Loops and Iteration

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Repeated Steps

```
n = 5
```

No   Yes

n > 0 ?

print(n)

n = n -1

print('End')
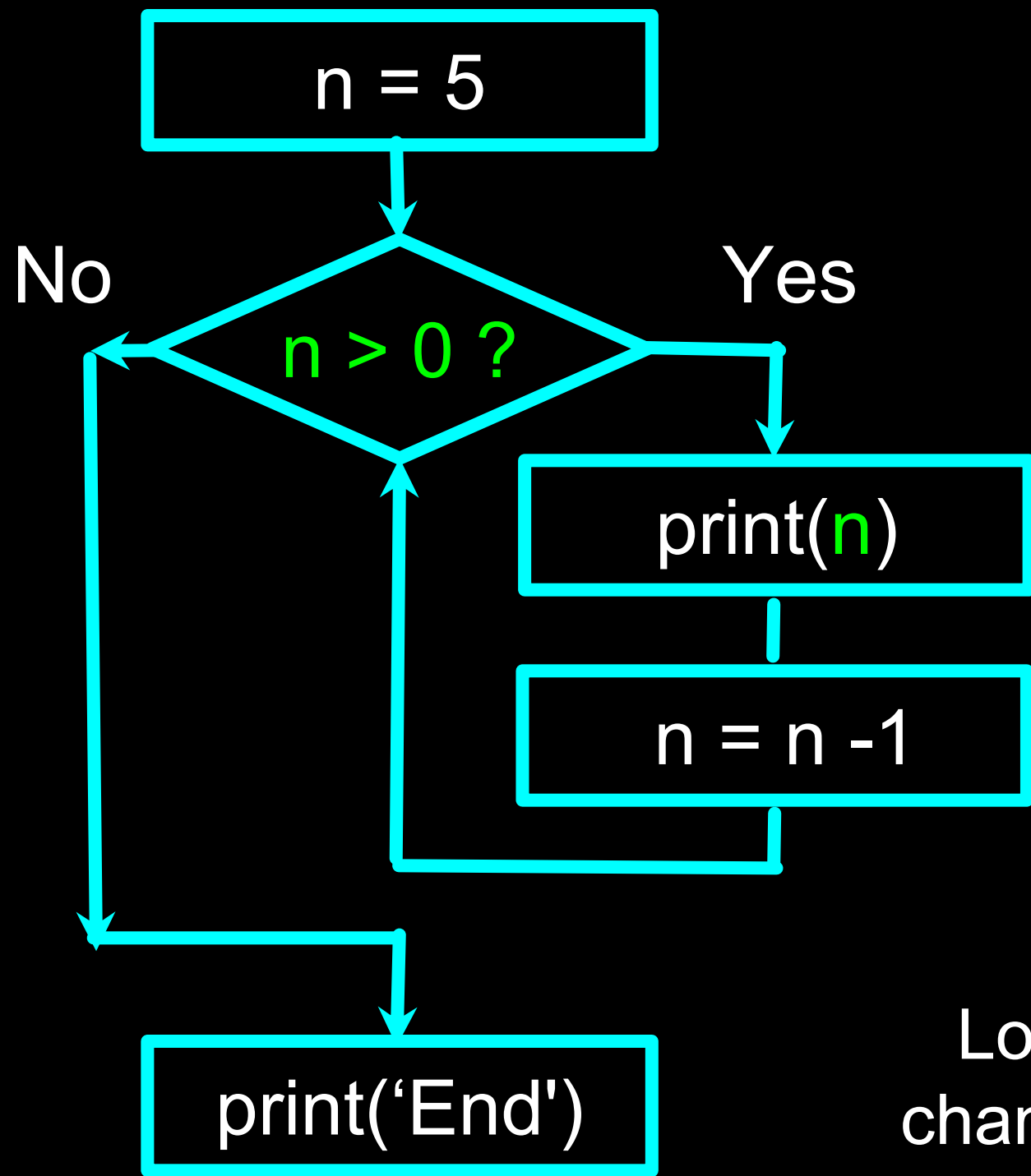
Output:

Program:
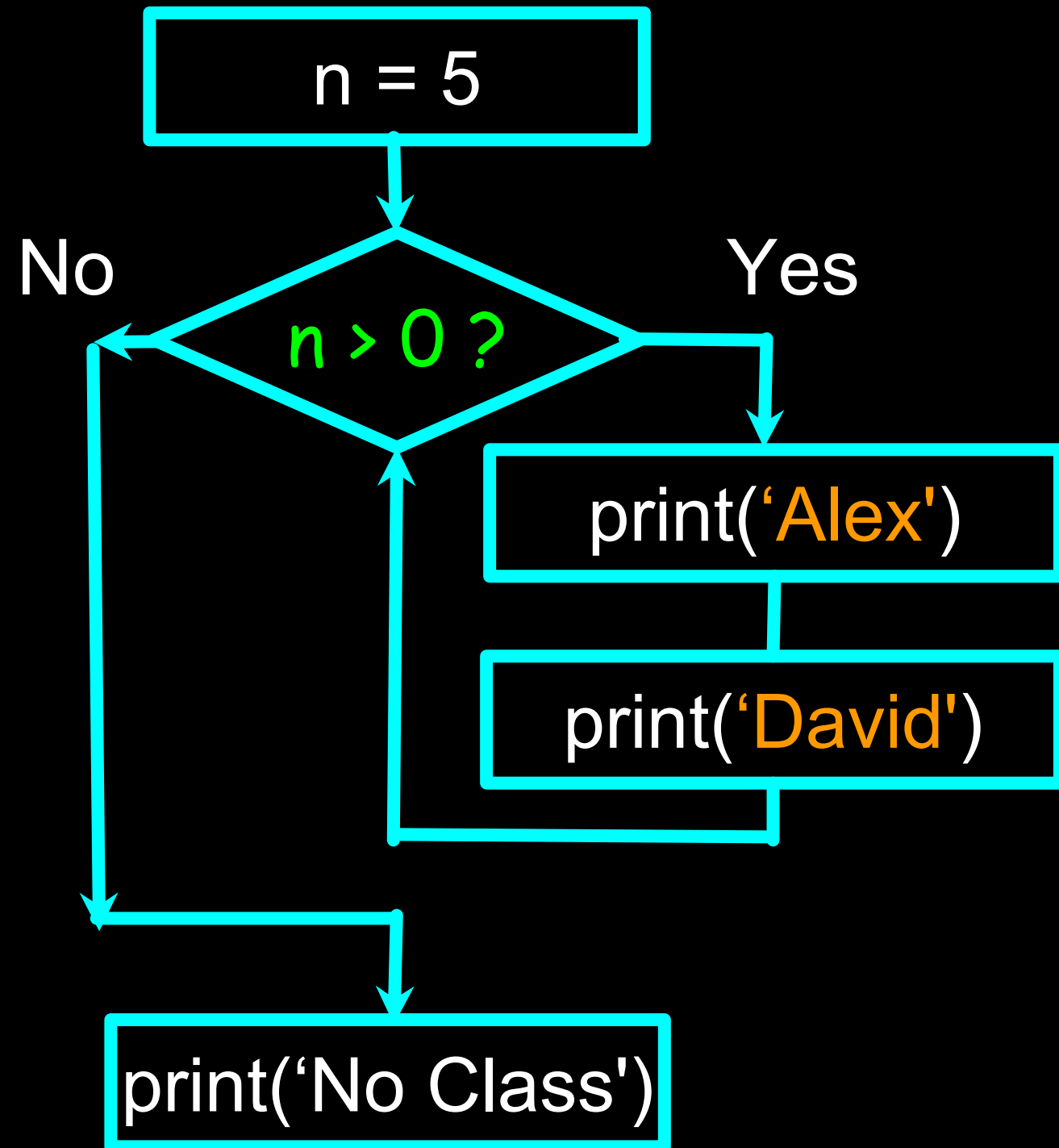
```
n = 5
while n > 0 :
    print(n)
    n = n – 1
print('Blastoff!')
print(n)
```
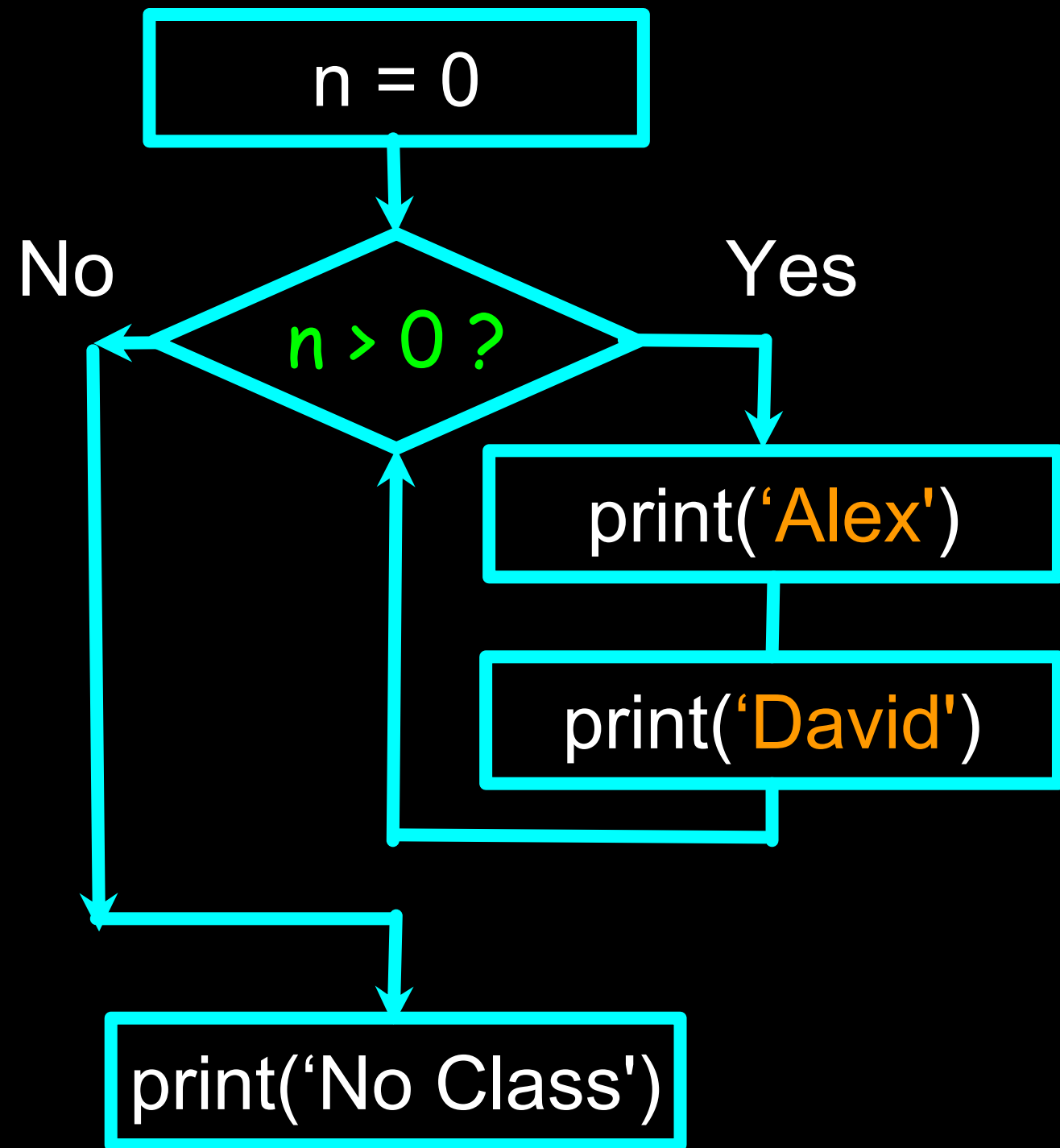
5
4
3
2
1

End
0

Loops (repeated steps) have iteration variables that change each time through a loop. Often these iteration variables go through a sequence of numbers.

An Infinite Loop

```python
n = 5
while n > 0 :
    print('Alex')
    print('David')
print('No Class')
```

What is wrong with this loop?

Another Loop

n = 0

n > 0 ?

No   Yes

print('Alex')

print('David')

print('No Class')

```
n = 0
while n > 0 :
    print('Alex')
    print('David')
print('No Class')
```

What is this loop doing?

Breaking Out of a Loop

- The break statement ends the current loop and jumps to the statement immediately following the loop

- It is like a loop test that can happen anywhere in the body of the loop

```python
while True:
    line = input('> ')
    if line == 'done' :
        break
    print(line)
print('Done!')
```

```
> hello there
hello there
> finished
finished
> done
Done!
```

Breaking Out of a Loop

- The break statement ends the current loop and jumps to the statement immediately following the loop

- It is like a loop test that can happen anywhere in the body of the loop
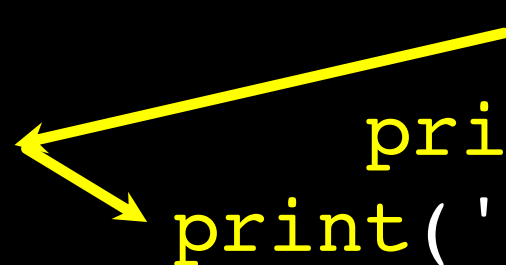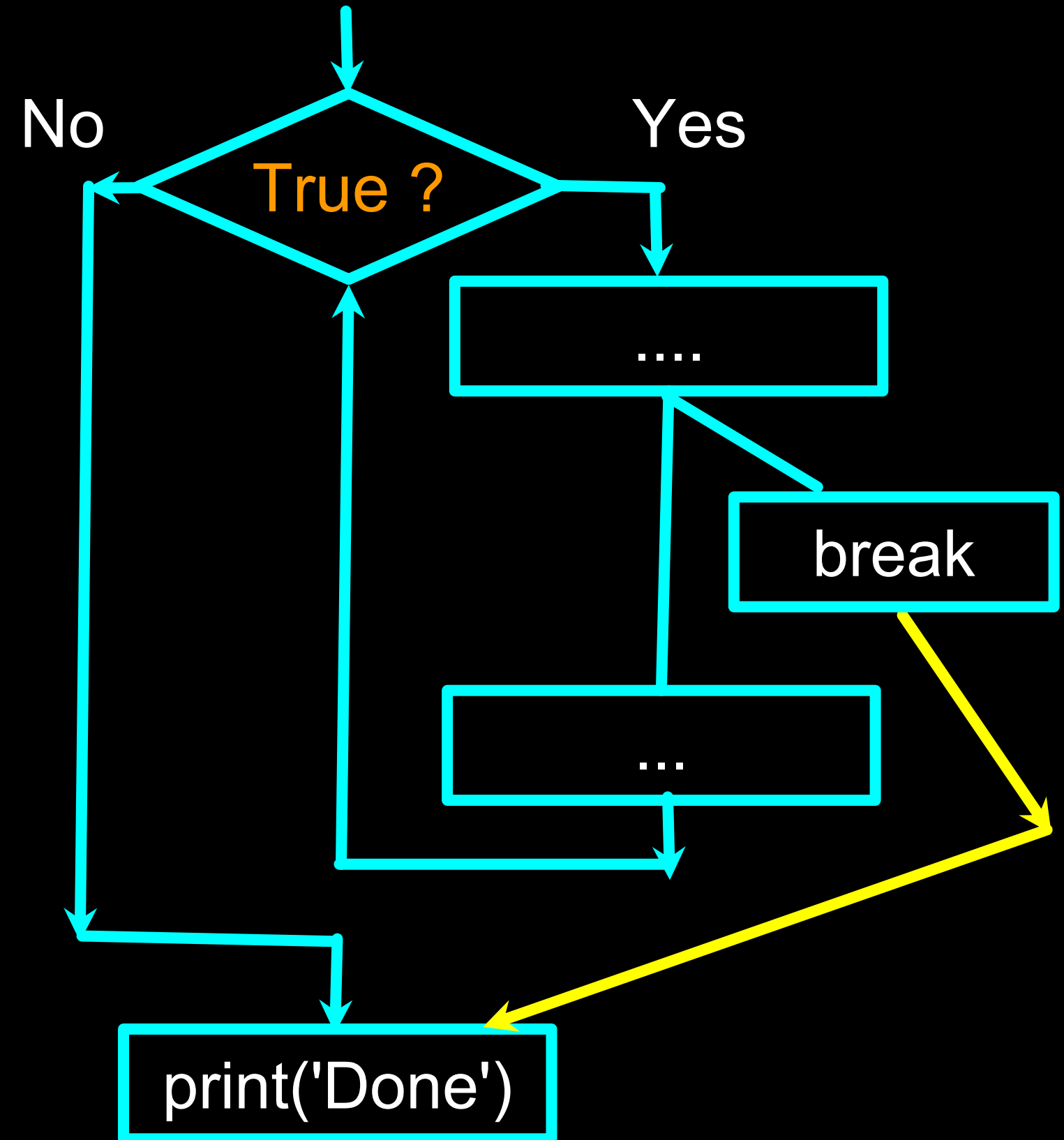
```python
while True:
    line = input('> ')
    if line == 'done' :
        break
    print(line)
print('Done!')
```

```
> hello there
hello there
> finished
finished
> done
Done!
```

```python
while True:
    line = input('> ')
    if line == 'done' :
        break
    print(line)
print('Done!')
```

No   True ?   Yes

....

break

...

print('Done')

Finishing an Iteration with continue

The continue statement ends the current iteration and jumps to the top of the loop and starts the next iteration

```python
while True:
    line = input('> ')
    if line[0] == '#' :
        continue
    if line == 'done' :
        break
    print(line)
print('Done!')
```

> hello there
hello there
> # don't print this
> print this!
print this!
> done
Done!

Finishing an Iteration with continue

The continue statement ends the current iteration and jumps to the top of the loop and starts the next iteration
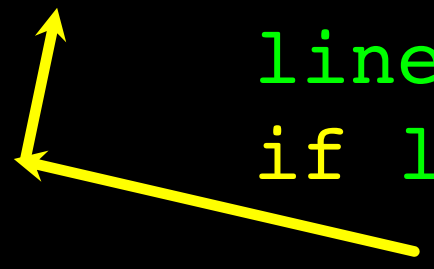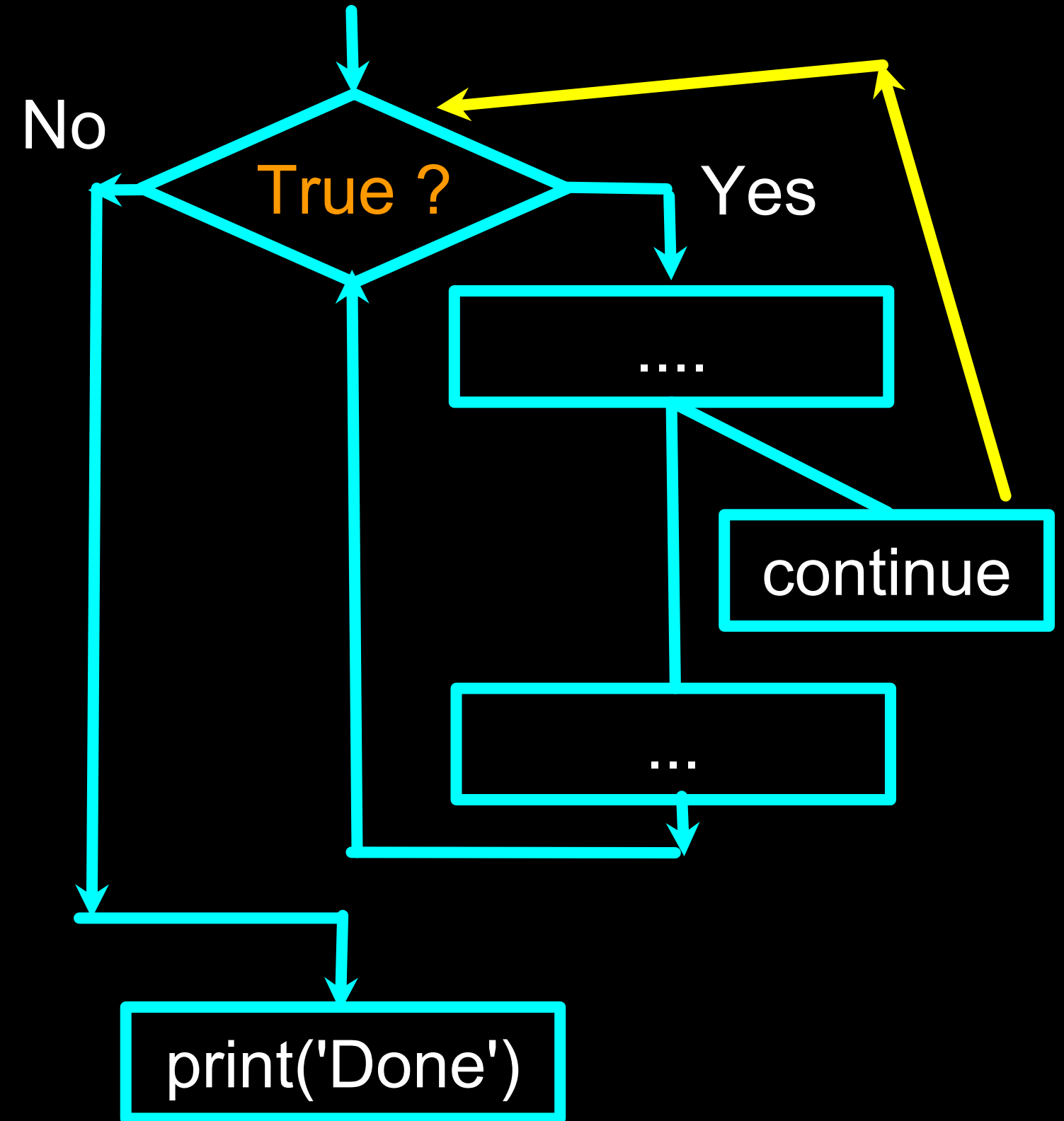
```python
while True:
    line = input('> ')
    if line[0] == '#' :
        continue
    if line == 'done' :
        break
    print(line)
print('Done!')
```

```
> hello there
hello there
> # don't print this
> print this!
print this!
> done
Done!
```

```python
while True:
    line = raw_input('> ')
    if line[0] == '#' :
        continue
    if line == 'done' :
        break
    print(line)
print('Done!')
```

No

True ?

Yes

....

continue

...

print('Done')

Indefinite Loops

- While loops are called "indefinite loops" because they keep going until a logical condition becomes False

- The loops we have seen so far are pretty easy to examine to see if they will terminate or if they will be "infinite loops"

- Sometimes it is a little harder to be sure if a loop will terminate

Definite Loops

Iterating over a set of items…

Definite Loops

- Quite often we have a list of items of the lines in a file - effectively a finite set of things

- We can write a loop to run the loop once for each of the items in a set using the Python for construct

- These loops are called "definite loops" because they execute an exact number of times

- We say that "definite loops iterate through the members of a set"

Introduction to Python Lists

- Most of our variables have one value in them - when we put a new value in the variable, the old value is overwritten

```
$ python3
>>> x = 2
>>> x = 4
>>> print(x)
4
```

- A collection allows us to put many values in a single "variable"

```
teacher = [ 'Alex', 'David']
student = [ 'Karen', 'Owen', 'Juhwan', 'Nicholas', 'Olivia', 'James', 'Jacob' ]
```

List

List is surrounded by square brackets and the elements in the list are separated by commas

A list element can be any Python object - even another list

A list can be empty

```
>>> print([1, 24, 76])
[1, 24, 76]
>>> print(['red', 'yellow', 'blue'])
['red', 'yellow', 'blue']
>>> print(['red', 24, 98.6])
['red', 24, 98.6]
>>> print([ 1, [5, 6], 7])
[1, [5, 6], 7]
>>> print([])
[ ]
```

A Simple Definite Loop

```python
for i in [5, 4, 3, 2, 1] :
    print(i)
print('End')
```
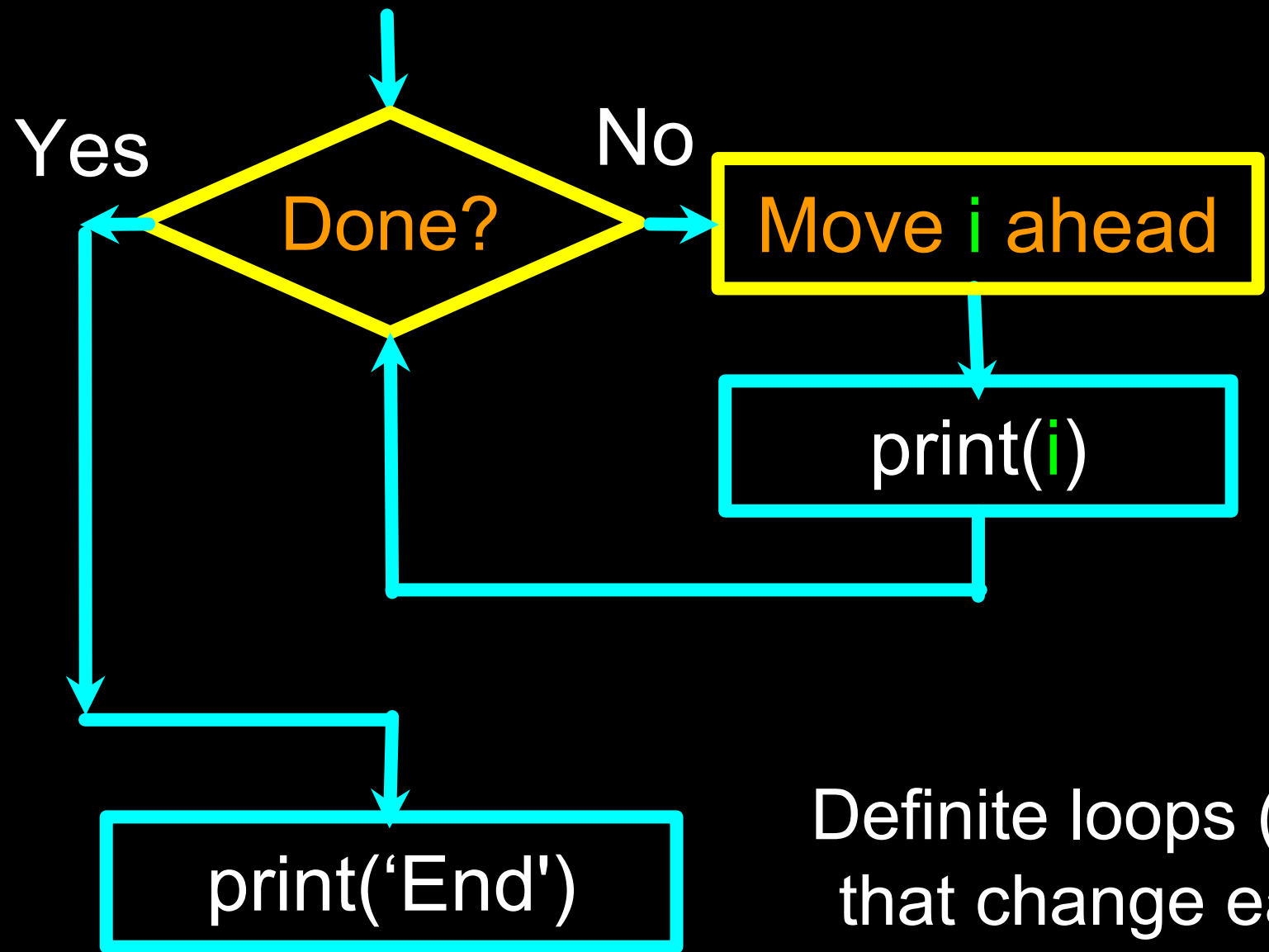
5
4
3
2
1
End

A Definite Loop with Strings

```python
friends = ['Joseph', 'Glenn', 'Sally']
for friend in friends :
    print('Happy New Year:', friend)
print('Done!')
```

Happy New Year: Joseph
Happy New Year: Glenn
Happy New Year: Sally

Done!

A Simple Definite Loop

Yes

No

Done?

Move i ahead

print(i)

print('End')

```
for i in [5, 4, 3, 2, 1] :
    print(i)
print('End')
```
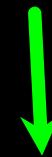
5
4
3
2
1
End

Definite loops (for loops) have explicit iteration variables that change each time through a loop. These iteration variables move through the sequence or set.
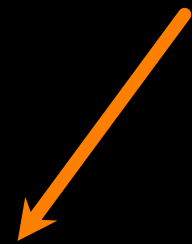
Looking at in...

- The iteration variable "iterates" through the sequence (ordered set)

- The block (body) of code is executed once for each value in the sequence

- The iteration variable moves through all of the values in the sequence

Five-element sequence

Iteration variable

```
for i in [5, 4, 3, 2, 1] :
    print(i)
```

```
for i in [5, 4, 3, 2, 1] :
    print(i)
```

- The iteration variable "iterates" through the sequence (ordered set)

- The block (body) of code is executed once for each value in the sequence

- The iteration variable moves through all of the values in the sequence

```
for i in [5, 4, 3, 2, 1] :
    print(i)
```
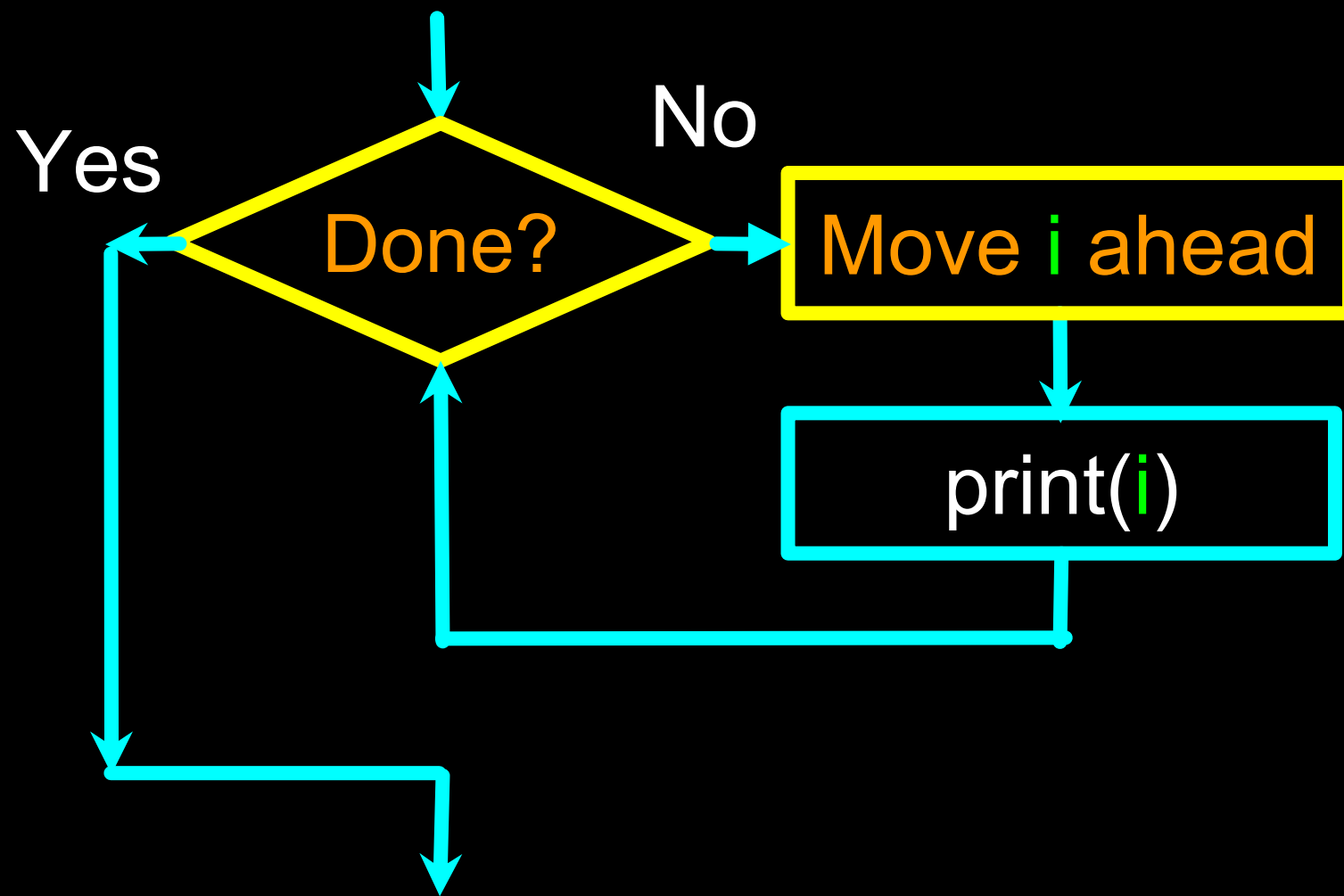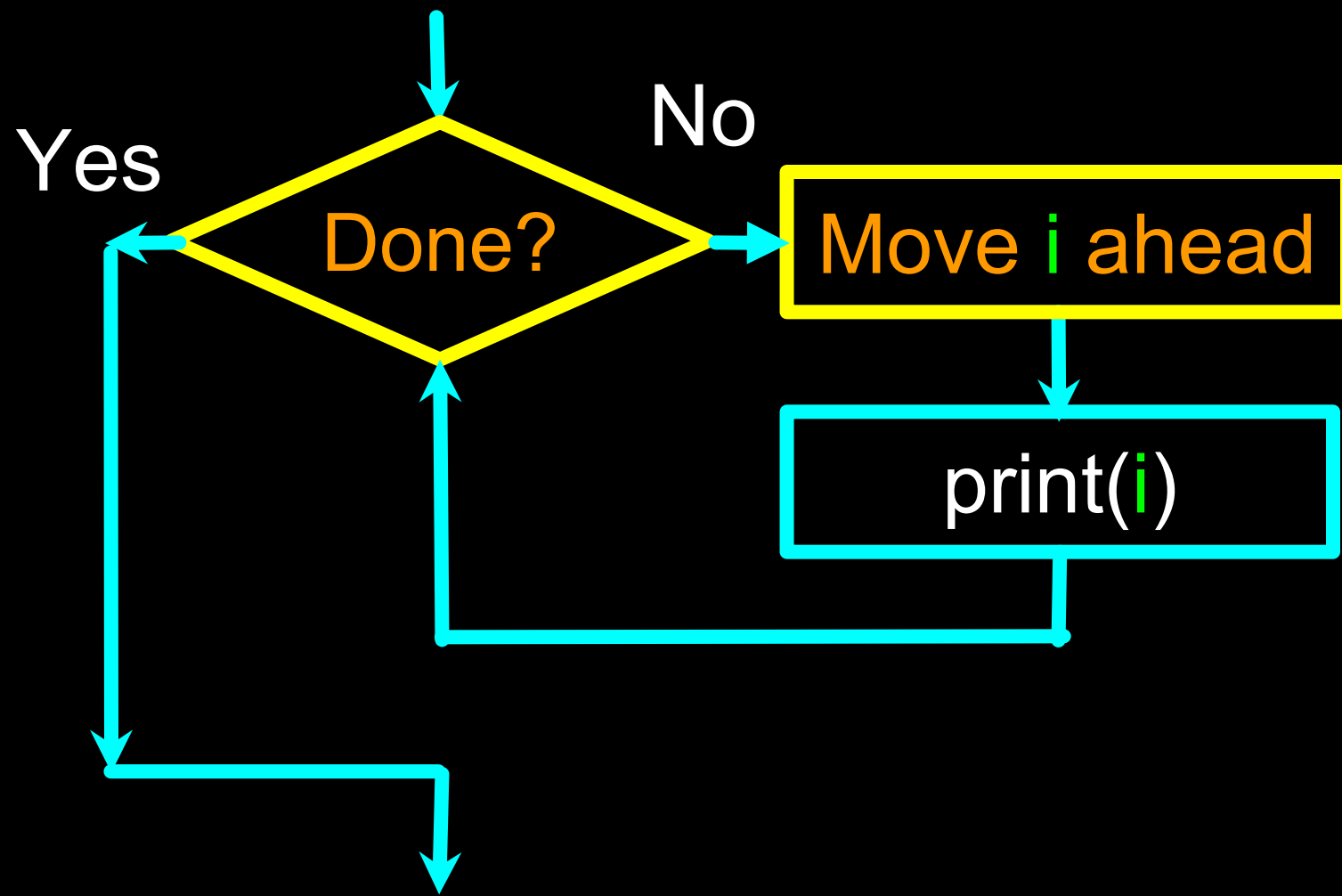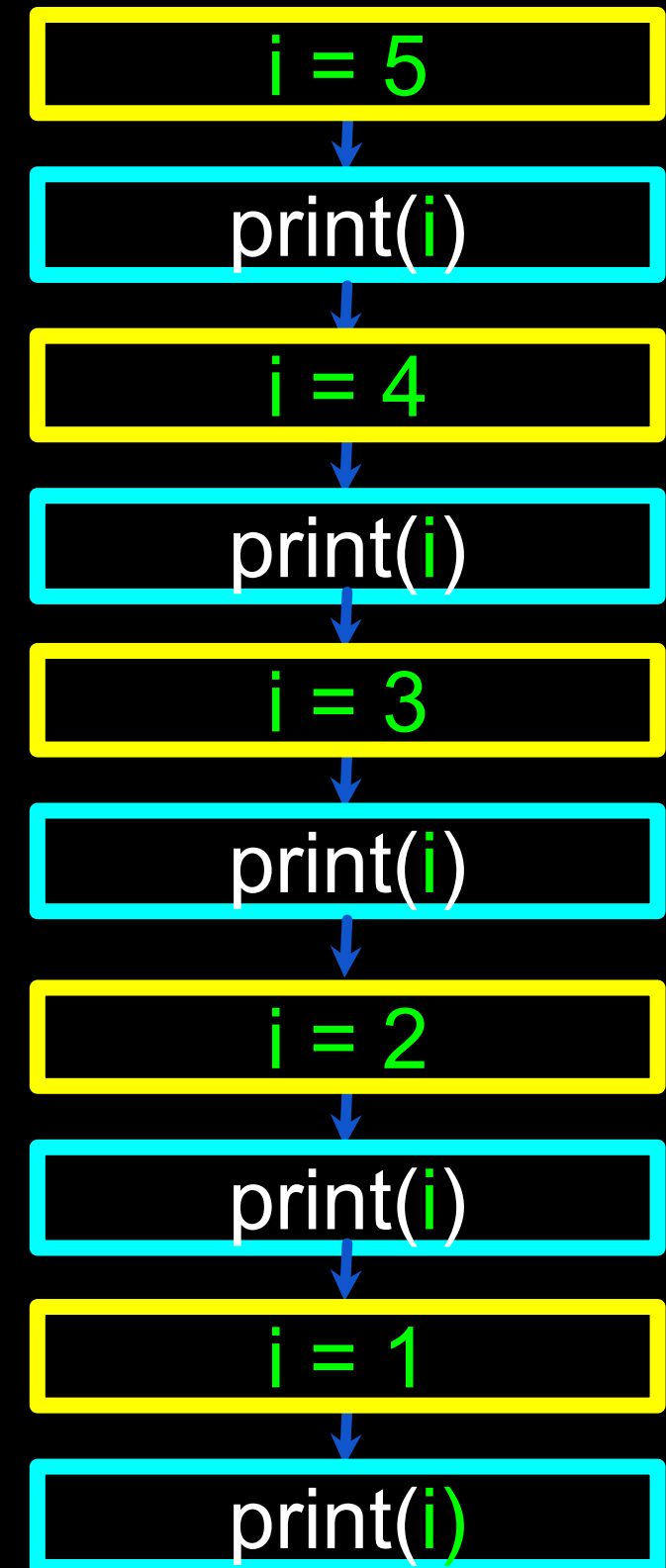
for Loop Conventions:

Set some variables to initial values

for thing in data:

Look for something or do something to each entry separately, updating a variable

Look at the variables

Looping Through a Set

```python
print('Before')
for thing in [9, 41, 12, 3, 74, 15] :
    print(thing)
print('After')
```

```
$ python simpleloop.py
Before
9
41
12
3
74
15
After
```

What is the Largest Number?

3   41   12   9   74   15

What is the Largest Number?

largest_so_far | None

What is the Largest Number?

3

largest_so_far   3

What is the Largest Number?

12

largest_so_far 41

What is the Largest Number?

9

largest_so_far   41

What is the Largest Number?

74

largest_so_far | 74

What is the Largest Number?

5

15

74

What is the Largest Number?

3   41   12   9   74   15

74

Finding the Largest Value

```python
largest_so_far = 0
print('Before', largest_so_far)
for the_num in [9, 41, 12, 3, 74, 15] :
    if the_num > largest_so_far :
        largest_so_far = the_num
    print(largest_so_far, the_num)

print('After', largest_so_far)
```

```
$ python largest.py
Before 0
9 9
41 41
41 12
41 3
74 74
74 15
After 74
```

We make a variable that contains the largest value we have seen so far. If the current number we are looking at is larger, it is the new largest value we have seen so far.

More Loop Patterns…

Counting in a Loop

```
count = 0
print('Before', count)
for number in [9, 41, 12, 3, 74, 15] :
    count = count + 1
    print(count, number)
print('After', count)
```

```
$ python countloop.py
Before 0
1 9
2 41
3 12
4 3
5 74
6 15
After 6
```

To count how many times we execute a loop, we introduce a counter variable that starts at 0 and we add one to it each time through the loop.

Summing in a Loop

```
total = 0
print('Before', total)
for number in [9, 41, 12, 3, 74, 15] :
    total = total + thing
    print(total, thing)
print('After', total)
```

```
$ python countloop.py
Before 0
9 9
50 41
62 12
65 3
139 74
154 15
After 154
```

To add up a value we encounter in a loop, we introduce a sum variable that starts at 0 and we add the value to the sum each time through the loop.

Finding the Average in a Loop

```
count = 0
total = 0
print('Before', count, total)
for value in [9, 41, 12, 3, 74, 15] :
    count = count + 1
    total = total + value
    print(count, sum, value)
print('After', count, total, total / count)
```

```
$ python averageloop.py
Before 0 0
1 9 9
2 50 41
3 62 12
4 65 3
5 139 74
6 154 15
After 6 154 25.666
```

An average just combines the counting and sum patterns and divides when the loop is done.

Filtering in a Loop

```python
print('Before')
for value in [9, 41, 12, 3, 74, 15] :
    if value > 20:
        print('Large number',value)
print('After')
```

```
$ python search1.py
Before
Large number 41
Large number 74
After
```

We use an if statement in the loop to catch / filter the values we are looking for.

Search Using a Boolean Variable

```python
found = False
print('Before', found)
for value in [9, 41, 12, 3, 74, 15] :
    if value == 3 :
        found = True
    print(found, value)
print('After', found)
```

```
$ python search1.py
Before False
False 9
False 41
False 12
True 3
True 74
True 15
After True
```

If we just want to search and know if a value was found, we use a variable that starts at False and is set to True as soon as we find what we are looking for.

How to Find the Smallest Value

```python
largest_so_far = -1
print('Before', largest_so_far)
for the_num in [9, 41, 12, 3, 74, 15] :
    if the_num > largest_so_far :
        largest_so_far = the_num
    print(largest_so_far, the_num)

print('After', largest_so_far)
```

```
$ python largest.py
Before -1
9 9
41 41
41 12
41 3
74 74
74 15
After 74
```

How would we change this to make it find the smallest value in the list?

Finding the Smallest Value

```python
smallest_so_far = -1
print('Before', smallest_so_far)
for the_num in [9, 41, 12, 3, 74, 15] :
    if the_num < smallest_so_far :
        smallest_so_far = the_num
    print(smallest_so_far, the_num)

print('After', smallest_so_far)
```

We switched the variable name to smallest_so_far and switched the > to <

Finding the Smallest Value

```python
smallest_so_far = -1
print('Before', smallest_so_far)
for the_num in [9, 41, 12, 3, 74, 15] :
    if the_num < smallest_so_far :
        smallest_so_far = the_num
    print(smallest_so_far, the_num)

print('After', smallest_so_far)
```

```
$ python smallbad.py
Before -1
-1  9
-1  41
-1 12
-1  3
-1  74
-1  15
After -1
```

We switched the variable name to smallest_so_far and switched the > to <

Finding the Smallest Value

```
smallest = None
print('Before')
for value in [9, 41, 12, 3, 74, 15] :
    if smallest is None :
        smallest = value
    elif value < smallest :
        smallest = value
    print(smallest, value)
print('After', smallest)
```

```
$ python smallest.py
Before
9 9
9 41
9 12
3 3
3 74
3 15
After 3
```

We still have a variable that is the smallest so far. The first time through the loop smallest is None, so we take the first value to be the smallest.

The is and is not Operators

```python
smallest = None
print('Before')
for value in [3, 41, 12, 9, 74, 15] :
    if smallest is None :
        smallest = value
    elif value < smallest :
        smallest = value
    print(smallest, value)

print('After', smallest)
```

- Python has an is operator that can be used in logical expressions

- Implies "is the same as"

- Similar to, but stronger than ==

- is not also is a logical operator