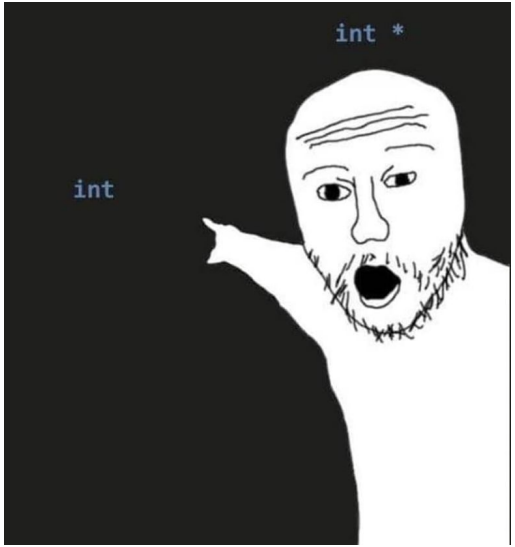
POINTERS



Sumaiyah Zahid

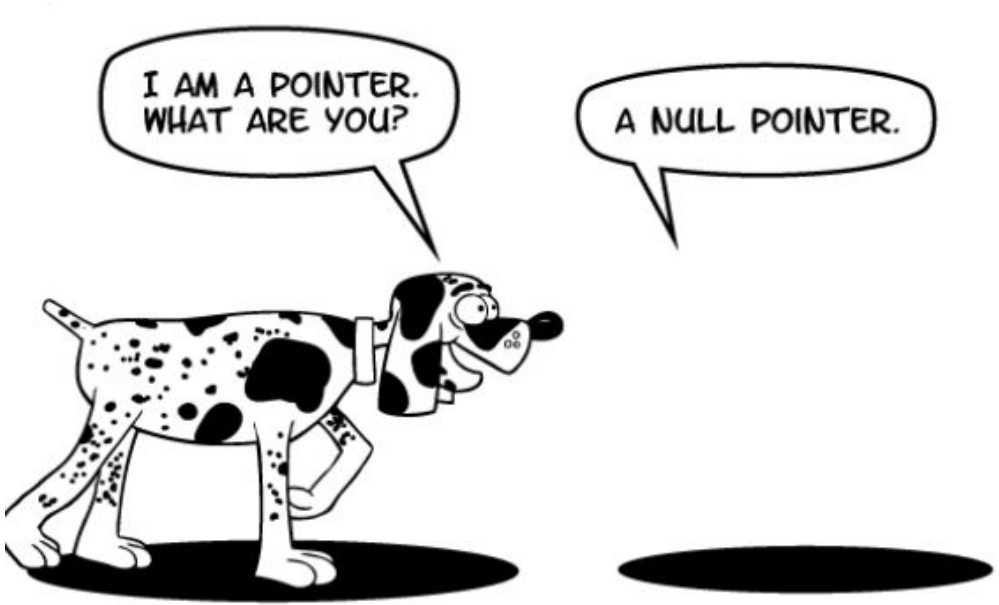
Why POinters?

- Increases the execution speed of program.
- Used for dynamic memory allocation.
- Pass by reference.
- Pointers makes possible to return more than one value in functions.
- To access variables that are declared outside the functions.
- Strings and arrays are more efficient with pointers.

NULL Pointer

"I points nothing"

```
int *p= NULL;
```



DANGLING POINTER

A pointer pointing to a memory location that has been deleted (or freed) is called dangling pointer.

Sometimes the programmer fails to initialize the pointer with a valid address, then this type of initialized pointer is known as a dangling pointer in C.

Pointers Practice

```
float num1 = 5.3;
float *ptr1 = &num1; float *ptr2 = ptr1;
printf("%0.1f, %0.1f\n", *ptr1, *ptr2);

float num2 = 7.6; ptr2 = &num2;
printf("%0.1f\n", *ptr1 + *ptr2);

float *ptr3 = ptr1;
*ptr1 = 2.2;  *ptr2 = *ptr3; *ptr1 = 1.1;
printf("%0.1f, %0.1f, %0.1f\n", *ptr1, *ptr2, *ptr3);

ptr1 = ptr2;  ptr2 = ptr3; *ptr1 = 7;
printf("%0.1f, %0.1f, %0.1f\n", *ptr1, *ptr2, *ptr3);
```

Pointers Arithmetic

```
int x = 10;
int *y = &x, *z;
*y = 5;
*y = *y + 10;
++*y;
(*y)++;
z = y;
++z;              // pointer increment
z = z + 10;
```

More Pointers :(

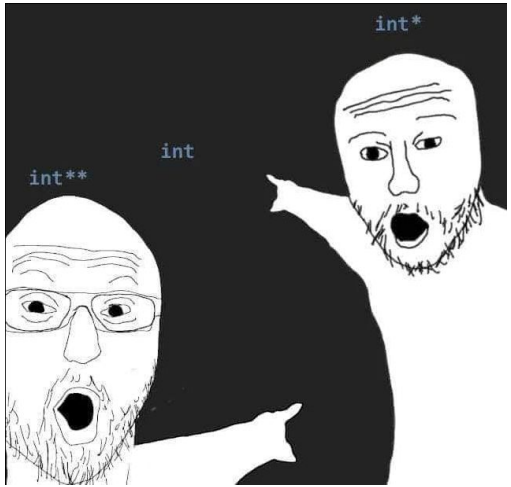
Double Pointer

Double Pointer is a pointer to pointer.

```
int x = 10;
int *y = &x;
int **z = &y;
```


```
printf("%d %d %d\n", x, *y, **z);
```

Why Use Double Pointers



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If you want to have a list of characters (a word), you can use `char *word`

If you want a list of words (a sentence), you can use `char **sentence`

If you want a list of sentences (a monologue), you can use `char ***monologue`

If you want a list of monologues (a biography), you can use `char ****biography`

If you want a list of biographies (a bio-library), you can use `char *****biolibrary`

If you want a list of bio-libraries (a ??lol), you can use `char ******lol`

... ...

yes, I know these might not be the best data structures

VOID POINTER

It is a general purpose pointer.

A pointer that has no associated data type with it.

It holds address of any type and can be typcasted to any type.

Type of Address Stored in Void Pointer	Dereferencing Void Pointer
Integer	*((int*)ptr)
Charcter	*((char*)ptr)
Floating	*((float*)ptr)

```c
#include <stdio.h>
int main()
{
    int a=0;
    char b='k';
    double c=345678666;
    float d=4.56;
    void *ptr=NULL;
   ptr = &a;
   printf("Value = %d Address =%d\n", *(int *)ptr, ptr);
   ptr = &b;
   printf("Value = %c Address =%d\n", *(char *)ptr, ptr);
   ptr = &c;
   printf("Value = %ld Address =%d\n", *(double *)ptr, ptr);
   ptr = &d;
   printf("Value = %f Address =%d\n", *(float *)ptr, ptr);

   return 0;
}
```

```
Value = 0 Address =6487572
Value = k Address =6487571
Value = 1241513984 Address =6487560
Value = 4.560000 Address =6487556
```

Casting Pointer

When assigning a memory address of a variable of one type to a pointer that points to another type it is best to use the cast operator to indicate the cast is intentional (this will remove the warning).

```
int V = 101;
float *P = (float *) &V; /* Casts int address to float * */
```

Removes warning, but is still a somewhat unsafe thing to do.

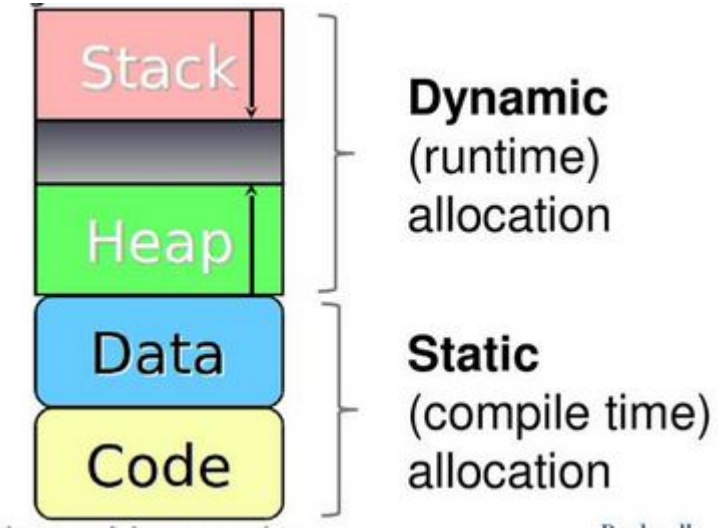
Dynamic Memory Allocation

Static Vs Dynamic Memory Allocation

Programmers can dynamically allocate storage space while the program is running, but cannot create new variable names "on the fly".

For this reason, dynamic allocation requires two criteria:

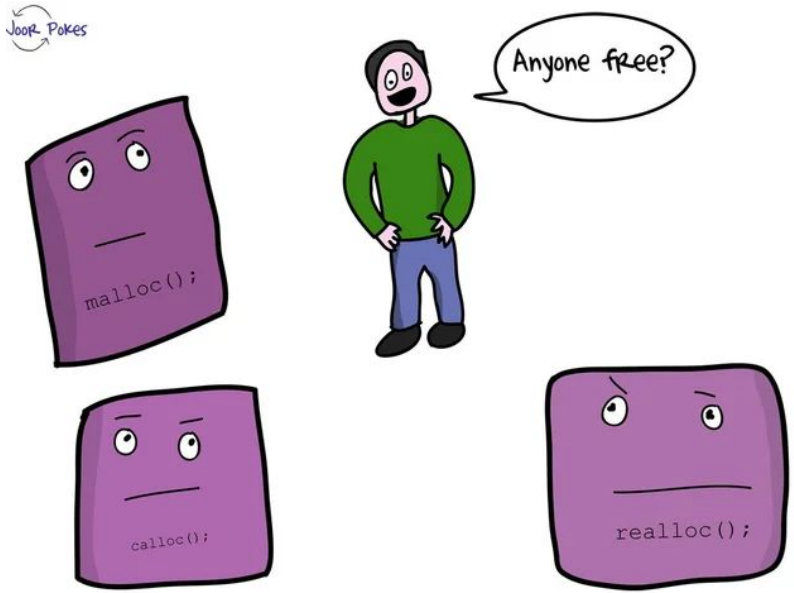
- Creating the dynamic space in memory
- Storing its address in a pointer (so that space can be accessed)



Dynamic Memory Allocation

To allocate memory dynamically, <stdlib.h> has following functions:

- malloc()
- calloc()
- realloc()
- free()



Julia Evans
@bork

memory allocation

your program has memory

10MB program binary

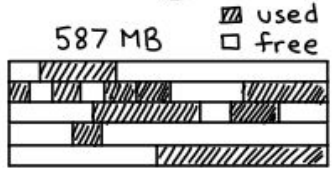
3MB stack

587MB heap

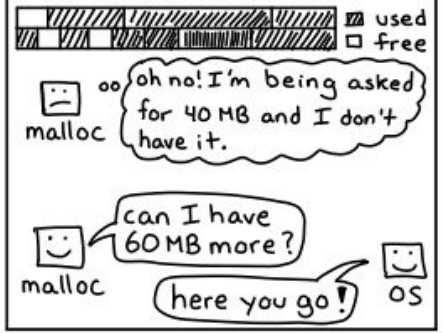
the heap is what your allocator manages

your memory allocator (malloc) is responsible for 2 things.

THING 1: keep track of what memory is used/free.



THING 2: Ask the OS for more memory!



your memory allocator's interface

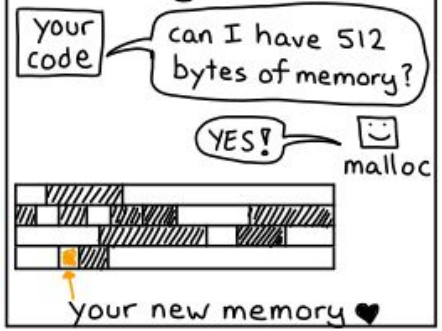
malloc (size_t size)
allocate size bytes of memory & return a pointer to it.

free (void* pointer)
mark the memory as unused (and maybe give back to the OS).

realloc(void* pointer, size_t size)
ask for more/less memory for pointer.

calloc (size_t members, size_t size)
allocate array + initialize to 0.

malloc tries to fill in unused space when you ask for memory



malloc isn't magic! it's just a function!

you can always:

→ use a different malloc library like jemalloc or tcmalloc (easy!)

→ implement your own malloc (harder)

C malloc()

"malloc" stands for memory allocation.

It reserves a block of memory of the specified number of bytes. And, returns a pointer of void which can be type casted in any form.

```
ptr = (castType*) malloc(size);
```

```
ptr = (float*) malloc(100 * sizeof(float)); // 400 bytes reserved
```

C calloc()

"calloc" stands for contiguous allocation.

It allocates memory and initializes all bits to zero.

```
ptr = (castType*) calloc(n, size);

ptr = (float*) calloc(100 , sizeof(float));

// 400 consecutive bytes reserved
```

C free()

Dynamically allocated memory created with either calloc() or malloc() doesn't get freed on their own.

You must explicitly use free() to release the space.

```
free(ptr);
```

```c
#include <stdio.h>
#include <stdlib.h>
int main()
{
  int n,i, *ptr, sum=0;
  printf("Enter the number of elements: ");
  scanf("%d", &n);
  ptr = (int*) malloc(n * sizeof(int));
  if(ptr == NULL)
  {
     printf("Error! Memory not allocated");
     return 0; }
  printf("Enter elements: ");
  for(i = 0; i < n; ++i) {
    scanf("%d", ptr+i);
    sum += *(ptr + i);
  }
  printf("Sum = %d", sum);
  free(ptr); // deallocating the memory
  return 0;  }
```

```c
#include <stdio.h>
#include <stdlib.h>
int main()
{
  int n,i, *ptr, sum=0;
  printf("Enter the number of elements: ");
  scanf("%d", &n);
  ptr = (int*) calloc(n , sizeof(int));
  if(ptr == NULL)
  {
     printf("Error! Memory not allocated");
     return 0; }
  printf("Enter elements: ");
  for(i = 0; i < n; ++i) {
    scanf("%d", ptr+i);
    sum += *(ptr + i);
  }
  printf("Sum = %d", sum);
  free(ptr); // deallocating the memory
  return 0;  }
```

C realloc()

If the dynamically allocated memory is insufficient or more than required, you can change the size of previously allocated memory using the realloc() function.

If enough space doesn’t exist in memory of current block to extend, new block is allocated for the full size of reallocation, then copies the existing data to new block and then frees the old block.

```
ptr = realloc(ptr, size);
```

```c
#include <stdio.h>
#include <stdlib.h>
int main()
{
  int n1,n2,i, *ptr, sum=0;
  printf("Enter the size: ");
  scanf("%d", &n1);
  ptr = (int*) malloc(n1 * sizeof(int));
  printf("Address of previously allocated memory : ");
  for(i = 0; i < n1; i++)
    printf("%d\n", ptr+i);
  printf("Enter the new size: ");
  scanf("%d", &n2);
  ptr = realloc(ptr, n2 * sizeof(int));// reallocating the memory
  printf("Address of newly allocated memory : ");
  for(i = 0; i < n2; i++)
    printf("%d\n", ptr+i);
  free(ptr); // deallocating the memory
  return 0;
}
```

```
Enter the size: 4
Address of previously allocated memory :
11604960
11604964
11604968
11604972
Enter the new size: 6
Address of newly allocated memory :
11604960
11604964
11604968
11604972
11604976
11604980
```

2D Array Using DMA

```
int *arr = (int*) malloc(m*n * sizeof(int));
```

To access any element:

```
*(arr + i*n + j)
```

```c
#include <stdio.h>
#include <stdlib.h>
void initialize_array(int m, int n,int *arr)
{    int i,j;
     for(i=0; i<m; i++)
       for(j=0; j<n; j++)
           *(arr + i*n + j) = i + j;  }
int main()
{
   int m=5, n=5,i,j;
   int *arr = (int*) malloc(m*n * sizeof(int));
   initialize_array(m, n, arr);
     for(i=0; i<m; i++)
     {
       for(j=0; j<n; j++)
         printf("%d ", *(arr + i*n + j));
       printf("\n");
     }
   free(arrr); // deallocating the memory
   return 0;}
```

Constant & Static

Constant Variables

The keyword `const` be used to declare constant variables.

They must be initialized when they are declared and cannot be modified later.

Using constant variables to specify array size makes program more scalable.

Constant variables are also called `named constants` or `read-only variables`.

Constant Variables & Constant Parameters

```
int main()
{
    const int a = 5;
    const int b;  // will cause error
    b = 10;       // will cause error

    const int arr[] = {1, 2, 3, 4, 5};
    arr[0] = 10;  // will cause error
}
```

```
int func(const int a, int b)
{
    a += 10;     //will cause error
    b += 20;
}
```

```c
#include <stdio.h>
int cube(const int *x,int *a);
int main()
{
   int num=4, result=0;
   cube(&num, &result);
   printf("%d", num);
   return 0;
}
int cube(const int *x,int *a)
{
     *a= (*x) * (*x) *(*x); // This is correct
    //*x= (*x) * (*x) *(*x); This is wrong
}
```

Constant Pointer

It is a pointer that cannot change the address its holding.

Once a constant pointer points to a variable then it cannot point to any other variable.

```
int * const ptr;
```

Constant with Pointers

There are four ways to use const with pointers:

- Non-constant pointers to non-constant data
- Non-constant pointers to constant data
- Constant pointers to non-constant data
- Constant pointers to constant data

Non-constant Pointers to Non-constant Data

The highest access is granted by a non-constant pointer to non-constant data.

Data can be modified through pointer, and pointer can be made to point to other data.

```
int main()
{
    int a = 10;
    int b = 50;

    int* pA = &a;
    *pA = 20;
    pA = &b;
}
```

Non-constant Pointers to constant Data

Pointer can be modified to point to any other data, but the data to which it points cannot be modified through that pointer.

```
const  int * pVal;
```

```
int main()
{
    int a = 10;
    int b = 50;

    const int* pA = &a;
    *pA = 20;        // this line will cause error
    pA = &b;
}
```

Non-constant Pointers to constant Data

```c
#include<stdio.h>

int main(void)
{
    int var1 = 0;
    const int* ptr = &var1;
    *ptr = 1;
    printf("%d\n", *ptr);

    return 0;
}
```

Compiler (2) | Resources | Compile Log | Debug | Find Results | Close

Line	Col	File	Message
		C:\Users\Dell\Documents\qusai.c	**In function 'main':**
7	10	C:\Users\Dell\Documents\qusai.c	[Error] assignment of read-only location '*ptr'

Constant Pointers to Non-constant Data

Always points to the same memory location, but the data at that location can be modified through the pointer.

```
int * const pVal = &val;
```

```
int main()
{
    int a = 10;
    int b = 50;

    int* const pA = &a;
    *pA = 20;
    pA = &b;     // this line will cause error
}
```

Constant Pointers to Non-constant Data

```c
#include<stdio.h>

int main(void)
{
    int var1 = 0, var2 = 0;
    int *const ptr = &var1;
    ptr = &var2;
    printf("%d\n", *ptr);

    return 0;
}
```

Compiler (2) | Resources | Compile Log | Debug | Find Results | Close

Line	Col	File	Message
		C:\Users\Dell\Documents\qusai.c	**In function 'main':**
7	9	C:\Users\Dell\Documents\qusai.c	[Error] assignment of read-only variable 'ptr'

.

t

Constant Pointers to Constant Data

Always points to the same memory location, and the data at that location cannot be modified via the pointer.

```
const int * const pVal = &val;
```

```
int main()
{
    int a = 10;
    int b = 50;

    const int* const pA = &a;
    *pA = 20;       // cannot do this
    pA = &b;    // cannot do this as well
}
```

Constant Pointer To Constant

```c
#include<stdio.h>

int main(void)
{
    int var1 = 0,var2 = 0;
    const int* const ptr = &var1;
    *ptr = 1;
    ptr = &var2;
    printf("%d\n", *ptr);

    return 0;
}
```

Compiler (3) | Resources | Compile Log | Debug | Find Results | Close

Line	Col	File	Message
		C:\Users\Dell\Documents\qusai.c	**In function 'main':**
7	10	C:\Users\Dell\Documents\qusai.c	[Error] assignment of read-only location '*ptr'
8	9	C:\Users\Dell\Documents\qusai.c	[Error] assignment of read-only variable 'ptr'

Static Storage Classes

Storage - Memory.

Default initial value - Zero.

Scope - Local to the block in which the variable is defined.

Life - Value of the variable persists between different function calls.

Static Storage Classes

```
void staticDemo()
{
    int val = 0;
    ++val;
    cout << “val = "  << val << endl;
}

int main()
{
    staticDemo();   // prints val = 1
    staticDemo();   // prints  val = 1
    staticDemo();   // prints val  = 1
}
```

```
void staticDemo()
{
    static int val = 0;
    ++val;
    cout << “val = "  << val << endl;
}

int main()
{
    staticDemo();   // prints val = 1
    staticDemo();   // prints  val = 2
    staticDemo();   // prints val  = 3
}
```

Structures & Pointers

Struct pointer

```
struct student {
char name[20]; float marks;int batch; char city; int roll_num; };


struct student *ptr, student1;
ptr=&student1;
```

```
(*ptr).batch= ptr->batch
```

-> member access operator for pointers

```c
#include <stdio.h>
struct student
{
char name[20]; float marks; int batch; char city; int roll_num;
};
int main()
{
  struct student student1, *ptr;
  ptr=&student1;
  printf("Enter your name :");     scanf("%s", ptr->name);
  printf("Enter your marks:");     scanf("%f", &ptr->marks);
  printf("Enter your batch:");     scanf("%d", &ptr->batch);
  printf("Enter your city:");      scanf(" %c",&ptr->city);
  printf("Enter your roll_num:");  scanf("%d", &ptr->roll_num);

  printf("Your data is\nName : %s \nMarks : %f\nBatch :
%d\nCity:%c\nRoll Number :%d", ptr->name, ptr->marks,   ptr->batch,
ptr->city, ptr->roll_num);
  return 0;
}
```

DMA of Struct

Sometimes, the number of struct variables you declared may be insufficient.

You may need to allocate memory during run-time.

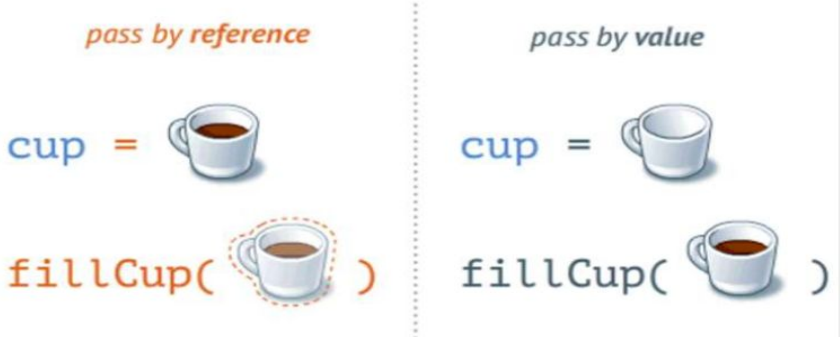
```c
#include <stdio.h>
#include <stdlib.h>
struct student
{
char name[20]; float marks; int batch; char city; int roll_num;
};
int main()
{
   struct student *ptr;   int i,n;
   printf("Enter the number of students: ");
   scanf("%d", &n);
   ptr = (struct student *) malloc(n * sizeof(struct student));
   for(i=0; i<n; i++)
     {
  printf("Enter your name :");     scanf("%s", (ptr+i)->name);
  printf("Enter your marks:");     scanf("%f", &(ptr+i)->marks);
  printf("Enter your batch:");     scanf("%d", &(ptr+i)->batch);
     }
   free(ptr); // deallocating the memory
   return 0;}
```

Functions & Pointers

C isn't that hard:

`Void (*(*(f[])())())` defines `f` as an array of unspecified size, of pointers to functions that return pointers to functions that return `void` .

Calling Functions



Call by value

- Copy of argument passed to function
- Changes in function do not affect original
- Use when function does not need to modify argument
- Avoids accidental changes

All the examples mentioned before are using call by value.

Call by reference (We will study later with Pointers)

- Passes original argument
- Changes in function effect original
- Only used with trusted functions

Pass By Reference

```
void function( int *p);
```

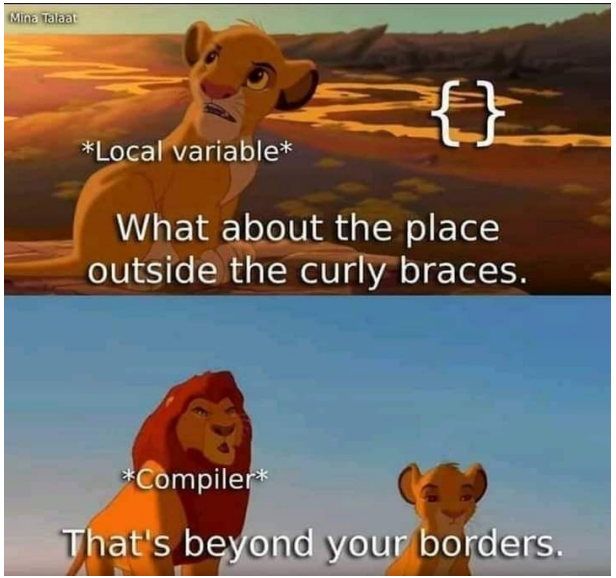
```
int *p,num=6;
p = &num;
function( p );
```

```c
#include <stdio.h>
int cube(int *a);
int main()
{
    int num=4, *p;
    p=&num;
    cube(p); // cube(&num);
    printf("%d", num);
    return 0;
}
int cube(int *a)   // a is an alias or nickname of p
{
     *a= (*a) * (*a) *(*a);
}
```

Returning A Pointer

```
int *function();

int *ptr;
ptr=function();
```



Never return a pointer to local variable from a function.

Local variable exists only inside the function and as soon as function ends the variable cease to exists. Even though the address returned by the function is assigned to ptr inside main(), the variable to which ptr points is no longer available. On dereference the ptr you will get some garbage value.

Returning A Pointer

Static variables have a property of preserving their value even after they are out of their scope!

Static variables help local variables to exist even when the function ends.

There is an always ocean of knowledge which depends how deep you want to dive.
https://www.geeksforgeeks.org/static-variables-in-c/

```c
#include <stdio.h>
int * cube(int a);
int main()
{
    int num=4, *p;
    p= cube(num);
    printf("%d", *p);
    return 0;
}
int * cube(int a)
{
     static int x=0;
     x= a*a*a;
     return &x;
}
```

Returning Array Using Pointers

We can return array by returning the address of array first element i.e. array name.

Your array should be static.

```c
#include <stdio.h>
int * initialize_array(int size);
int main()
{
   int *p,i;
   p=initialize_array(5);
   for(i=0; i<5; i++)
      printf("\n%d", *p++);
   return 0;
}
int * initialize_array(int size)
{
     static int arr[10];
     int i;
     for(i=0; i<size; i++)
        arr[i]=i;
     return arr;
}
```

```
0
1
2
3
4
```

Passing A 2d array To Function

A two-dimensional array is treated as an array of arrays.

That is, when we access the array using only one subscript, we get a pointer to the corresponding row.

Function Pointer

A pointer which keeps address of a function is known as function pointer.

```
void *(*ptr)();
```

- We are simply declaring a double pointer.
- Write () symbol after “Double Pointer“.
- void represents that, function is not returning any value.
- () represents that, function is not taking any parameter.

Function Pointer

```
ptr = &display;  // initializing the pointer
(*ptr)();    // calling a function
```

```
(*ptr)() = (*ptr)();
         = (*&display)();
         = (display)();
         = display();
```

Requirement	Declaration of Function Pointer	Initialization of Function Pointer	Calling Function using Pointer
Return Type : None Parameter : None	`void *(*ptr)();`	`ptr = &display;`	`(*ptr)();`
Return Type : Integer Parameter : None	`int *(*ptr)();`	`ptr = &display;`	`int result;` `result = (*ptr)();`
Return Type : Float Parameter : None	`float *(*ptr)();`	`ptr = &display;`	`float result;` `result = (*ptr)();`
Return Type : Char Parameter : None	`char *(*ptr)();`	`ptr = &display;`	`char result;` `result = (*ptr)();`

```c
#include <stdio.h>
void smile();     // Function Declaration or Prototype
int main()
{
   void *(*ptr)();
    ptr = &smile;  // Initializing the pointer

   (*ptr)();   // Function Call

   return 0;
}
void smile()     // Function Definition
{
   printf("\nSmile, and the world smiles with you...");
}
```

Function Prototype

```
#include<stdio.h>

char * getName(int *,float *);
```

Function Definition

```
char *getName(int *ivar,float *fvar)
{
char *str="www.nu.edu.pk";
return(str);
}
```

Main

```
int main()
{
char *name; int num = 100; float marks = 99.12;
char *(*ptr)(int*,float *);
ptr=&getName;
name = (*ptr)(&num,&marks);
printf("Name : %s",name);
return 0;
}
```

```c
#include<stdio.h>
char *getName(int *ivar,float *fvar)
{
char *str="www.nu.edu.pk";
return(str);
}
int main()
{
char *name;
int num = 100;
float marks = 99.12;

char *(*ptr)(int*,float *);
ptr=&getName;
name = (*ptr)(&num,&marks);
printf("Name : %s",name);
return 0;
}
```

Thank You