Modular Programming

Lengthier programs

- *Prone to errors*
- *tedious to locate and correct the errors*

To overcome this

Programs broken into a number of smaller logical components, each of which serves a specific task.

Advantages of modularization

- Reusability
- Debugging is easier
- Build library

Functions

- *A **function** is a set of instructions to carryout a particular task.*

- *Using functions we can structure our programs in a more modular way.*

Functions

- *Standard functions*

  (library functions or built in functions)

- *User-defined functions*

  Written by the user(programmer)

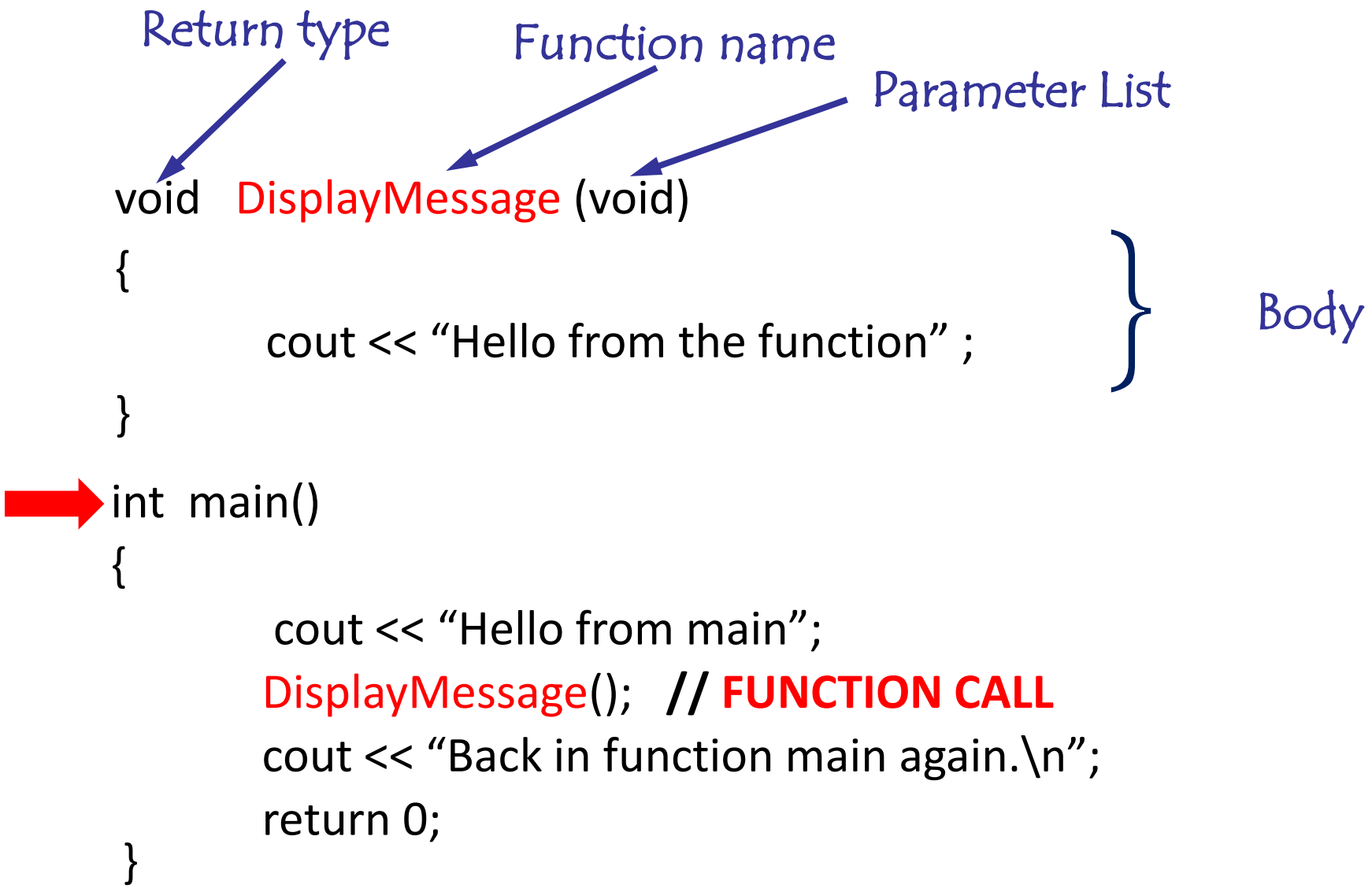
Defining a Function

- ✓ ***Name***
  - *You should give functions descriptive names*
  - *Same rules as variable names, generally*
- ✓ ***Return type***
  - *Data type of the value returned to the part of the program that activated (called) the function.*
- ✓ ***Parameter list***
  - *A list of variables that hold the values being passed to the function*
- ✓ ***Function body***
  - *Statements enclosed in curly braces that perform the function's operations(tasks)*

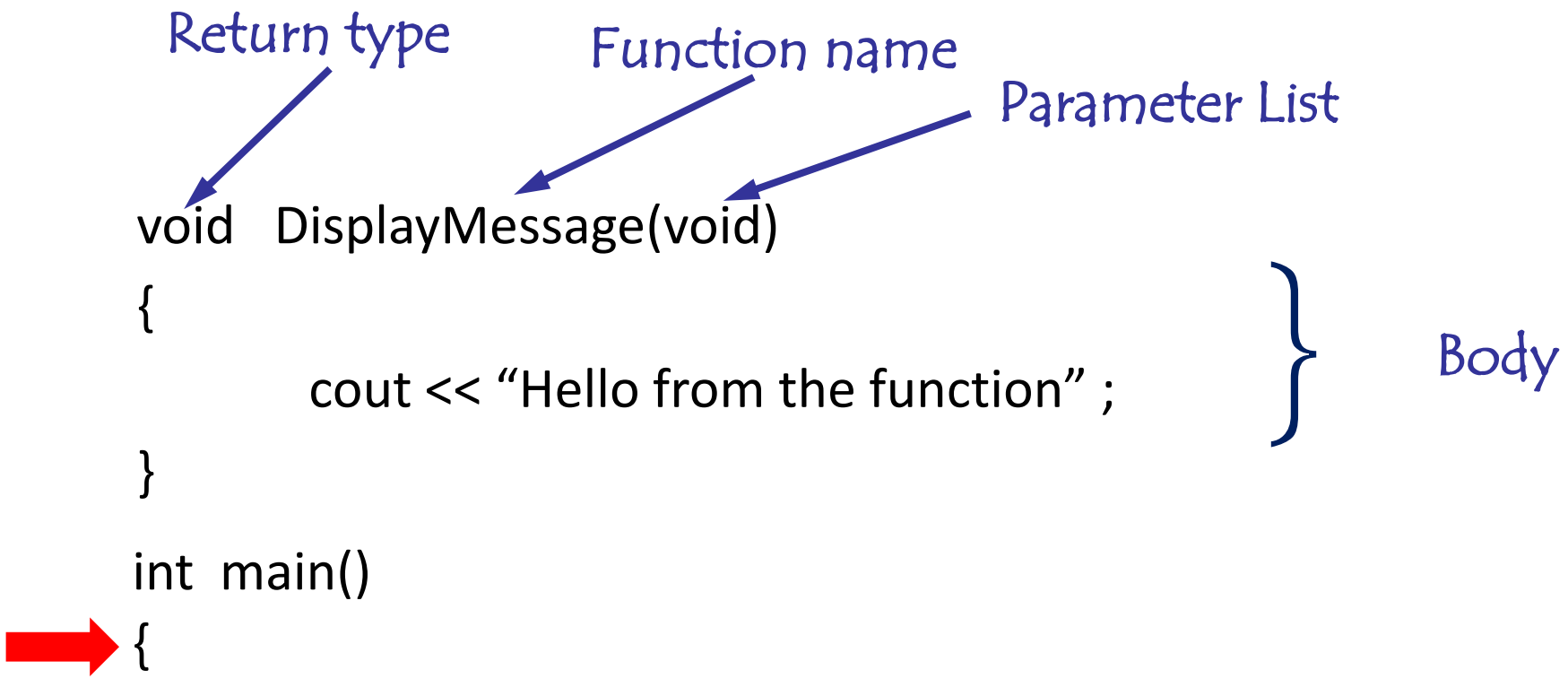
The general form of a function definition

```
return_type  function_name( parameter_definition )
   {
        variable   declaration;
        statement1;
        statement2;
                .
                .
                .
        return(value_computed);
   }
```

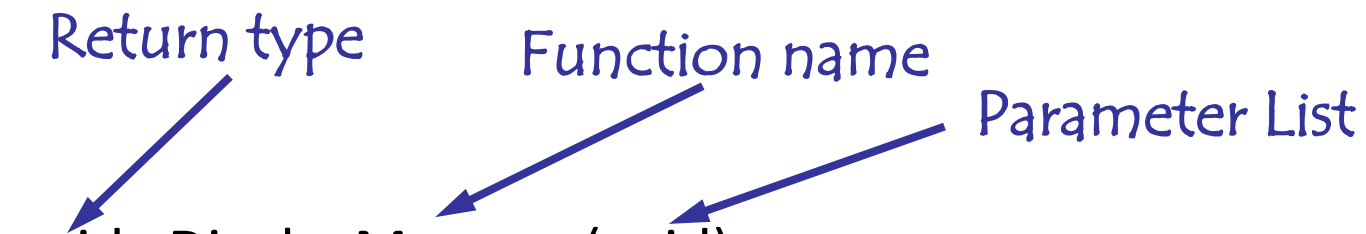
Functions


Return type
Function name
Parameter List
void DisplayMessage (void)
{
cout << "Hello from the function" ;
}
Body
int main()
{
cout << "Hello from main";
DisplayMessage(); // FUNCTION CALL
cout << "Back in function main again.\n";
return 0;
}

Functions


Return type
Function name
Parameter List
void DisplayMessage(void)
{
cout << “Hello from the function” ;
}
Body
int main()
{
cout << “Hello from main”;
DisplayMessage(); // FUNCTION CALL
cout << “Back in function main again.\n”;
return 0;
}

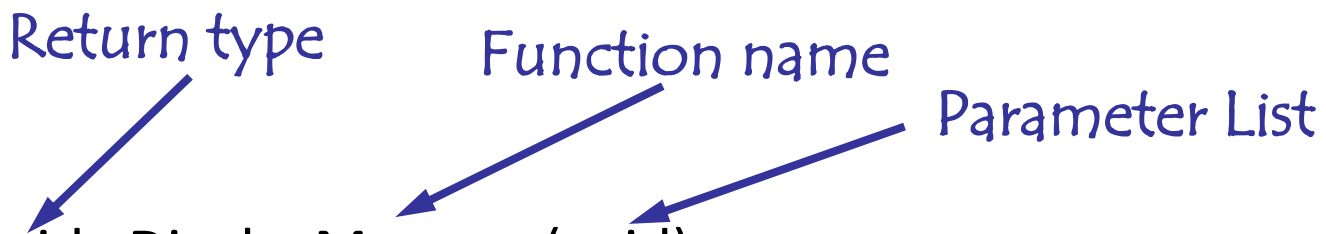
Functions




```
void   DisplayMessage(void)
{
        cout << "Hello from the function" ;
}

int  main()
{
        cout << "Hello from main";
        DisplayMessage();   // FUNCTION CALL
        cout << "Back in function main again.\n";
        return 0;
 }
```

Body

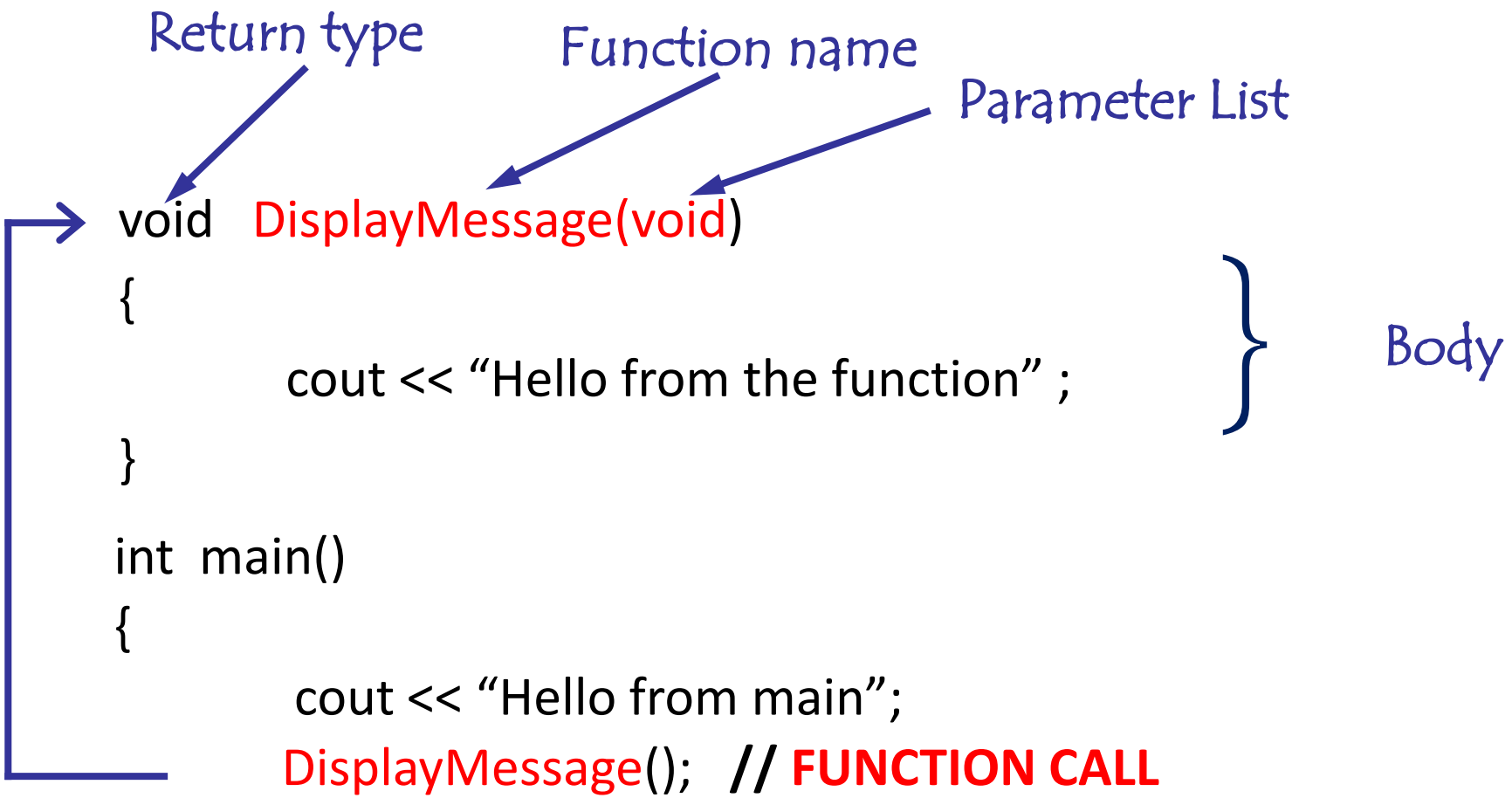
Functions



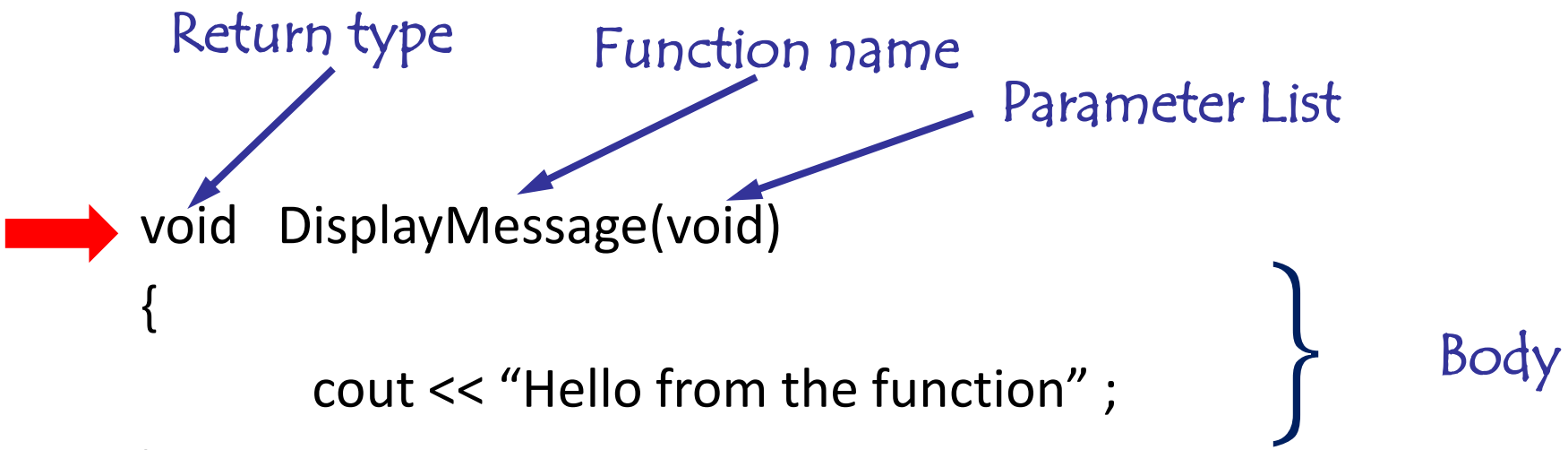

```
void   DisplayMessage(void)
{
        cout << "Hello from the function" ;
}

int  main()
{
         cout << "Hello from main";
         DisplayMessage();   // FUNCTION CALL
         cout << "Back in function main again.\n";
         return 0;
 }
```

Body

Functions

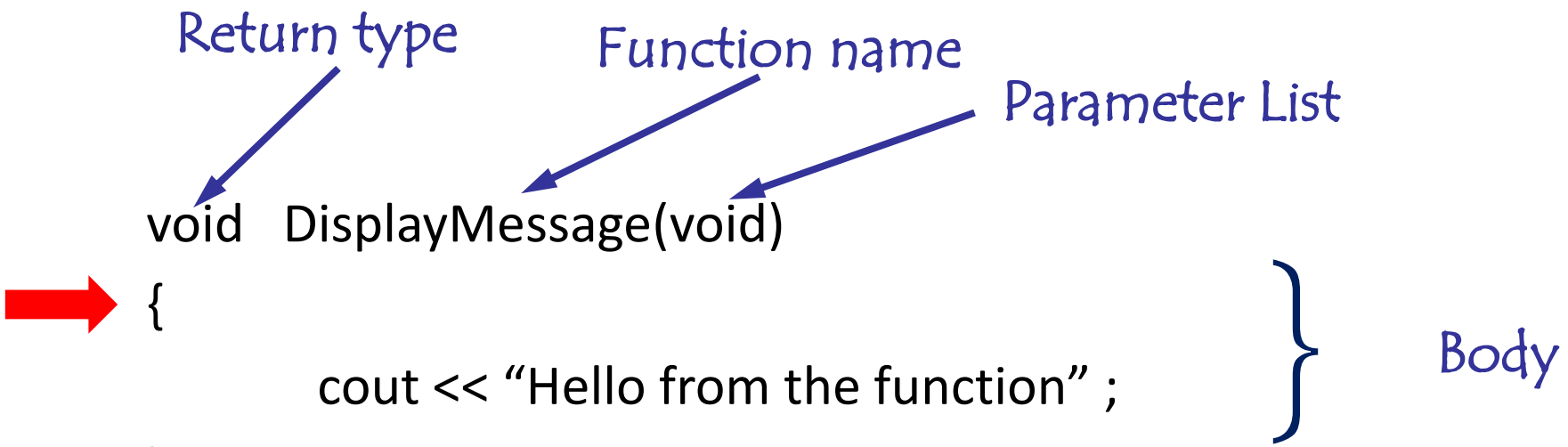

Return type
Function name
Parameter List
void DisplayMessage(void)
{
cout << “Hello from the function” ;
}
Body
int main()
{
cout << “Hello from main”;
DisplayMessage(); // FUNCTION CALL
cout << “Back in function main again.\n”;
return 0;
}

Functions



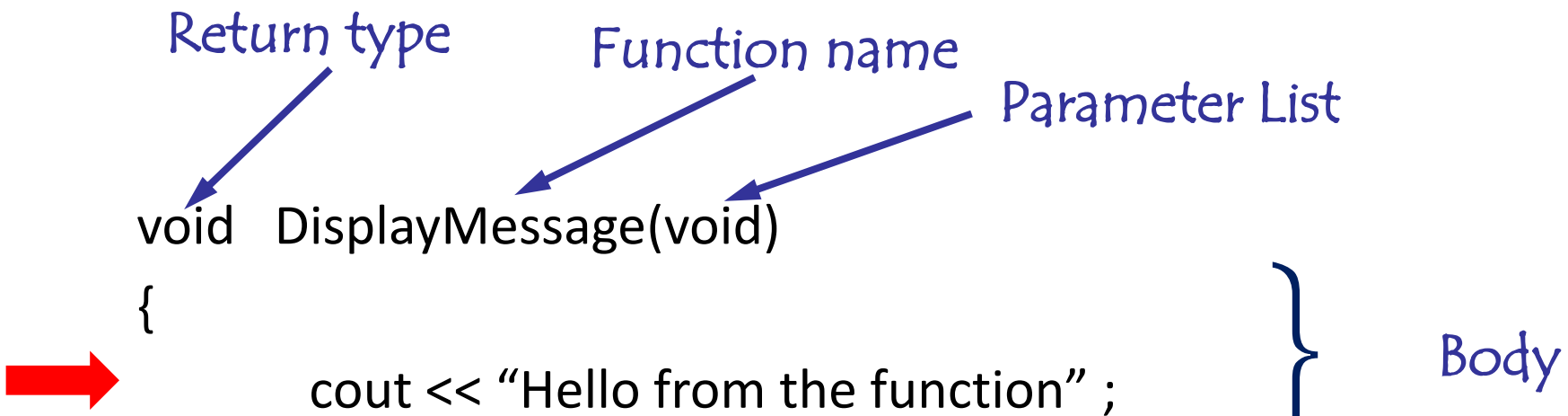

```
int  main()
{
        cout << “Hello from main”;
       DisplayMessage();   // FUNCTION CALL
       cout << “Back in function main again.\n”;
       return 0;
 }
```

Functions



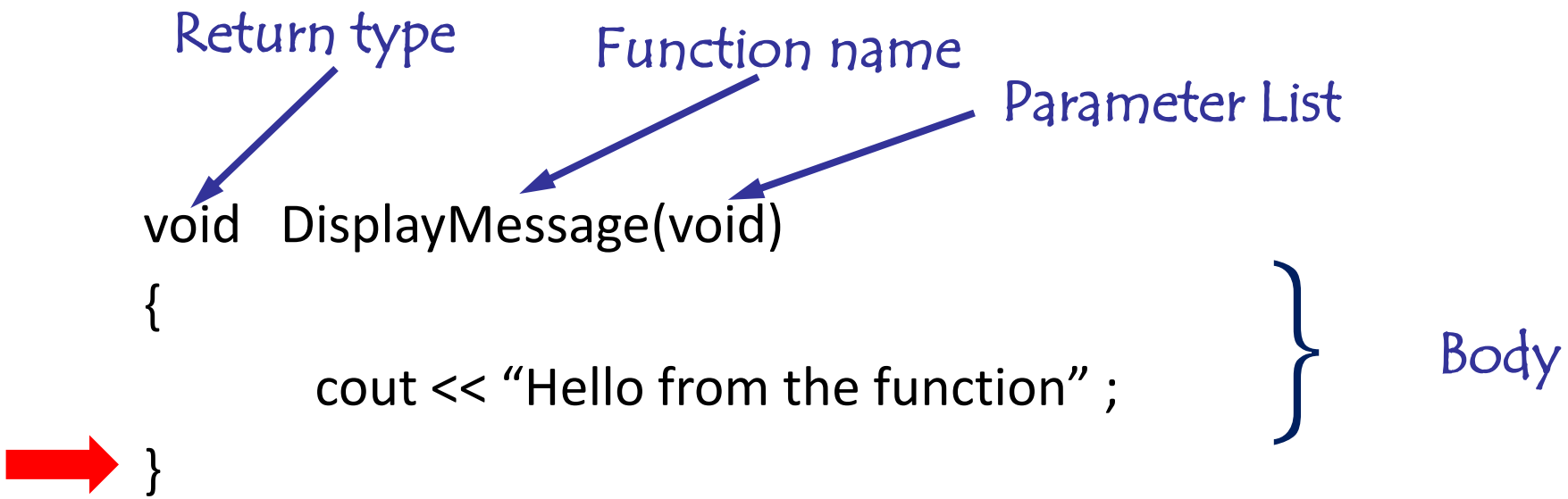

```
int  main()
{
        cout << “Hello from main”;
       DisplayMessage();   // FUNCTION CALL
       cout << “Back in function main again.\n”;
       return 0;
 }
```

Functions



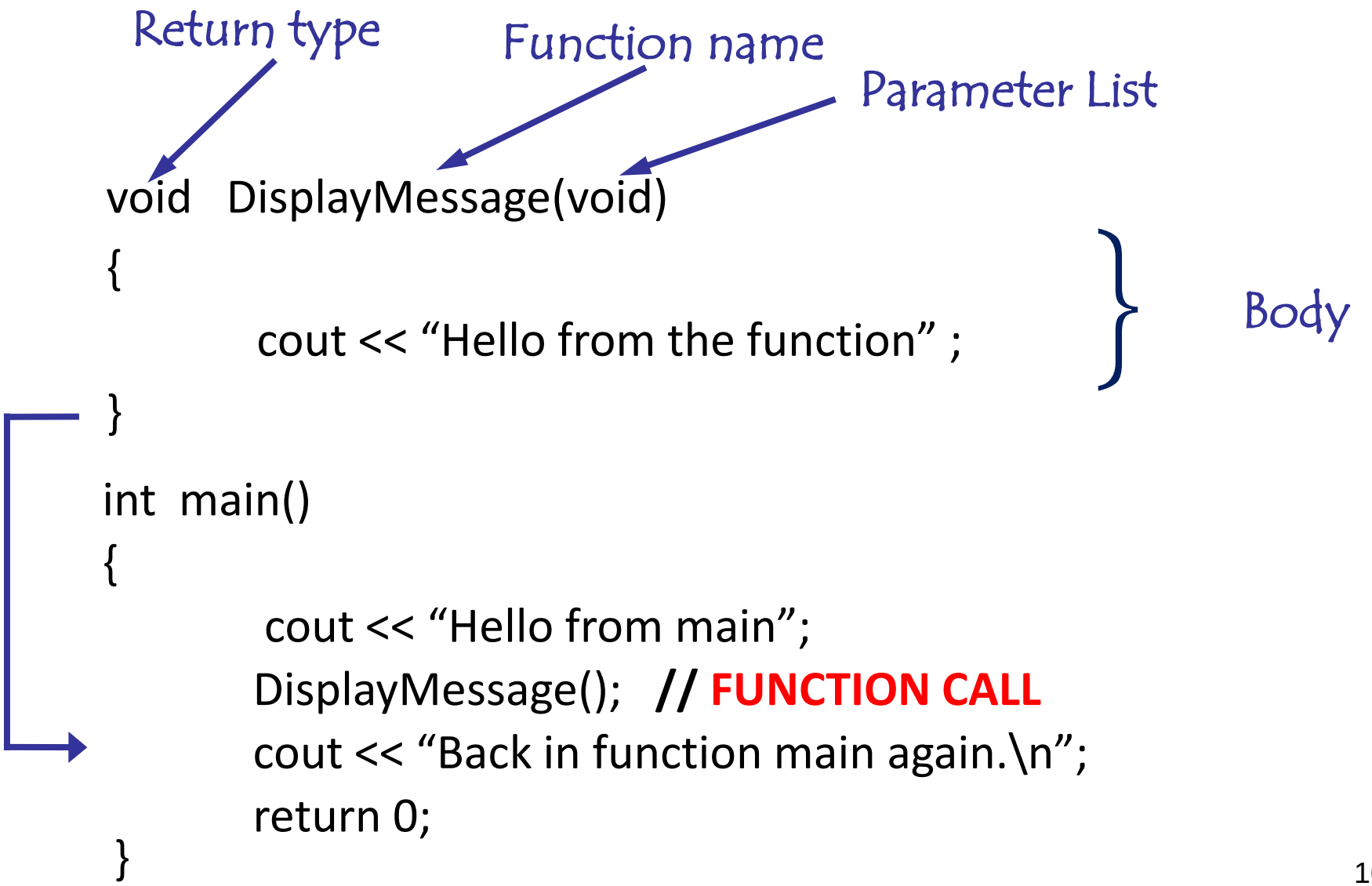

```
int  main()
{
        cout << "Hello from main";
       DisplayMessage();   // FUNCTION CALL
       cout << "Back in function main again.\n";
       return 0;
 }
```

Functions

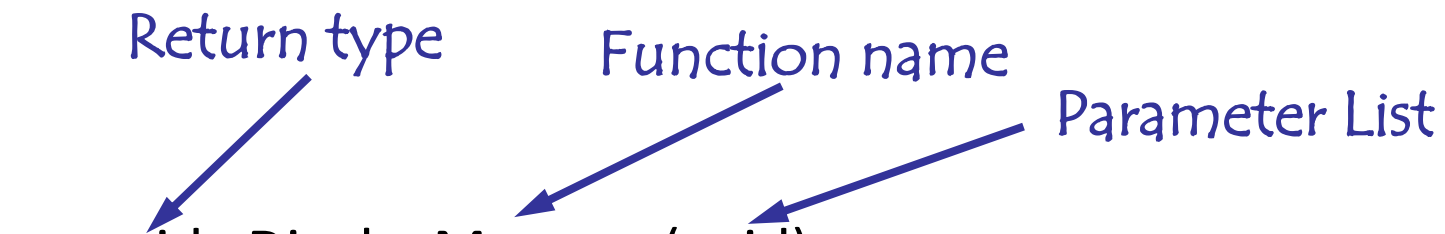



```
int  main()
{
        cout << “Hello from main”;
       DisplayMessage();   // FUNCTION CALL
       cout << “Back in function main again.\n”;
       return 0;
 }
```

Functions


Return type
Function name
Parameter List
void DisplayMessage(void)
{
cout << "Hello from the function" ;
}
Body
int main()
{
cout << "Hello from main";
DisplayMessage(); // FUNCTION CALL
cout << "Back in function main again.\n";
return 0;
}

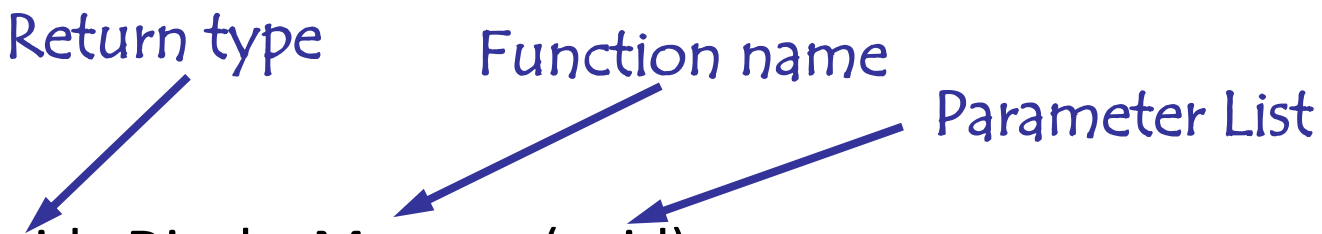
Functions




```
void   DisplayMessage(void)
{
        cout << "Hello from the function" ;
}

int  main()
{
         cout << "Hello from main";
        DisplayMessage();   // FUNCTION CALL
        cout << "Back in function main again.\n";
        return 0;
 }
```

Body

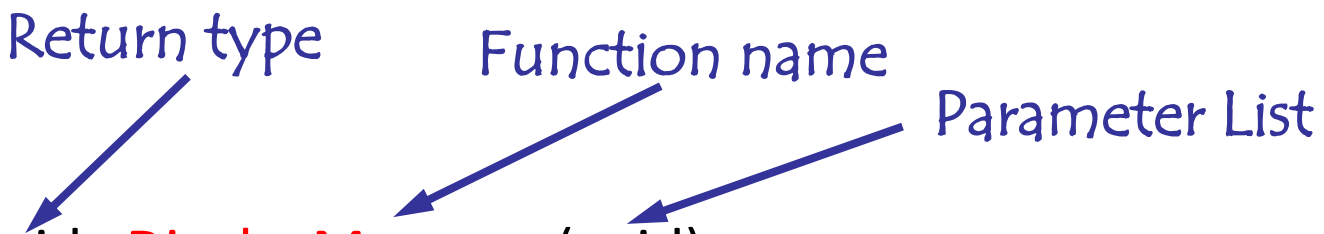
Functions




```
void   DisplayMessage(void)
{
        cout << "Hello from the function" ;
}

int  main()
{
         cout << "Hello from main";
        DisplayMessage();   // FUNCTION CALL
        cout << "Back in function main again.\n";
        return 0;
 }
```

Body

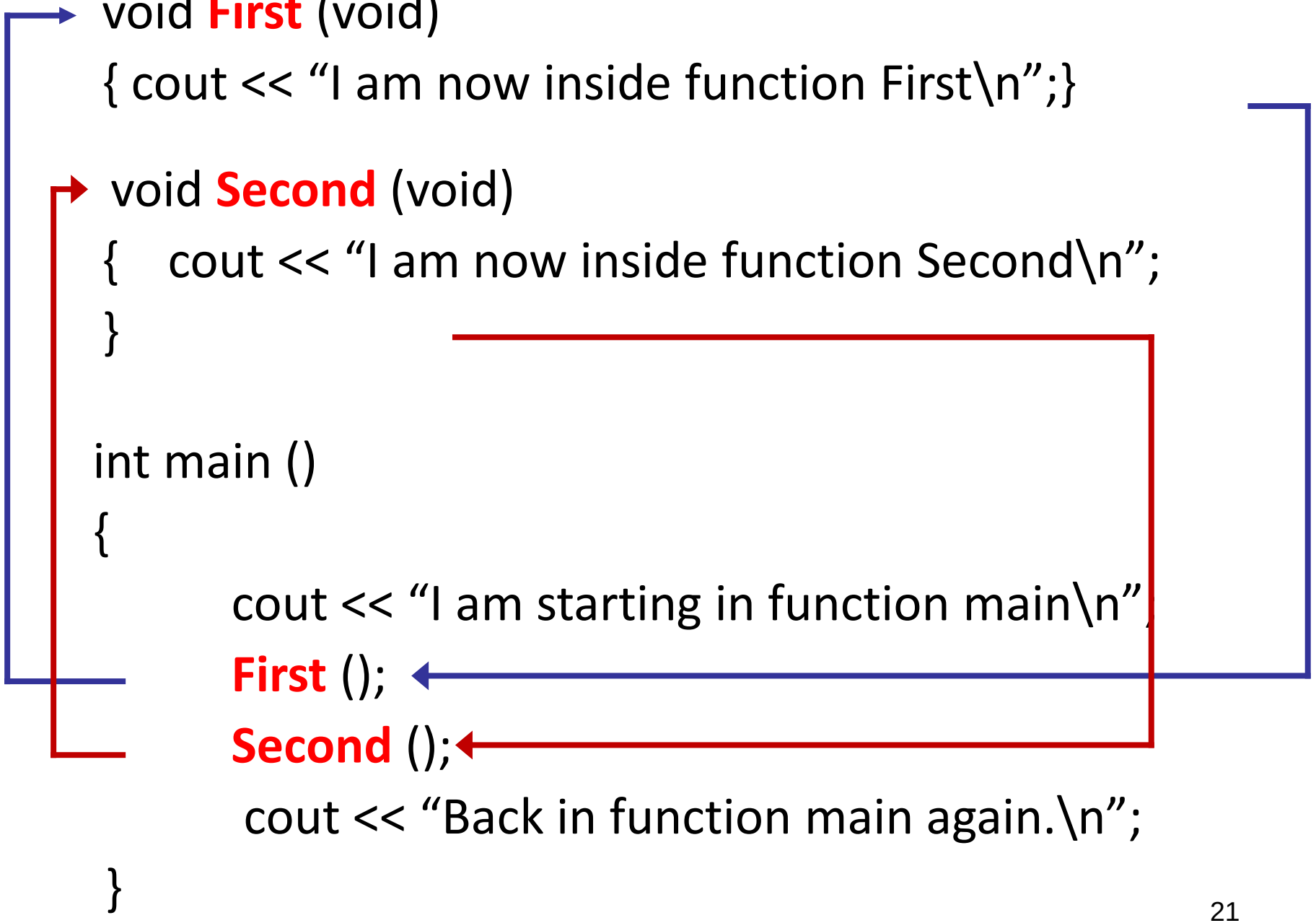
Functions




```
void   DisplayMessage (void)
{
        cout << "Hello from the function" ;
}

int  main()
{
         cout << "Hello from main";
        DisplayMessage();   // FUNCTION CALL
        cout << "Back in function main again.\n";
        return 0;
}
```

Body

```
void DisplayMessage(void); //fn declaration

int main()
{
        cout << "Hello from main";
        DisplayMessage();   // FUNCTION CALL
        cout << "Back in function main again.\n";
 }

// FUNCTION DEFINITION

void DisplayMessage(void)
{
        cout << "Hello from the function" ;
 }
```


void First (void)
{ cout << "I am now inside function First\n";}
void Second (void)
{ cout << "I am now inside function Second\n";
}
int main ()
{
cout << "I am starting in function main\n";
First ();
Second ();
cout << "Back in function main again.\n";
}

Arguments and parameters

- Both arguments and parameters are variables used in a program & function.
- Variables used in the *function reference or function call* are called as arguments. These are written within the parenthesis followed by the name of the function. They are also called actual parameters.
- Variables used in *function definition* are called parameters, They are also referred to as formal parameters.

```
 3  int    sum( int    x , int    y );
 4
 5  int main()
 6  {
 7      int   a = 10 , b = 20 , c;
 8      c = sum(a,b);
 9      cout<<c;
10      return 0;
11  }
12
13  int sum( int   x, int    y )
14  {
15      return    x + y;
16  }
```

```
 3  int    sum( int p , int q );
 4
 5  int main()
 6  {
 7      int  a = 10 , b = 20 , c;
 8      c = sum(a,b);
 9      cout<<c;
10      return 0;
11  }
12
13  int sum( int  x, int   y )
14  {
15      return   x + y;
16  }
```

```
 3  int    sum( int , int );
 4
 5  int main()
 6  {
 7      int   a = 10 , b = 20 , c;
 8      c = sum(a,b);
 9      cout<<c;
10      return 0;
11  }
12
13  int sum( int   x, int    y )
14  {
15      return    x + y;
16  }
```

Functions- points to note

1. The parameter list must be separated by commas.

   ```
   dispChar( int n, char c);
   ```

2. The parameter names do not need to be the same in the prototype declaration and the function definition.
3. The types must match the types of parameters in the function definition, in number and order.

   ```
   void dispChar ( int n, char c);//proto-type
   void dispChar ( int num, char letter) // function definition
   { cout<<" You have entered  "<< n<< "&" <<c; }
   ```

4. Use of parameter names in the declaration is optional.

   ```
   void dispChar ( int , char);//proto-type
   ```

Functions- points to note

4. If the function has no formal parameters, the list is written as (void).
5. The return type is optional, when the function returns **int** type data.
6. The return type must be **void** if no value is returned.
7. When the declared types do not match with the types in the function definition, compiler will produce error.

Functions- Categories

1. Functions with no parameters and no return values.
2. Functions with parameters and no return values.
3. Functions with parameters and one return value.
4. Functions with no parameters but return a value.

Fn with No parameters & No return values

```
 3  void dispPattern()
 4  {
 5      int i;
 6      for ( i = 1 ; i <= 20 ; i++ )
 7          cout<<"*";
 8  }
 9
10  int main()
11  {
12      cout<<"\nfn to display a line of stars\n";
13      dispPattern();
14      return 0;
15  }
```

Fn with parameters & No return values

```
 3  void dispPattern( char c )
 4  {
 5      int i;
 6      for ( i = 1 ; i <= 20 ; i++ )
 7          cout<<c;
 8  }
 9
10  int main()
11  {
12      cout<<"\nfn to display a line of stars\n";
13      dispPattern( '#' );
14      dispPattern( '*' );
15      dispPattern('@');
16      return 0;
17  }
```

Fn with parameters & One return value

```
 3  int  fnAdd( int x, int y )
 4  {
 5      int z;
 6      z = x + y;
 7      return(z);
 8  }
 9
10  int main()
11  {
12      int a=10, b=20, c;
13      c = fnAdd( a , b );
14      cout<<"Sum is "<< c;
15      return 0;
16  }
```

Fn with No parameters but A return value

```
 3  int readNum()
 4  {
 5      int z;
 6      cin>>z;
 7      return z;
 8  }
 9
10  int main()
11  {
12      int c;
13      cout<<"\nEnter a number \n";
14      c = readNum();
15      cout<<"\nThe number read is "<<c;
16      return 0;
17  }
```

To be solved …Functions

Write appropriate functions to

1. Find the factorial of a number ‘n’.
2. Reverse a number ‘n’.
3. Check whether the number ‘n’ is a palindrome.
4. Generate the Fibonacci series for given limit ‘n’.
5. Check whether the number ‘n’ is prime.
6. Generate the prime series using the function written for prime check, for a given limit.

Functions- Parameter Passing

- Pass by value (call by value)
- Pass by reference (call by reference)

```
 3  void incr( int );
 4  int main()
 5  {
 6      int a = 10;
 7      incr( a );
 8      cout<<a;
 9      return   0;
10  }
11  void    incr( int    a )
12  {
13      a++;
14  }
```

Question..

1. **Write a function prototype for a function named *test()* that takes three arguments (two integer arguments, and a character argument), and returns a float value.**

Ans: **float test(int , int , char);**

Questions..

2. What is the output of the following code?

```
 3  int multiply(int x, y)
 4  {
 5      return x * y;
 6  }
 7  int main()
 8  {
 9      int a = 5, b = 6, c;
10      c = multiply( a , b );
11      return 0;
12  }
```

Error !

Questions..

3. What is the output of the following code?

```
 3  void compute_double( int , int );
 4
 5  int main()
 6  {
 7      int p = 10, q = 15;
 8      compute_double( p , q );
 9      cout<<p<<"\t"<<q;
10      return 0;
11  }
12  void compute_double( int x, int y)
13  {
14      x = x * 2;
15      y = y * 2;
16  }
```

```
10      15
```

Functions- Parameter Passing

- Pass by value (call by value)
- **Pass by reference (call by reference)**

Reference variable

- *A reference variable is an alias, that is, another name for an already existing variable.*
- *Once a reference is initialized with a variable, either the variable name or the reference name may be used to refer to the variable.*

***Syntax**:*

Datatype ***&*** *RefVariable = valVariable;*

Example**:* ***int &r = i; *// **i** declared earlier*

```
3  int main()
4  {
5      int a = 10;
6      int &ref_a = a;
7
8      cout<<a<<"\n";
9      cout<<ref_a<<"\n";
10
11     a *= 2;
12
13     cout<<a<<"\n";
14     cout<<ref_a<<"\n";
15
16     ref_a++;
17
18     cout<<a<<"\n";
19     cout<<ref_a<<"\n";
20 }
```

OUTPUT

```
10
10
20
20
21
21
```

C++ References vs Pointers:

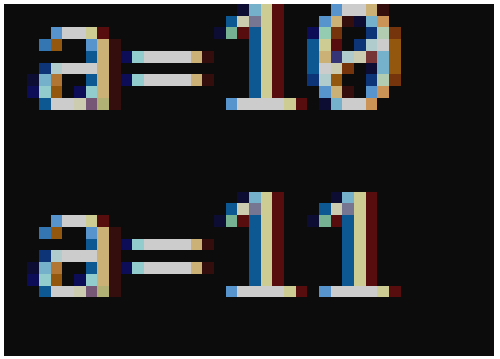
Three major differences between references and pointers are:

- *You cannot have NULL references. You must always be able to assume that a reference is connected to a legitimate piece of storage.*
- *Once a reference is initialized to an object, it cannot be changed to refer to another object. Pointers can be pointed to another object at any time.*
- *A reference must be initialized when it is created. Pointers can be initialized at any time.*

- *Datatype & RefVariable = valVariable;*

```
 3  void increment( int& );
 4  int main()
 5  {
 6      int a = 10;
 7      increment( a );
 8      cout<<a;
 9      return 0;
10  }
11
12  void increment( int &x )
13  {
14      x++;
15  }
```

OUTPUT



```
3   void compute_double( int , int&  );
4   int main()
5   {
6       int p = 10, q = 15;
7       compute_double( p , q );
8       cout<<p<<"\t"<<q;
9       return 0;
10  }
11  void compute_double( int x, int &y)
12  {
13      x = x * 2;
14      y = y * 2;
15  }
```

OUTPUT

Passing 1D-Array to a function

```
Sum = 100
```

```
3   int sum_array( int [ ], int );
4   int main()
5   {
6       int A[] = { 10, 20, 30, 40 }, n = 4;
7       int total = sum_array( A, n );
8       cout<<"Sum = "<<total;
9       return 0;
10  }
11
12  int sum_array( int arr[ ], int size )
13  {
14      int sum = 0;
15      for( int i = 0 ; i < size ; i++ )
16          sum += arr[i];
17      return sum;
18  }
```

```
 3  void incr_array( int [ ], int );
 4  int main()
 5  {
 6      int A[] = { 10, 20, 30, 40 }, n = 4;
 7      incr_array( A, n );
 8      for( int i = 0; i < n; i++ )
 9          cout<<A[i]<<"\n";
10      return 0;
11  }
12
13  void incr_array( int arr[ ], int size )
14  {
15      for( int i = 0 ; i < size ; i++ )
16          arr[i]++;
17  }
```

```
11
21
31
41
```

Passing 1D-Array to Function

Rules to pass an array to a function

- *The function must be called by passing only the name of the array.*
- *In the function definition, the formal parameter must be an array type; the size of the array does not need to be specified.*
- *The function prototype must show that argument is an array.*

Passing 2D-Array to Function

```
 3  int matrix_sum( int [ ][10], int, int );
 4  int main()
 5  {
 6      int mat[][10] = {{1,2},{3,4},{5,6}};
 7      int row_size=3, col_size = 2;
 8
 9      int total = matrix_sum(mat,row_size,col_size);
10      cout<<total;
11      return 0;
12  }
```

```
13  int matrix_sum( int M[][10], int r, int c )
14  {
15      int sum = 0;
16      for( int i = 0; i < r; i++ )
17          for( int j = 0; j < c; j++ )
18              sum += M[i][j];
19      return sum;
20  }
```

Passing 2D-Array to Function

Rules to pass a 2D- array to a function

- *The function must be called by passing only the array name.*
- *In the function definition, we must indicate that the array has two-dimensions by including two set of brackets.*
- *The size of the second dimension must be specified.*
- *The prototype declaration should be similar to function header.*

Function overloading, default arguments and inline functions

Function Overloading

- *Using the concept of function overloading - we can design a family of functions with one function name but with different argument lists.*
- *The function would perform different operations depending on the argument list in the function call.*

Example

```
void display ( int );

void display ( long );

void display ( char [ ] );
```

```
void display( int   var )
{
    cout<<var<<endl;
}

void display( long   var )
{
    cout<<var<<endl;
}

void display( char  var[ ] )
{
    cout<<var<<endl;
}
```

```
 3  void display(int);
 4  void display(long);
 5  void display(char []);
 6
 7  int  main( )
 8  {
 9     int  i = 10;
10     long  j = 600000;
11     char str[]="HELLO";
12     display( i );
13     display( j );
14     display( str );
15     return 0;
16  }
```

```
17  void display(char var[])
18  {
19      cout<<var<<endl;
20  }
21  void display(int var)
22  {
23      cout<<var<<endl;
24  }
25  void display(long var)
26  {
27      cout<<var<<endl;
28  }
```

Default arguments

- ✓ *Default values are given in the function prototype declaration.*
- ✓ *Whenever a call is made to a function without specifying an argument, the program will automatically assign values to the parameters*
- ✓ *Only the trailing arguments can have default values and therefore we must add defaults from right to left.*
- ✓ *We cannot provide a default value to a particular argument in the middle of an argument list.*

Function with default arguments - Example

```
 4  double power( double x, double n=2)
 5  {
 6      return pow(x,n);
 7  }
 8  int  main( )
 9  {
10    double a = 10, b = 5, c = 3;
11    double r1 = power( a );
12    double r2 = power( b , c );
13    cout<<"r1="<<r1;
14    cout<<"\nr2="<<r2;
15    return 0;
16  }
```

OUTPUT

```
r1=100
r2=125
```

Function with default arguments - Example-1

```
 4  double power( double, double = 2);
 5  int  main( )
 6  {
 7    double a = 10, b = 5, c = 3;
 8    double r1 = power( a );
 9    double r2 = power( b , c );
10    cout<<"r1="<<r1;
11    cout<<"\nr2="<<r2;
12    return 0;
13  }
14
15  double power( double x, double n)
16  {
17      return pow(x,n);
18  }
```

OUTPUT

```
r1=100
r2=125
```

Function with default arguments - Example-2

```
3   int add( int a, int b=2, int c=3 )
4   {
5       return a + b + c;
6   }
7   int  main( )
8   {
9       int x = 10, y = 20, z = 30;
10      cout<< add( x ) <<"\n";
11      cout<< add( x, y ) <<"\n";
12      cout<< add( x, y, z );
13      return 0;
14  }
```

OUTPUT

```
15
33
60
```

```
int Display( int a=1, int b, int c )     // Invalid

int Display( int a=1, int b=2, int c ) // Invalid

int Display( int a, int b=2, int c )  // Invalid
```

Inline functions

- *An inline function is a function that is expanded in line when it is invoked(or called).*

- *The compiler replaces the function call with the corresponding function code (similar to the macros expansion).*

The inline functions are defined as follows:

```
inline function-header
{
        Function body
}
```

Example:

```
inline  double  cube( double  a )
 {
    return  a*a*a;
}
```

The above inline function can be invoked by statements like

```
double   c = cube(3.0);
double   d = cube( 2.5+1.5 );
```

- *All inline functions must be defined before they are called.*
- *It is easy to make a function as inline function. Just prefix the keyword inline to the function definition.*
- *The inline expansion makes a program run faster because the overhead of a function call and return is eliminated.*
- *However, it makes the program to take up more memory because the statements that define the inline function are reproduced at each point where the function is called.*

```
inline   float   mul ( float   x, float   y )
{
          return  x*y;
}
inline   double   div ( double  p, double   q )
{
          return  p/q;
}
```

```
int   main()
{
          float   a = 12.5;
          float   b = 10;
          cout << mul(a,b)<<"\n";
          cout << div(a,b)<<"\n";
          return 0;
}
```

Passing structure to a function

```
4   struct Emp
5   {
6       char name[50];
7       int age;
8       float salary;
9   };
```

```
10  void getData(Emp &p)
11  {
12      strcpy(p.name,"John");
13      p.age = 30;
14      p.salary = 30000;
15  }
16  void displayData( Emp &p )
17  {
18      cout<<"Name: "<<p.name<<endl;
19      cout<<"Age: "<<p.age<<endl;
20      cout<<"Salary: "<<p.salary;
21  }
```

```
22  int main()
23  {
24      Emp p;
25      getData(p);
26      displayData(p);
27      return 0;
28  }
```

```
Name: John
Age: 30
Salary: 30000
```

Passing structure to function

```
4  struct Emp
5  {
6      char name[50];
7      int age;
8      float salary;
9  };
10 void getData( Emp& );
11 void displayData( Emp& );
12
13 int main()
14 {
15     Emp p;
16     getData(p);
17     displayData(p);
18     return 0;
19 }
```

```
20 void getData(Emp &p)
21 {
22     strcpy(p.name,"John");
23     p.age = 30;
24     p.salary = 30000;
25 }
26 void displayData( Emp &p )
27 {
28     cout<<"Name: "<<p.name<<endl;
29     cout<<"Age: "<<p.age<<endl;
30     cout<<"Salary: "<<p.salary;
31 }
```

Recursion

- Recursion is the property that when a called function calls themselves.
- It is useful for many tasks, like sorting or calculate the factorial of numbers.
- For example, to obtain the factorial of a number (n!) the mathematical formula would be:

  n! = n * (n-1) * (n-2) * (n-3) ... * 1//recurrence formula

  more precisely, 5! (factorial of 5) would be:

  5! = 5 * 4 * 3 * 2 * 1 = 120

Factorial

```
long int factorial (long a)
{
    if (a ==0)
      return  1;
    return (a * factorial (a-1));
 }
```

```
long fact = factorial (number);
```

```
long int factorial ( long a )
 {
    if (a ==0)
       return (1);
    return (a * factorial (a-1));
 }
long fact = factorial( 5 );
```

```
long int factorial ( long a )
 {
    if (a ==0)
       return (1);
    return (a * factorial (a-1));
 }
long fact = factorial( 5 );
```

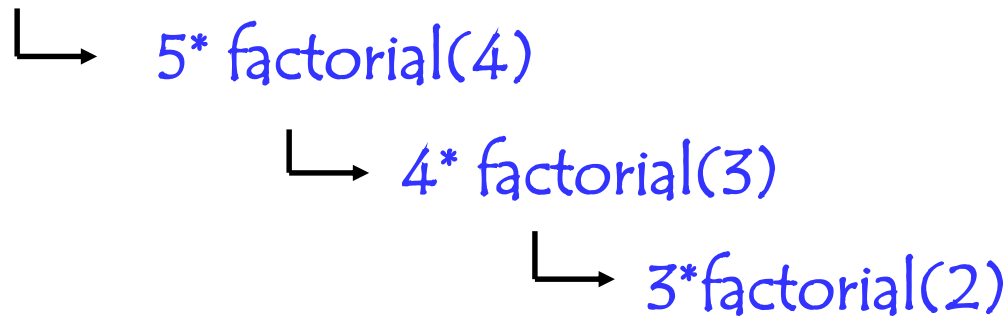
5* factorial(4)

```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
   return (a * factorial (a-1));
}
long fact = factorial( 5 );
```

↳ 5* factorial(4)

↳ 4* factorial(3)

```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
    return (a * factorial (a-1));
}
long fact = factorial( 5 );
```



```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
    return (a * factorial (a-1));
}
long fact = factorial( 5 );
```

↳ 5* factorial(4)

↳ 4* factorial(3)

↳ 3*factorial(2)

↳ 2* factorial(1)

```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
    return (a * factorial (a-1));
}
long fact = factorial( 5 );
```

└→ 5* factorial(4)

└→ 4* factorial(3)

└→ 3*factorial(2)

└→ 2* factorial(1)

└→ 1*factorial(0)

└→ 1

```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
    return (a * factorial (a-1));
}
long fact = factorial( 5 );
```

└→ 5* factorial(4)

└→ 4* factorial(3)

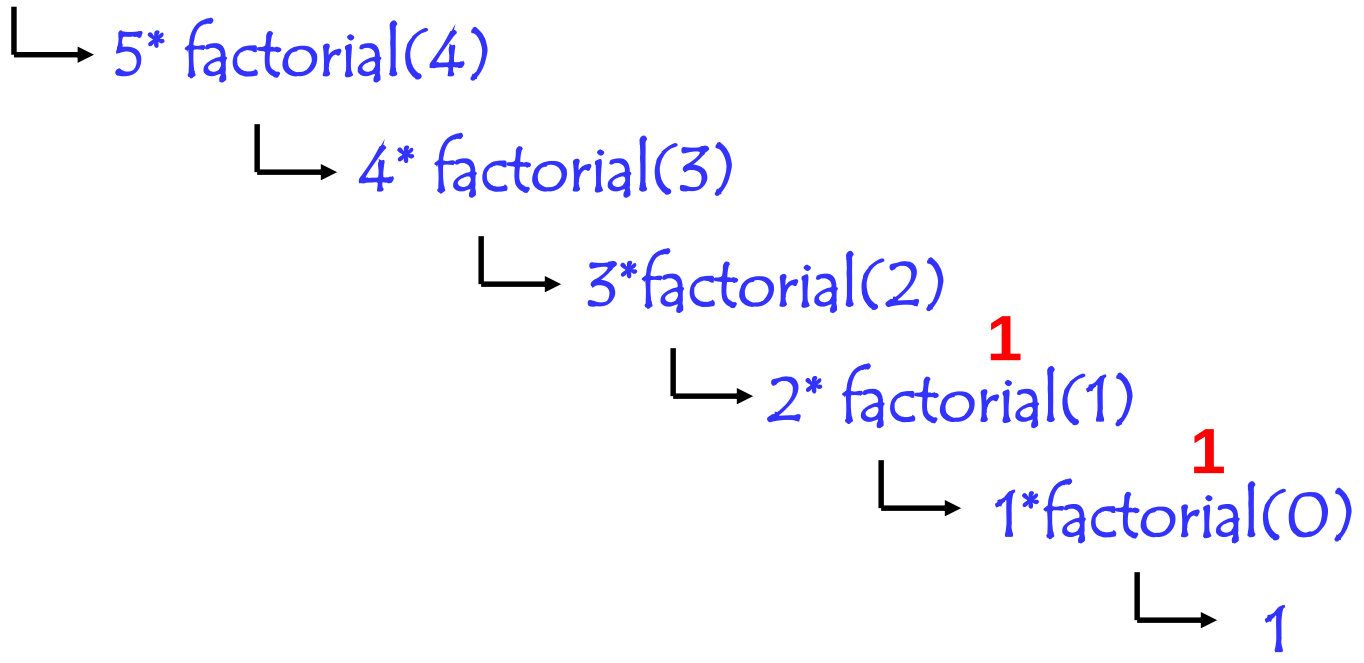
└→ 3*factorial(2)

└→ 2* factorial(1)

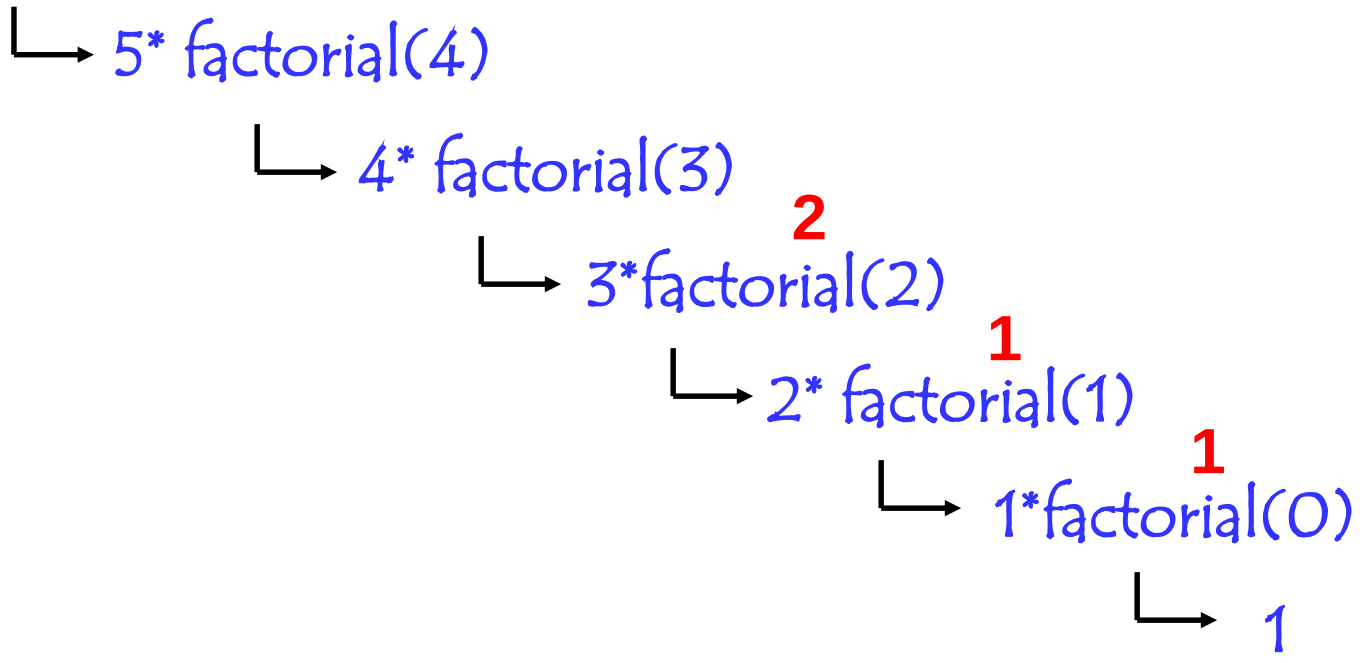
└→ 1*factorial(0) **1**

└→ 1

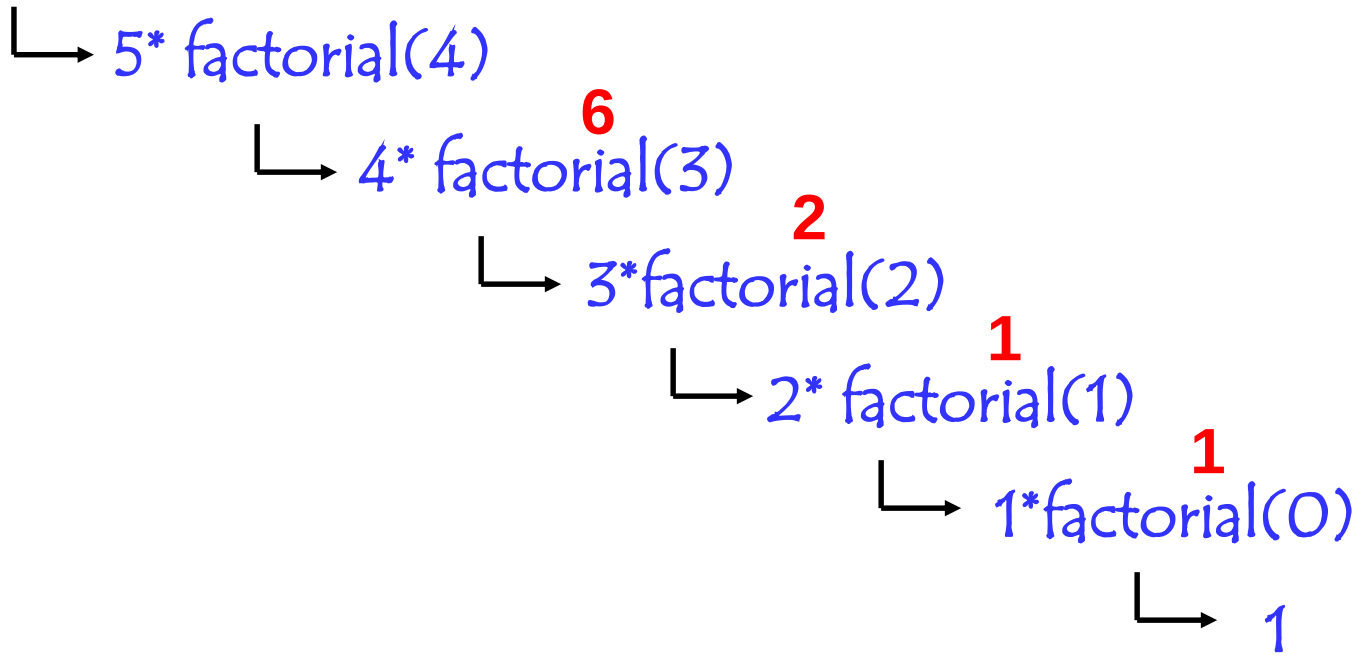
```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
   return (a * factorial (a-1));
}
long fact = factorial( 5 );
```



```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
    return (a * factorial (a-1));
}
long fact = factorial( 5 );
```



```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
    return (a * factorial (a-1));
}
long fact = factorial( 5 );
```



```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
   return (a * factorial (a-1));
}
long fact = factorial( 5 );
```

24

└→ 5* factorial(4)

6

└→ 4* factorial(3)

2

└→ 3*factorial(2)

1

└→ 2* factorial(1)

1

└→ 1*factorial(0)

└→ 1

```
long int factorial ( long a )
{
   if (a ==0)
      return (1);
   return (a * factorial (a-1));
}
```

120

```
long fact = factorial( 5 );
```

24

```
└→ 5* factorial(4)
```

6

```
└→ 4* factorial(3)
```

2

```
└→ 3*factorial(2)
```

1

```
└→ 2* factorial(1)
```

1

```
└→ 1*factorial(0)
└→ 1
```

To be solved using recursive fns…

- Write a recursive function to generate n^{th} Fibonacci term. Print first N Fibonacci terms using this function.

  [Hint: Fibonacci series is 0, 1, 1, 2, 3, 5, 8 …]
- Write a recursive function to reverse a number.
- Find GCD of two numbers.

  (Ex: GCD of 9,24 is 3)
- Write a function to sort a list of number.

Question: Array sum using recursion

```
3   int Cal_Sum(int Arr[], int size )
4   {
5       if ( size <= 0 )
6           return 0;
7       return  Arr[size - 1] + Cal_Sum(Arr, size - 1);
8   }

10  int main()
11  {
12      int Arr[] = { 10 , 20 , 30 , 40 , 50 } , size = 5;
13      int sum = Cal_Sum( Arr , size );
14      cout<< sum;
15      return 0;
16  }
```

Reversing a Number: Recursion

```
int  rev(int num){
   static int n = 0;
   if(num > 0)
     n = (n* 10) + (num%10) ;
   else
     return n;
   return  rev(num/10);
}
```

Output:

n = 234

rev = 432

81