CPS 188

Computer Programming Fundamentals

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Topic 5.1: Basic looping

Toronto Metropolitan University

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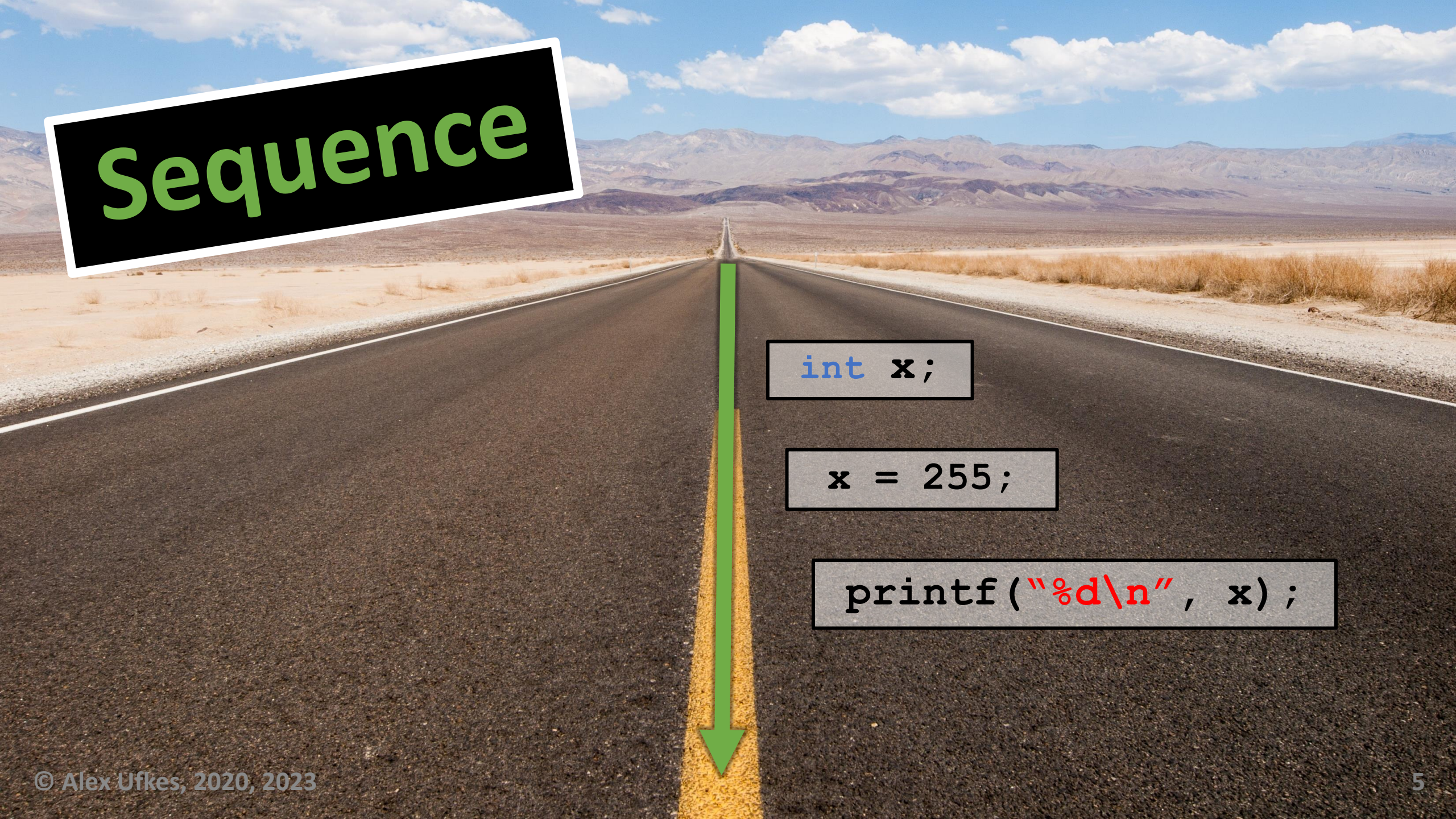
Today

Looping #1

Iteration basics, `for` loops,
`while` loops, `do/while` loops

Control Structures

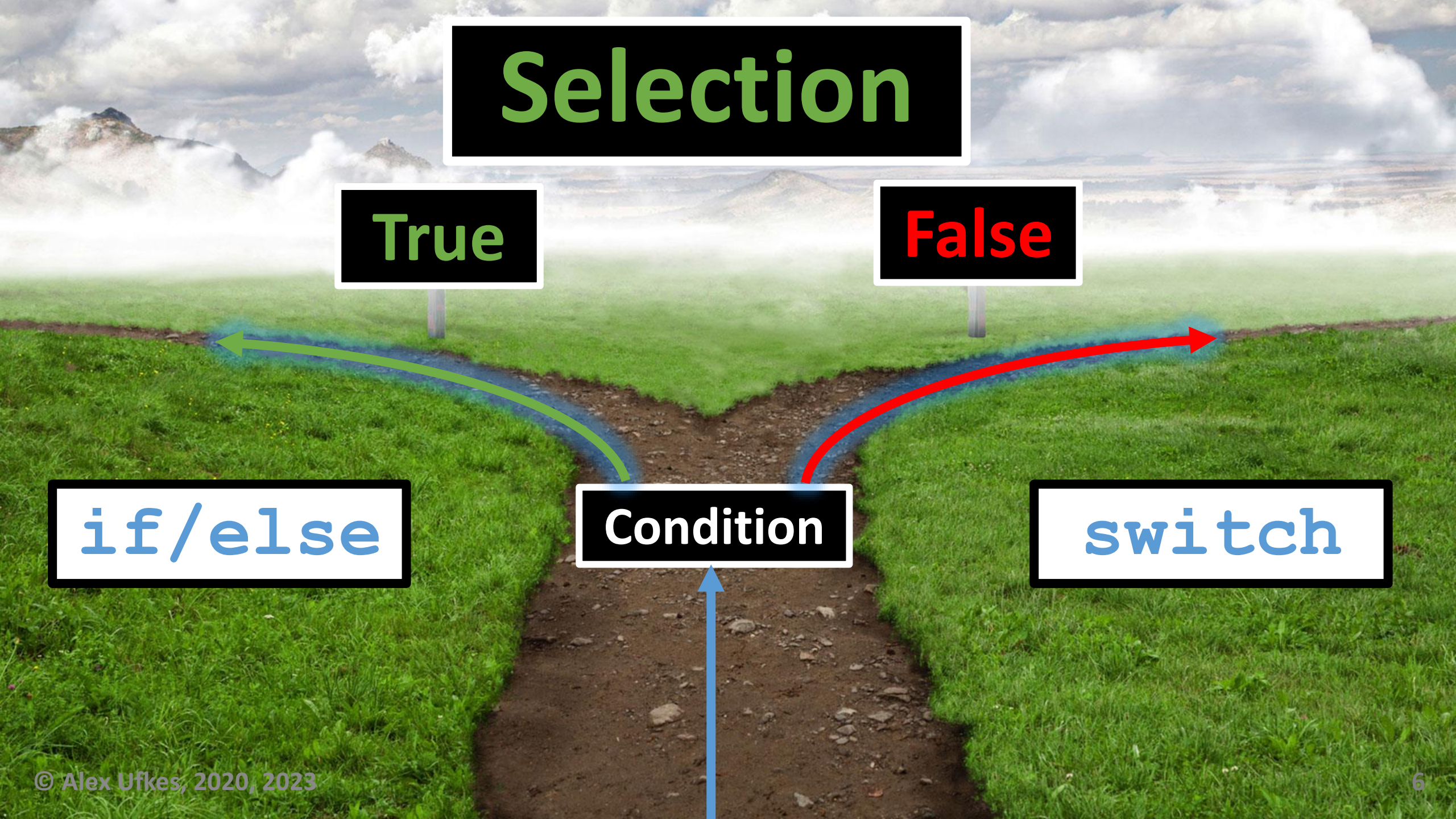
Sequence



```
int x;
```

```
x = 255;
```

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



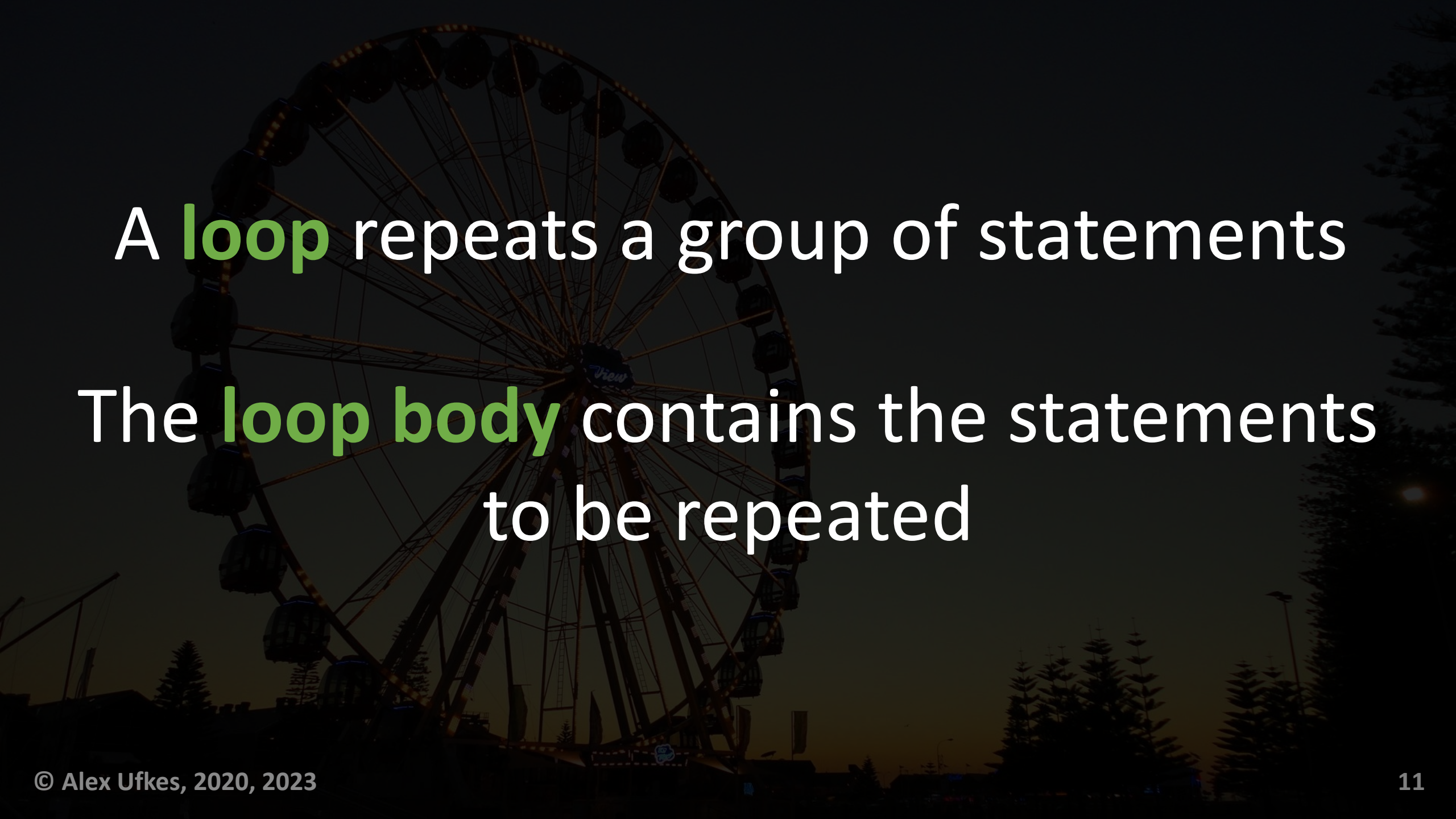
Write a code snippet to print “Hello, World!” five times to the screen.

```
printf(“Hello, World!\n“);
printf(“Hello, World!\n“);
printf(“Hello, World!\n“);
printf(“Hello, World!\n“);
printf(“Hello, World!\n“);
```

Write a code snippet to print "Hello, World!" <u>fifty</u> times to the screen.

```
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
printf("Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n Hello, World!\n");
```

Write a code snippet to print “Hello, World!” FIVE THOUSAND times to the screen.



A **loop** repeats a group of statements

The **loop body** contains the statements to be repeated

3

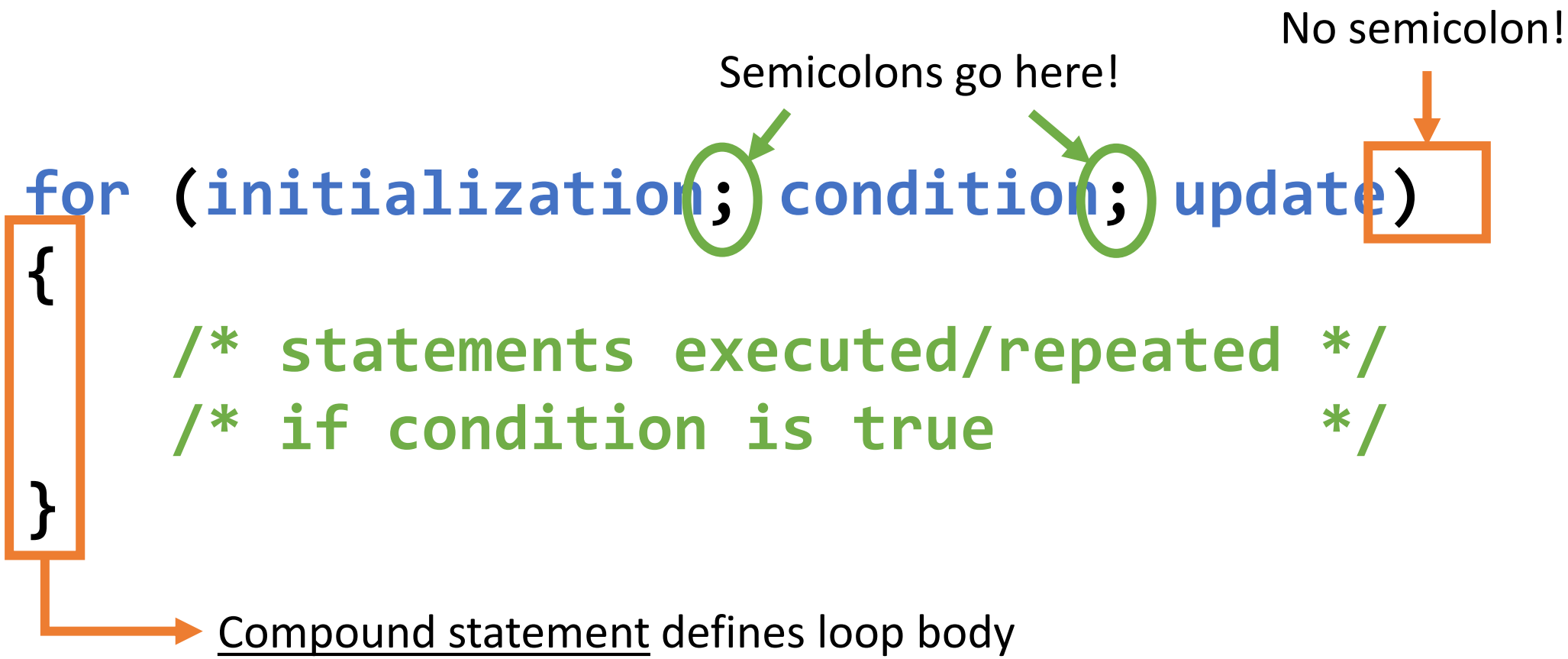
Loop Structures

1) `for` loop

2) `while` loop

3) `do/while` loop

`for` loop



```
int i;

for (i = 1; i <= 3; i++)
{
    printf("Hello, World!\n");
}
```

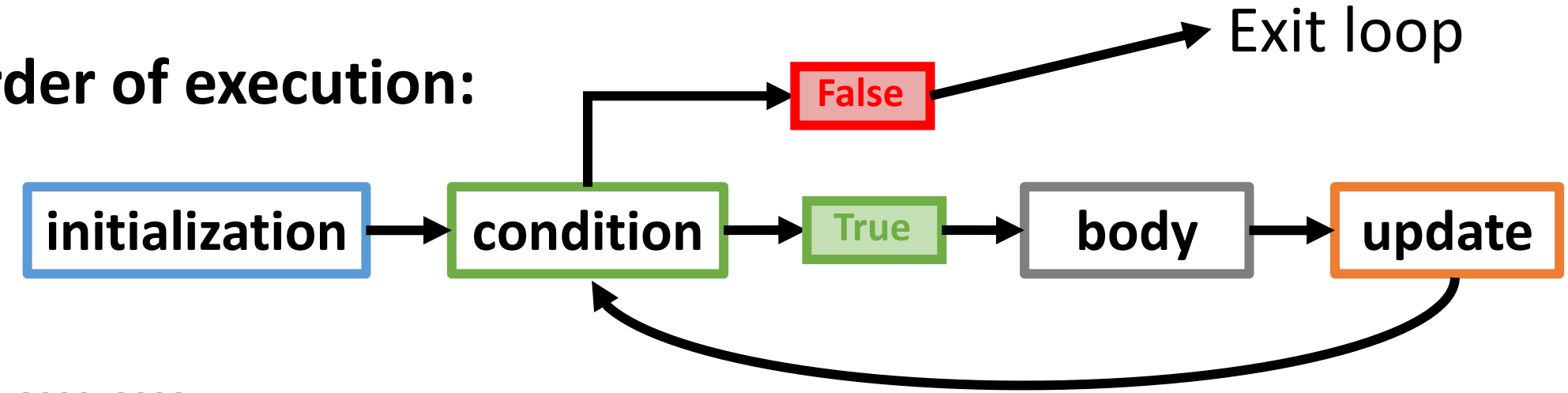
initialization

condition

update

Loop body

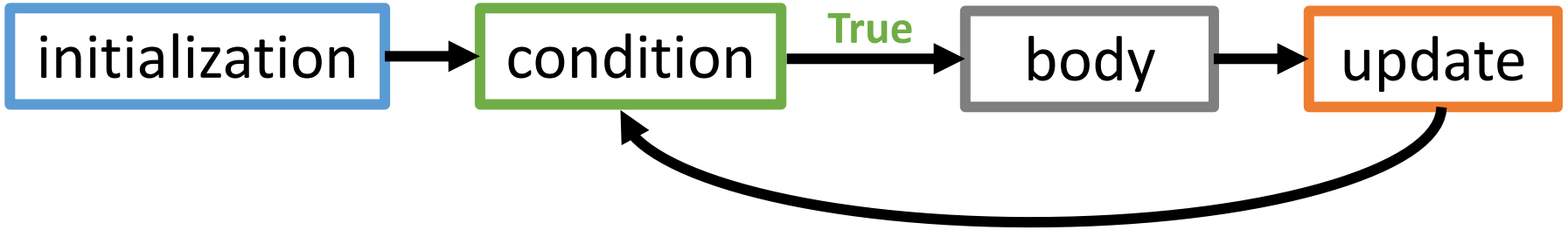
Order of execution:



```
int i;

for (i = 1; i <= 3; i++)
{
    printf("Hello, World!\n");
}
```

Output:

```
Hello, World!
Hello, World!
Hello, World!
```




```
int val;

for (val = 1; val <= 2; val++)
    printf("inside loop: val = %d\n", val);

printf("outside loop: val = %d\n", val);
```

Output:

```
inside loop: val = 1
inside loop: val = 2
outside loop: val = 3
```

What is the output?

```
int n;
for (n = 50; n <= 100; n++)
{
    printf("%d\n", n);
}
```

Numbers between 50-100, inclusive

Write code snippet using a for loop to do the following:

Print all even numbers between 0 and 100.

```
int n;
for (n = 0; n <= 100; n += 2)
{
    printf("%d\n", n);
}
```

Increase **n** by **2**

Another (less efficient) option:

```
int n;
for (n = 0; n <= 100; n++)
{
    if (n % 2 == 0)     /* if(!(n % 2)) */
    {
        printf("%d\n", n);
    }
}
```

Control structures can be nested inside each other any way you like

Write code snippet using a for loop to do the following:

Print all numbers between 0 and 100 in *descending* order.

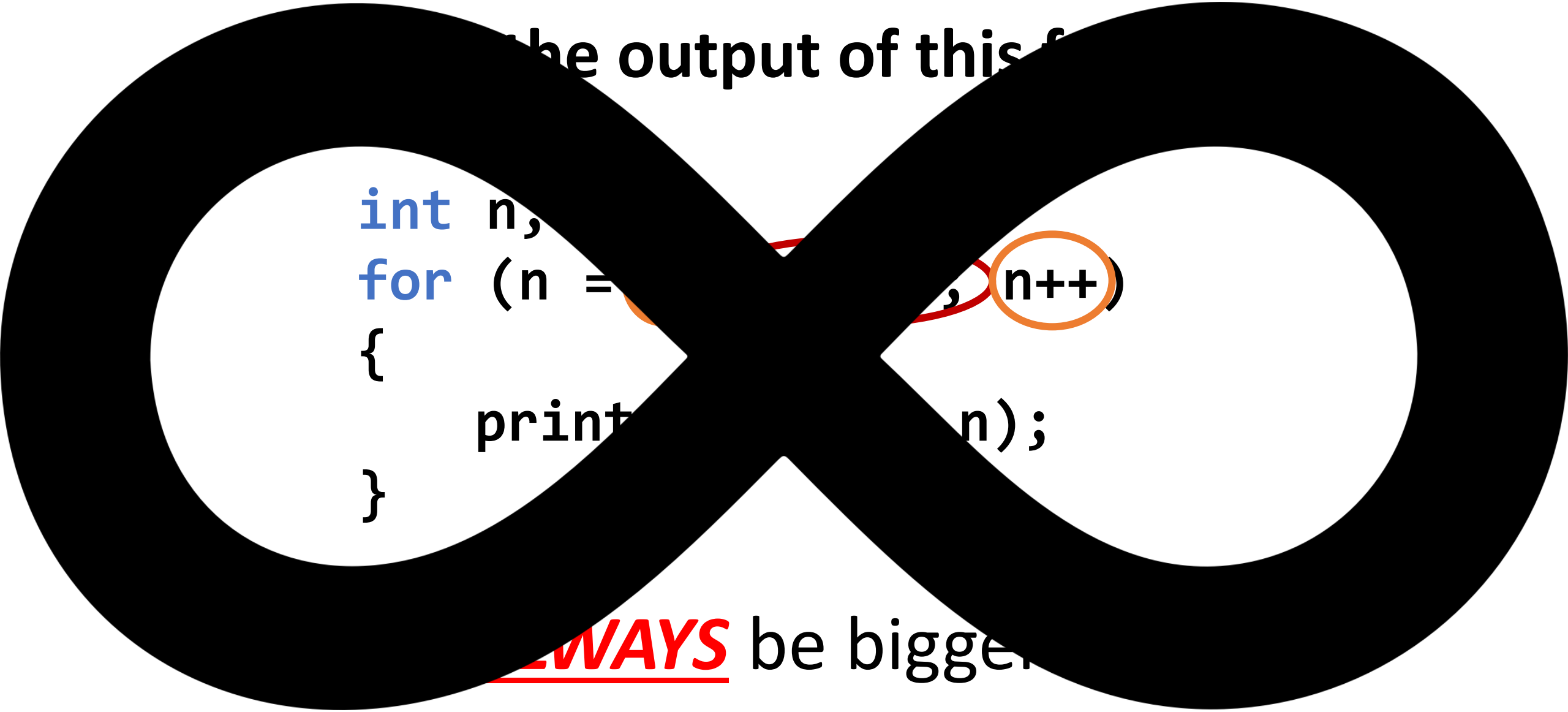
```
int n;
for (n = 100; n >= 0; n--)
{
    printf("%d\n", n);
}
```

Decrement!

What is the output of this for loop?

```
int n;
for (n = 1; n >= 0; n++)
{
    printf("%d\n", n);
}
```

n will ***ALWAYS*** be bigger than 0!



he output of this f

```
int n,
for (n =                    , n++)
{
    print                   n);
}
```

_EWAYS be bigge

Infinite Loops

```
int n;
for (n = 1; n >= 0; n++) {
    printf("%d\n", n);
}
```

This loop is not *truly* infinite. Eventually, `n` will overflow and become negative, thus making the condition `n >= 0` false.

Infinite Loops

Let's cause an overflow in a short amount of time:

```
int n;
for (n = 1; n >= 0; n += 100000) {
    printf("%d\n", n);
}
printf("%d\n", n);
```

Infinite Loops

Can we make a loop that doesn't end due to overflow?

```
int n;
for (n = 1; 1; n++) {
    printf("%d\n", n);
}
```

Condition is always true. Variable `n` will still overflow, but it won't cause the loop to exit.

Beware Infinite Loops!

Quincy 2005 - [infiniteLoop]

File Edit View Project Debug Tools Window Help

```
#include <stdio.h>

int main (void)
{
    int n;

    for(n = 1; n >= 0; n++)
    {
        printf("%d\n", n);
    }

}
```

Press F1 for help

How about something more complicated?

Write code snippet using a for loop to do the following:

Calculate the factorial of a number entered by the user.

Factorial:

The product of all positive integers less than or equal to a given non-negative number.

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

Write code snippet using a for loop to do the following:

Calculate the factorial of a number entered by the user.

Where to start?

This is doable!

```
int num;
printf("Enter a number: ");
scanf("%d", &num);
```

Yay!

Write code snippet using a for loop to do the following:

Calculate the factorial of a number entered by the user.

Now what? We know we need a for loop.

```
int num, i, fact = 1;
printf("Enter a number: ");
scanf("%d", &num);

for (                    )
{

}
```

And how about some extra variables?

One to control the loop, and another to store the result.

Write code snippet using a for loop to do the following:

Calculate the factorial of a number entered by the user.

```
int num, i, fact = 1;
printf("Enter a number: ");
scanf("%d", &num);

for ( i = 1;  i <= num; i++)
{
    fact = fact * i;
}
```

Multiply **fact** by **i** at each iteration.

To calculate the factorial of **num**, we need to multiply together every number from 1 to **num**.

Initialize: `i = 1`

Condition: `i <= num`

Update: `i++`

Write code snippet using a for loop to do the following:

Calculate the factorial of a number entered by the user.

```
int num, i, fact = 1;
printf("Enter a number: ");
scanf("%d", &num);

for (i = 1; i <= num; i++)
{
    fact = fact * i;
}

printf("Factorial of %d is %d \n", num, fact);
```

Finally,

Print the result.

```
int num = 5, i, fact = 1;
for (i = 1; i <= num; i++) {
      fact = fact * i;
      printf("After iteration %d, fact = %d\n", i, fact);
}
printf("\nFactorial of %d is %d \n", num, fact);
```

Let's simplify for the sake of demonstration. Let num = 5.

Output:

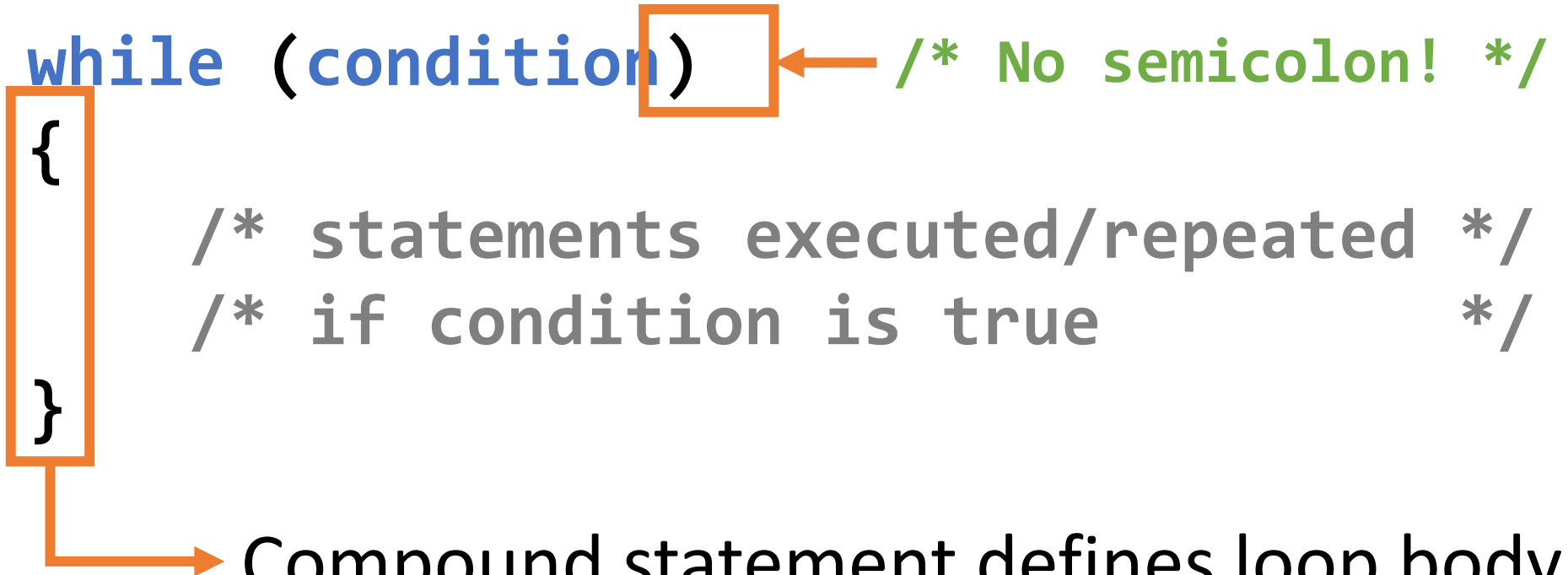
```
After iteration 1, fact = 1      /* fact =  1*1 = 1   */
After iteration 2, fact = 2      /* fact =  1*2 = 2   */
After iteration 3, fact = 6      /* fact =  2*3 = 6   */
After iteration 4, fact = 24     /* fact =  6*4 = 24  */
After iteration 5, fact = 120    /* fact = 24*5 = 120 */

Factorial of 5 is 120
```

1) `for` loop

2) `while` loop

3) `do/while` loop

`while` loop



```c
int n = 1;              /* initialize */
while (n <= 2)          /* condition  */
{
    printf("%d\n", n);
    n = n + 1;          /* update     */
}
```

Unlike a `for` loop, a `while` loop ***only*** requires that we provide a condition for it to compile.

We must be very careful to include the initialization and the update steps on our own.

```
int n = 1, a = 1;                /* initialize */
while (n <= 2)                   /* condition  */
{
    a = a + 1;                   /* update…?   */
    printf("%d\n", a);
    printf("%d\n", a*2);
    n += 1;
}
```

Is there something wrong with this loop?

`n` is never updated!

Without an update statement, we have an infinite loop!

Write code snippet using a while loop to do the following:

Print all odd numbers between 0 and 100.

```
int n = 1;              /* Initialize */

while ( n <= 100)       /* Condition  */
{
    printf("%d\n", n);
    n = n + 2;          /* Update     */
}
```

Write code snippet using a while loop to do the following:

Print all odd numbers between 1 and 30 divisible by 3 or 5.

```
int n = 1;  /* Initialize */
while ( n <= 30) {  /* Condition */
    if (n%3 == 0 || n%5 == 0)
        printf("%d ", n);
    n+=2;/* Update */
}
```

Console:

```
3 5 9 15 21 25 27
```

Write code snippet using a while loop to do the following:

Print all perfect squares less than 100.

```
int n = 1;                  /* Initialize */
while ( n*n < 100 )         /* Condition  */
{
    printf("%d ", n*n);
    n++;                    /* Update     */
}
```

Console:

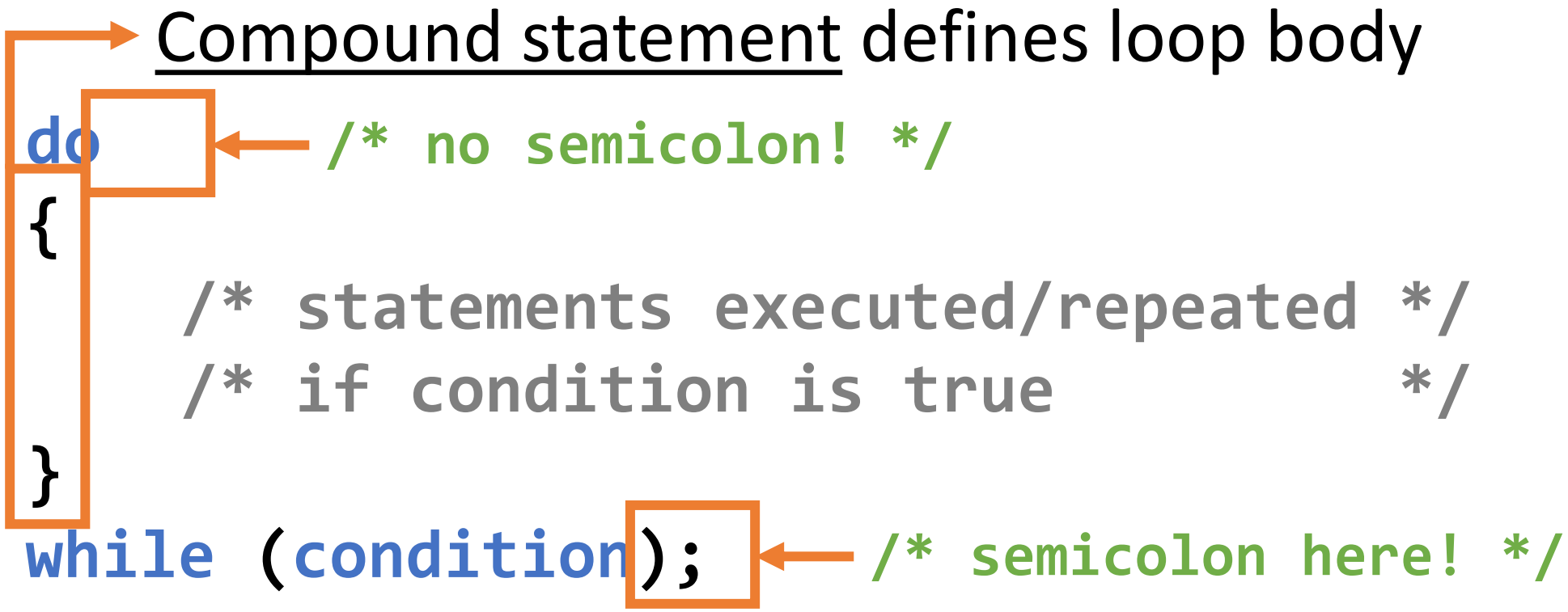
```
1 4 9 16 25 36 49 64 81
```

1) `for` loop

2) `while` loop

3) `do/while` loop

`do while` loop



```
int n = 1;              /* initialize */

do
{
    printf("%d ", n);
    n = n + 1;          /* update     */
}
while (n <= 5);         /* condition  */
```

Output:

```
1 2 3 4 5
```

`while` VS `do/while`

```
while (condition) {
  /* statements */
}
```

Condition checked at the ***start***.
If condition is initially **false**, body never executes.

Condition checked at the ***end***.
If condition is initially **false**, body will still execute **once**.

```
do {
  /* statements */
} while (condition);
```

The body of a `do/while` loop will execute **at least once**.

```c
int n = 5;

while (n <= 2)
{
  printf("%d\n", n);
  n = n + 1;
}
printf("Done loop.\n");
```

Output:

```
Done loop.
```

```c
int n = 5;

do {
  printf("%d\n", n);
  n = n + 1;
}
while (n <= 2);
printf("Done loop.\n");
```

Output:

```
5
Done loop.
```

When is it useful to execute at least once?

Two words:

Input Validation

Write code snippet to do the following:

Read in numbers until a negative value is entered.

```
int value;

do {
    printf("Enter an integer: ");
    scanf("%d", &value);
}
while ( value >= 0 );
```

`for` loop

Use when the number of iterations is known in advance.

```
int i;
for (i = 1; i <= 5; i++) {
    printf("Hello, World!\n");
}
```

A `for` loop conveniently integrates the initialization, condition, and update steps into a single line.

`do/while` loop

Use when the loop body must execute at least once.

```
int value;
do {
    printf("Enter an integer: ");
    scanf("%d", &value);
} while (value >=0);
```

A `do/while` loop is ideal for input validation.

`while` loop

Use in all other situations.

```
int n = 1;
while (n <= 2) {
    printf("%d\n", n);
    n = n + 1;
}
```

A `while` loop can be adapted to any looping task.

A Loop is as Loop is a Loop

If the task can be solved with a `while` loop, it can also be solved with a `for` loop, and so on.

By adjusting initializations, conditions, and updates, every loop can be tweaked to be the functional equivalent of another.

This is FANTASTIC practice! Try solving a looping problem with each of three loop styles.

`break`

vs.

`continue`

Remember break?

```
int n = 1;
while (1) {          /* Always true! */
    printf("%d ", n++);
    if (n > 5)
        break;       /* break exits the loop */
}
```

Console:

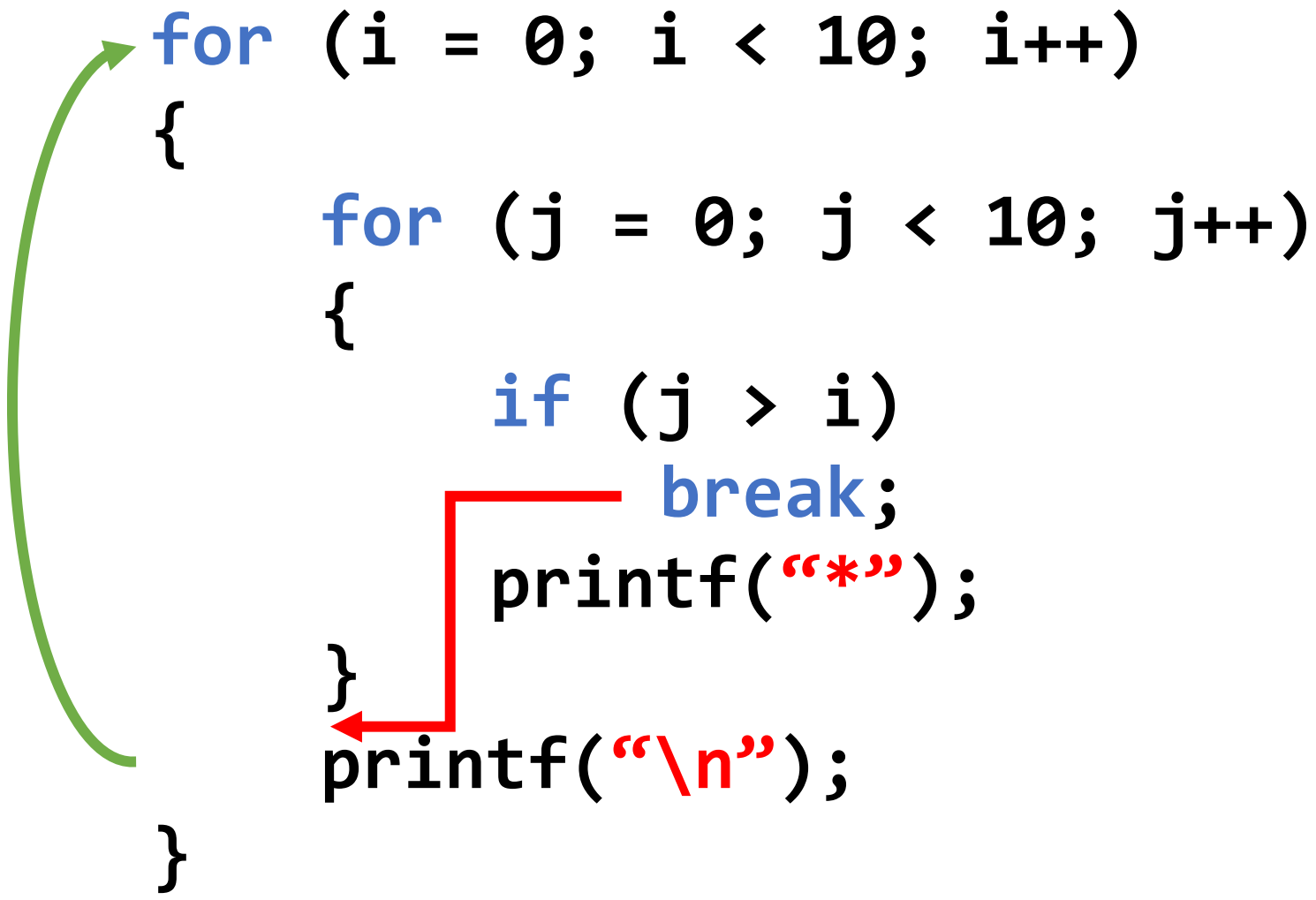
```
1 2 3 4 5
```

A **break** statement jumps out of the *innermost* enclosing loop of the statement

```
int i = 1;
while (1)  /* Condition is always true */
{
     if (i >= 6)    }  /* if + break is used
          break;    }     to exit the loop  */
     printf("%d ", i);
     i = i + 1;
}
```

Output: 1 2 3 4 5

A **break** statement jumps out of the *innermost* enclosing loop of the statement



`break` VS `continue`

The `continue` statement ends the *current iteration* of a loop

Contrast with the `break` statement, which exits the loop entirely.

The `continue` statement skips the *current iteration* of a loop

```
for (n = 1; n <= 10; n++)
{
    if (n % 2 != 0)
        continue;
    printf("%d ", n);
}
```

Continue if n is odd

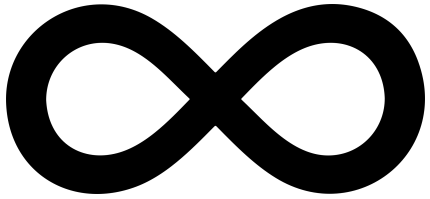
Output: `2 4 6 8 10`

Spot the ERROR?

```c
#include <stdio.h>

int main(void)
{
    int n, x = -3;
    for (n = x, n <= 0, n += 1)
        printf("%d\n", n);

    return 0;
}
```

Should be semicolons, not commas

```c
#include <stdio.h>

int main(void)
{
    int n;
    for (n = 1; n != 50; n *= 2) {
        printf("%d\n", n);
    }

    return 0;
}
```



```c
#include <stdio.h>

int main (void)
{
    int x = 5;
    while( x > 0 );
        x--;

    return 55;
}
```

```
#include <stdio.h>

int main(void)
{
    for (i = 1; i <= 12; i++)
    {
        printf("%d\n",i);
    }

    return (0);
}
```

Variable not declared!

```c
#include <stdio.h>

int main(void)
{
    int n;

    do
    {
        printf("Enter a number ");
        printf("between 1 and 9: ");
        scanf ("%d", &n);
    }while (n < 1 || n > 9)

  return (0);
}
```

Questions?