Sequences
The Sequence Abstraction
The Sequence Abstraction

red, orange, yellow, green, blue, indigo, violet.
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There isn't just one sequence class or data abstraction (in Python or in general).
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The sequence abstraction is a collection of behaviors:
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The sequence abstraction is a collection of behaviors:

- **Length.** A sequence has a finite length.
- **Element selection.** A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.
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0, 1, 2, 3, 4, 5, 6.

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There is built-in syntax associated with this behavior, or we can use functions.

A list is a kind of built-in sequence
Lists

['Demo']
Lists are Sequences
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
```
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
```
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8
```
Lists are Sequences

>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8

**Length.** A sequence has a finite length.

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4
>>> digits[3]
8
```

**Length.** A sequence has a finite length.

**Element selection.** A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.

```python
>>> [2, 7] + digits * 2
[2, 7, 1, 8, 2, 8, 1, 8, 2, 8]
```
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8
```

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```python
>>> [2, 7] + digits * 2
[2, 7, 1, 8, 2, 8, 1, 8, 2, 8]
```

```python
>>> pairs = [[10, 20], [30, 40]]
```
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8
```

**Length.** A sequence has a finite length.

**Element selection.** A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.

```python
>>> [2, 7] + digits * 2
[2, 7, 1, 8, 2, 8, 1, 8, 2, 8]

>>> pairs = [[10, 20], [30, 40]]
>>> pairs[1]
[30, 40]
```
Lists are Sequences

```python
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8

Length. A sequence has a finite length.

Element selection. A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.

```python
>>> [2, 7] + digits * 2
[2, 7, 1, 8, 2, 8, 1, 8, 2, 8]

>>> pairs = [[10, 20], [30, 40]]
>>> pairs[1]
[30, 40]
>>> pairs[1][0]
30
```
For Statements

(Demo)
Sequence Iteration
def count(s, value):
    total = 0
    for element in s:
        if element == value:
            total = total + 1
    return total
def count(s, value):
    total = 0
    for element in s:
        if element == value:
            total = total + 1
    return total

Name bound in the first frame of the current environment (not a new frame)
For Statement Execution Procedure
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for <name> in <expression>:
  <suite>
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1. Evaluate the header <expression>, which must yield an iterable value (a sequence)
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for <name> in <expression>:
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```

1. Evaluate the header `<expression>`, which must yield an iterable value (a sequence)

2. For each element in that sequence, in order:
   
   A. Bind `<name>` to that element in the current frame
   
   B. Execute the `<suite>`
Sequence Unpacking in For Statements
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```python
>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]
>>> same_count = 0
```
Sequence Unpacking in For Statements

A sequence of fixed-length sequences

```python
>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]
>>> same_count = 0
```
Sequence Unpacking in For Statements

A sequence of fixed-length sequences

>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]

>>> same_count = 0

>>> for x, y in pairs:
...     if x == y:
...         same_count = same_count + 1

>>> same_count
2
Sequence Unpacking in For Statements

A sequence of fixed-length sequences

```python
>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]
```

```python
>>> same_count = 0
```

```python
>>> for x, y in pairs:
...     if x == y:
...         same_count = same_count + 1
```

```python
>>> same_count
2
```
Sequence Unpacking in For Statements

A sequence of fixed-length sequences

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>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]
```

```python
>>> same_count = 0
```

```python
>>> for x, y in pairs:
...     if x == y:
...         same_count = same_count + 1
```

```python
>>> same_count
2
```
The Range Type

A range is a sequence of consecutive integers.*
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* Ranges can actually represent more general integer sequences.
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..., -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, ...

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range(−2, 2)

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\[ \ldots, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, \ldots \]

\[ \text{range}(-2, 2) \]

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Element selection: starting value + index

>>> list(range(-2, 2))
[-2, -1, 0, 1]

>>> list(range(4))
[0, 1, 2, 3]

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\[
\begin{align*}
\text{List constructor:} & \quad \text{list(range(-2, 2))} \\
& \quad [-2, -1, 0, 1]
\end{align*}
\]

\[
\begin{align*}
\text{Range with a 0 starting value:} & \quad \text{list(range(4))} \\
& \quad [0, 1, 2, 3]
\end{align*}
\]

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>>> list(range(-2, 2))
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```

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[0, 1, 2, 3]
```

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List Comprehensions
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```python
>>> letters = ['a', 'b', 'c', 'd', 'e', 'f', 'm', 'n', 'o', 'p']
>>> [letters[i] for i in [3, 4, 6, 8]]
```
List Comprehensions

```python
>>> letters = ['a', 'b', 'c', 'd', 'e', 'f', 'm', 'n', 'o', 'p']
>>> [letters[i] for i in [3, 4, 6, 8]]
['d', 'e', 'm', 'o']
```
List Comprehensions
List Comprehensions

[<map exp> for <name> in <iter exp> if <filter exp>]
List Comprehensions

\[
\langle \text{map exp} \rangle \ \text{for} \ \langle \text{name} \rangle \ \text{in} \ \langle \text{iter exp} \rangle \ \text{if} \ \langle \text{filter exp} \rangle
\]

Short version: \[
\langle \text{map exp} \rangle \ \text{for} \ \langle \text{name} \rangle \ \text{in} \ \langle \text{iter exp} \rangle
\]
List Comprehensions

[<map exp> for <name> in <iter exp> if <filter exp>]

Short version: [<map exp> for <name> in <iter exp>]

A combined expression that evaluates to a list using this evaluation procedure:
List Comprehensions

\[
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\]

A combined expression that evaluates to a list using this evaluation procedure:

1. Add a new frame with the current frame as its parent
List Comprehensions

\[
[\text{map exp} \ for \ <name> \ in \ <iter \ exp> \ if \ <filter \ exp>]
\]

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A combined expression that evaluates to a list using this evaluation procedure:
1. Add a new frame with the current frame as its parent
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\[
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A combined expression that evaluates to a list using this evaluation procedure:

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2. Create an empty result list that is the value of the expression
3. For each element in the iterable value of <iter exp>: 


List Comprehensions

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List Comprehensions

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2. Create an empty result list that is the value of the expression
3. For each element in the iterable value of \text{iter exp}:
   A. Bind \text{name} to that element in the new frame from step 1
   B. If \text{filter exp} evaluates to a true value, then add the value of \text{map exp} to the result list
Strings
Strings are an Abstraction
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Representing data:

'200'    '1.2e-5'    'False'    '[1, 2]'
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Representing language:

""""""And, as imagination bodies forth
The forms of things to unknown, and the poet's pen
Turns them to shapes, and gives to airy nothing
A local habitation and a name.
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Strings are an Abstraction

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Representing programs:

'curry = lambda f: lambda x: lambda y: f(x, y)'
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(Demo)
String Literals Have Three Forms

```python
>>> 'I am string!'
'I am string!'

>>> "I've got an apostrophe"
"I've got an apostrophe"

>>> '您好'
'您好'
```
String Literals Have Three Forms

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---

Single-quoted and double-quoted strings are equivalent
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>>> """The Zen of Python
claims, Readability counts.
Read more: import this.""""
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A backslash "escapes" the following character

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A backslash "escapes" the following character

"Line feed" character represents a new line
Strings are Sequences
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Length and element selection are similar to all sequences
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```python
>>> city = 'Berkeley'
>>> len(city)
8
>>> city[3]
'k'
```
Strings are Sequences

Length and element selection are similar to all sequences

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>>> city = 'Berkeley'
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Careful: An element of a string is itself a string, but with only one element!
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However, the "in" and "not in" operators match substrings
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'k'
```

However, the "in" and "not in" operators match substrings

```python
>>> 'here' in "Where's Waldo?"
True
>>> 234 in [1, 2, 3, 4, 5]
False
>>> [2, 3, 4] in [1, 2, 3, 4, 5]
False
```
Strings are Sequences

Length and element selection are similar to all sequences

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>>> city = 'Berkeley'
>>> len(city)
8
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'k'
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True
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False
>>> [2, 3, 4] in [1, 2, 3, 4, 5]
False
```

When working with strings, we usually care about whole words more than letters
Dictionaries

{"Dem": 0}
Limitations on Dictionaries
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Dictionaries are **unordered** collections of key-value pairs
Limitations on Dictionaries

Dictionaries are *unordered* collections of key-value pairs

Dictionary keys do have two restrictions:
Limitations on Dictionaries

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• A key of a dictionary cannot be a list or a dictionary (or any mutable type)
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This first restriction is tied to Python's underlying implementation of dictionaries.
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The second restriction is part of the dictionary abstraction
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Dictionary keys do have two restrictions:

- A key of a dictionary **cannot be** a list or a dictionary (or any mutable type)
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This first restriction is tied to Python's underlying implementation of dictionaries

The second restriction is part of the dictionary abstraction

If you want to associate multiple values with a key, store them all in a sequence value