes undefined

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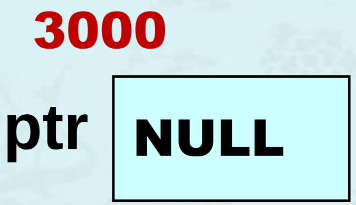

NOTE:

- deallocates the array pointed to by ptr
- ptr itself is not deallocated
- the value of ptr becomes undefined

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,

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

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,

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

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

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