Efficiently combining, counting, and iterating

WRITING EFFICIENT PYTHON CODE



Logan Thomas
Scientific Software Technical Trainer, Enthought

datacamp

Pokémon Overview

- Trainers (collect Pokémon)



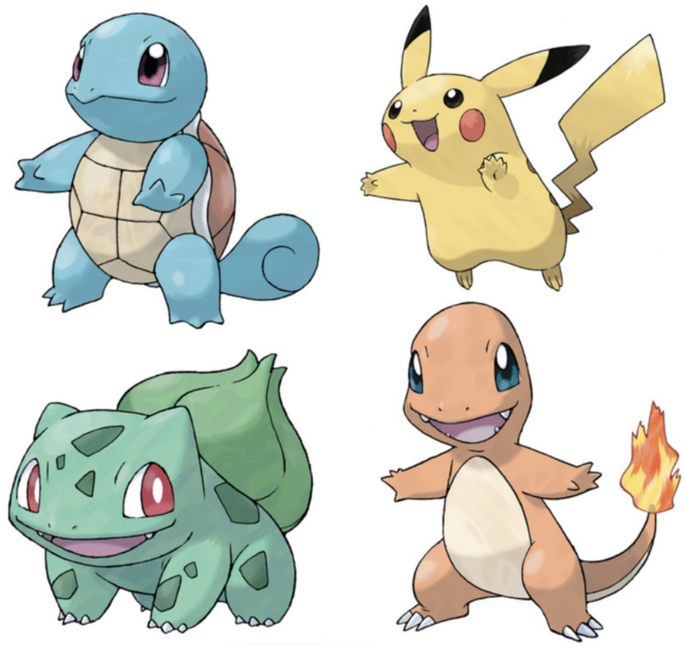
Trainer

Pokémon Overview

- Pokémon (fictional animal characters)



Trainer



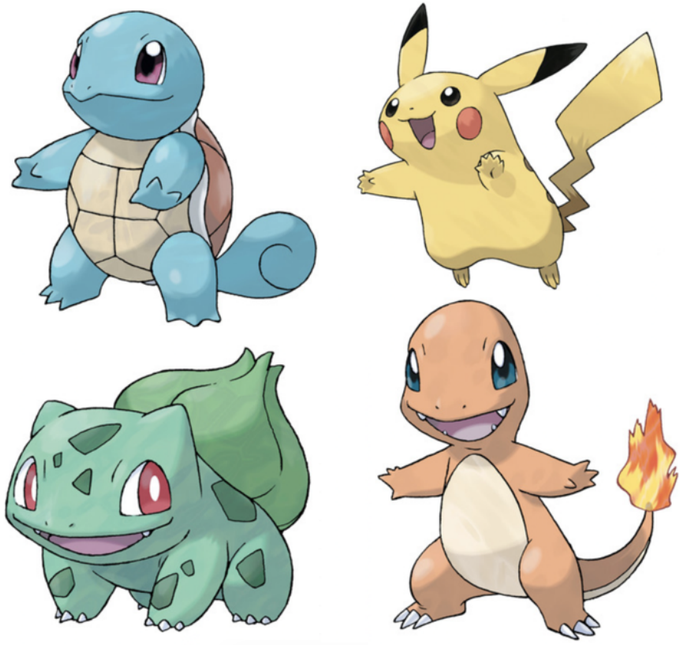
Pokémon

Pokémon Overview

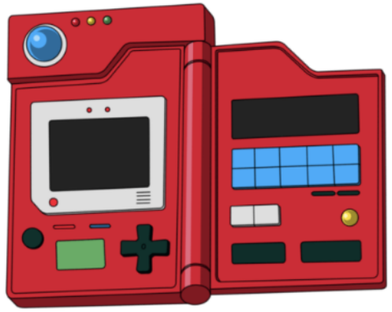
- Pokédex (stores captured Pokémon)



Trainer



Pokémon



Pokédex

Pokémon Description

Squirtle is a Water type Pokémon introduced in Generation 1. It is known as the 'Tiny Turtle Pokémon'.



Pokédex data

National №	**007**
Type	WATER
Legendary	False

Base stats

HP	44	
Attack	48	
Defense	65	
Sp. Atk	50	
Sp. Def	64	
Speed	43	
Total	**314**	

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Total	**314**	

Combining objects

```
names = ['Bulbasaur', 'Charmander', 'Squirtle']
hps = [45, 39, 44]
```

```
combined = []

for i,pokemon in enumerate(names):
    combined.append((pokemon, hps[i]))

print(combined)
```

```
[('Bulbasaur', 45), ('Charmander', 39), ('Squirtle', 44)]
```

Combining objects with zip

```
names = ['Bulbasaur', 'Charmander', 'Squirtle']
hps = [45, 39, 44]
```

```
combined_zip = zip(names, hps)
print(type(combined_zip))
```

```
<class 'zip'>
```

```
combined_zip_list = [*combined_zip]

print(combined_zip_list)
```

```
[('Bulbasaur', 45), ('Charmander', 39), ('Squirtle', 44)]
```

The collections module

- Part of Python's Standard Library (built-in module)
- Specialized container datatypes
  - Alternatives to general purpose dict, list, set, and tuple
- Notable:
  - `namedtuple` : tuple subclasses with named fields
  - `deque` : list-like container with fast appends and pops
  - `Counter` : dict for counting hashable objects
  - `OrderedDict` : dict that retains order of entries
  - `defaultdict` : dict that calls a factory function to supply missing values

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  - **`Counter` : dict for counting hashable objects**
  - `OrderedDict` : dict that retains order of entries
  - `defaultdict` : dict that calls a factory function to supply missing values

Counting with loop

```
# Each Pokémon's type (720 total)
poke_types = ['Grass', 'Dark', 'Fire', 'Fire', ...]
type_counts = {}
for poke_type in poke_types:
    if poke_type not in type_counts:
        type_counts[poke_type] = 1
    else:
        type_counts[poke_type] += 1
print(type_counts)
```

```
{'Rock': 41, 'Dragon': 25, 'Ghost': 20, 'Ice': 23, 'Poison': 28, 'Grass': 64,
 'Flying': 2, 'Electric': 40, 'Fairy': 17, 'Steel': 21, 'Psychic': 46, 'Bug': 65,
 'Dark': 28, 'Fighting': 25, 'Ground': 30, 'Fire': 48,'Normal': 92, 'Water': 105}
```

collections.Counter()

```
# Each Pokémon's type (720 total)
poke_types = ['Grass', 'Dark', 'Fire', 'Fire', ...]
from collections import Counter
type_counts = Counter(poke_types)
print(type_counts)
```

```
Counter({'Water': 105, 'Normal': 92, 'Bug': 65, 'Grass': 64, 'Fire': 48,
         'Psychic': 46, 'Rock': 41, 'Electric': 40, 'Ground': 30,
         'Poison': 28, 'Dark': 28, 'Dragon': 25, 'Fighting': 25, 'Ice': 23,
         'Steel': 21, 'Ghost': 20, 'Fairy': 17, 'Flying': 2})
```

The itertools module

- Part of Python's Standard Library (built-in module)
- Functional tools for creating and using iterators
- Notable:
  - Infinite iterators: `count` , `cycle` , `repeat`
  - Finite iterators: `accumulate` , `chain` , `zip_longest` , etc.
  - Combination generators: `product` , `permutations` , `combinations`

The itertools module

- Part of Python's Standard Library (built-in module)
- Functional tools for creating and using iterators
- Notable:
  - Infinite iterators: `count`, `cycle`, `repeat`
  - Finite iterators: `accumulate`, `chain`, `zip_longest`, etc.
  - **Combination generators: `product`, `permutations`, `combinations`**

Combinations with loop

```
poke_types = ['Bug', 'Fire', 'Ghost', 'Grass', 'Water']
combos = []

for x in poke_types:
    for y in poke_types:
        if x == y:
            continue
        if ((x,y) not in combos) & ((y,x) not in combos):
            combos.append((x,y))
print(combos)
```

```
[('Bug', 'Fire'), ('Bug', 'Ghost'), ('Bug', 'Grass'), ('Bug', 'Water'),
 ('Fire', 'Ghost'), ('Fire', 'Grass'), ('Fire', 'Water'),
 ('Ghost', 'Grass'), ('Ghost', 'Water'), ('Grass', 'Water')]
```

itertools.combinations()

```
poke_types = ['Bug', 'Fire', 'Ghost', 'Grass', 'Water']
from itertools import combinations
combos_obj = combinations(poke_types, 2)
print(type(combos_obj))
```

```
<class 'itertools.combinations'>
```

```
combos = [*combos_obj]
print(combos)
```

```
[('Bug', 'Fire'), ('Bug', 'Ghost'), ('Bug', 'Grass'), ('Bug', 'Water'),
 ('Fire', 'Ghost'), ('Fire', 'Grass'), ('Fire', 'Water'),
 ('Ghost', 'Grass'), ('Ghost', 'Water'), ('Grass', 'Water')]
```

Let's practice!

WRITING EFFICIENT PYTHON CODE

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Set theory

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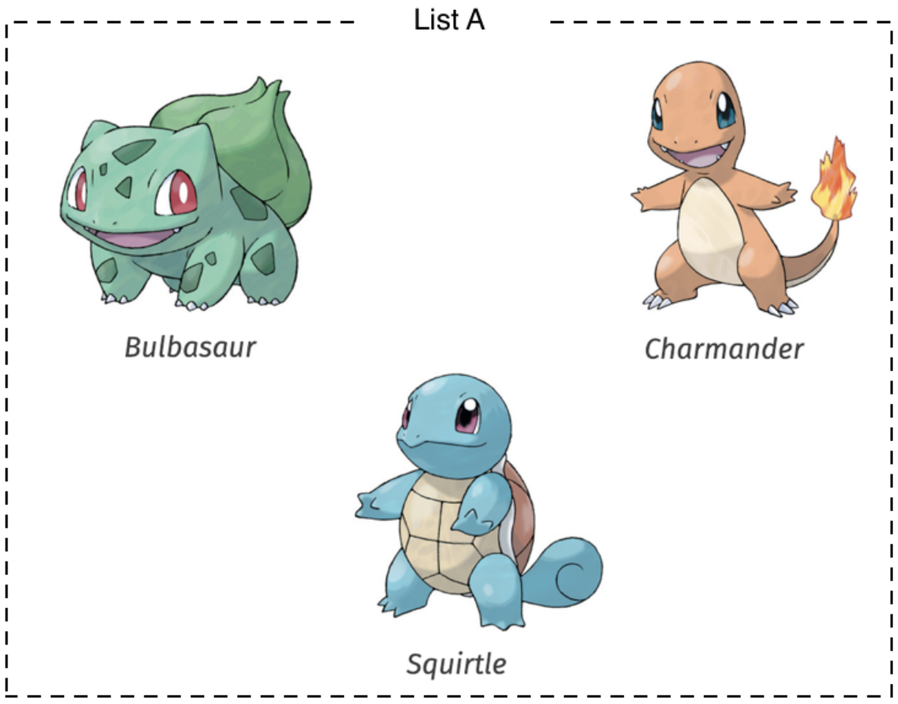
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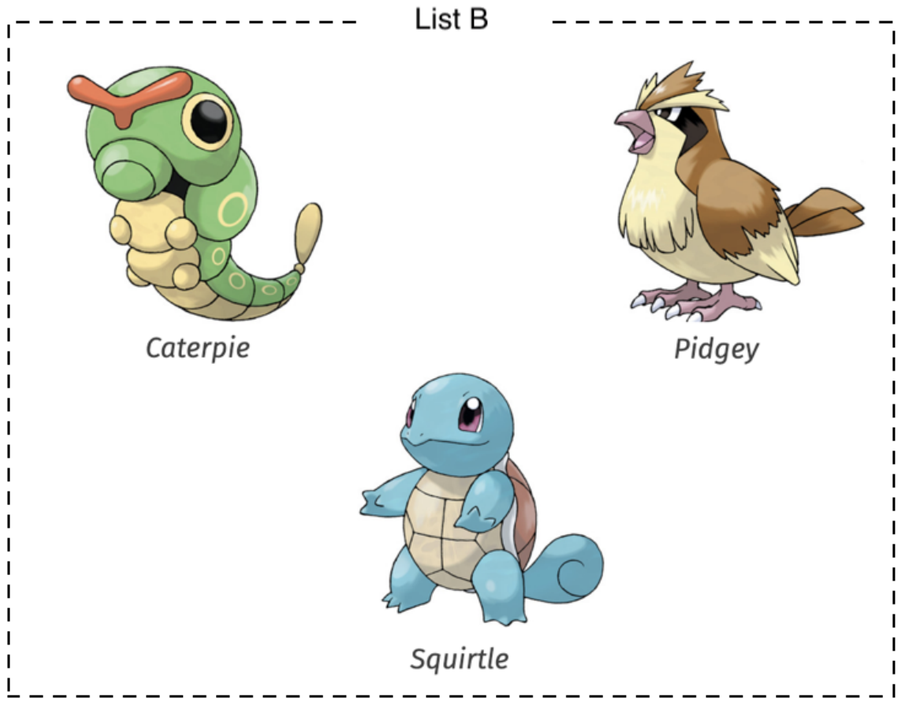
Set theory

- Branch of Mathematics applied to collections of objects
  - i.e., `sets`
- Python has built-in `set` datatype with accompanying methods:
  - `intersection()` : all elements that are in both sets
  - `difference()` : all elements in one set but not the other
  - `symmetric_difference()` : all elements in exactly one set
  - `union()` : all elements that are in either set
- Fast membership testing
  - Check if a value exists in a sequence or not
  - Using the `in` operator

Comparing objects with loops

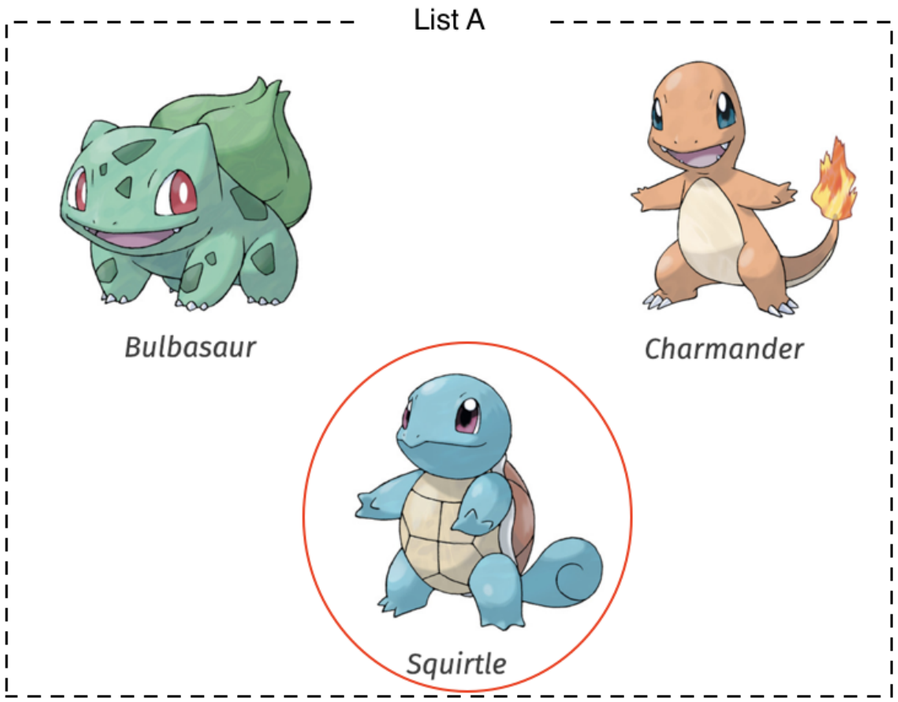
```
list_a = ['Bulbasaur', 'Charmander', 'Squirtle']
list_b = ['Caterpie', 'Pidgey', 'Squirtle']
```

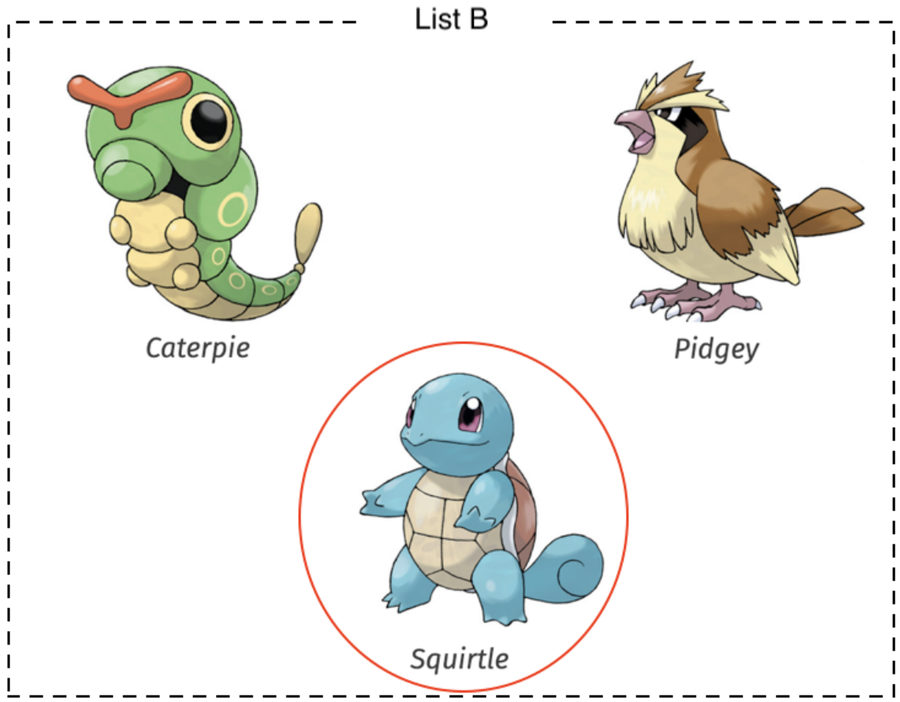




Comparing objects with loops

```
list_a = ['Bulbasaur', 'Charmander', 'Squirtle']
list_b = ['Caterpie', 'Pidgey', 'Squirtle']
```





```
list_a = ['Bulbasaur', 'Charmander', 'Squirtle']
list_b = ['Caterpie', 'Pidgey', 'Squirtle']
```

```
in_common = []

for pokemon_a in list_a:
    for pokemon_b in list_b:
        if pokemon_a == pokemon_b:
            in_common.append(pokemon_a)

print(in_common)
```

```
['Squirtle']
```

```
list_a = ['Bulbasaur', 'Charmander', 'Squirtle']
list_b = ['Caterpie', 'Pidgey', 'Squirtle']
```

```
set_a = set(list_a)
print(set_a)
```

```
{'Bulbasaur', 'Charmander', 'Squirtle'}
```

```
set_b = set(list_b)
print(set_b)
```

```
{'Caterpie', 'Pidgey', 'Squirtle'}
```

```
set_a.intersection(set_b)
```

```
{'Squirtle'}
```

Efficiency gained with set theory

```
%%timeit
in_common = []

for pokemon_a in list_a:
    for pokemon_b in list_b:
        if pokemon_a == pokemon_b:
            in_common.append(pokemon_a)
```

```
601 ns ± 17.1 ns per loop (mean ± std. dev. of 7 runs, 1000000 loops each)
```

```
%timeit in_common = set_a.intersection(set_b)
```

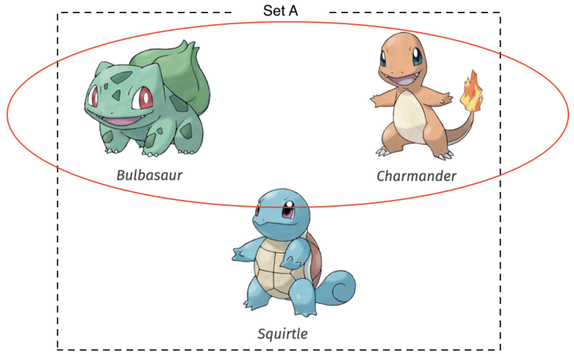
```
137 ns ± 3.01 ns per loop (mean ± std. dev. of 7 runs, 10000000 loops each)
```

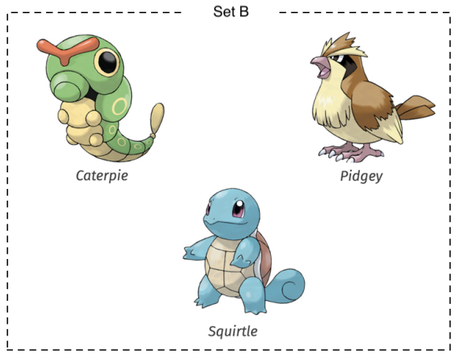
Set method: difference

```
set_a = {'Bulbasaur', 'Charmander', 'Squirtle'}
set_b = {'Caterpie', 'Pidgey', 'Squirtle'}
```

```
set_a.difference(set_b)
```

```
{'Bulbasaur', 'Charmander'}
```



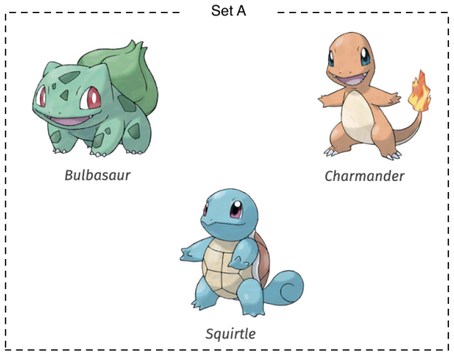


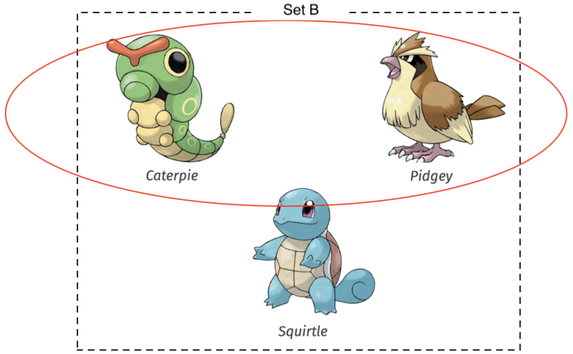
Set method: difference

```
set_a = {'Bulbasaur', 'Charmander', 'Squirtle'}
set_b = {'Caterpie', 'Pidgey', 'Squirtle'}
```

```
set_b.difference(set_a)
```

```
{'Caterpie', 'Pidgey'}
```



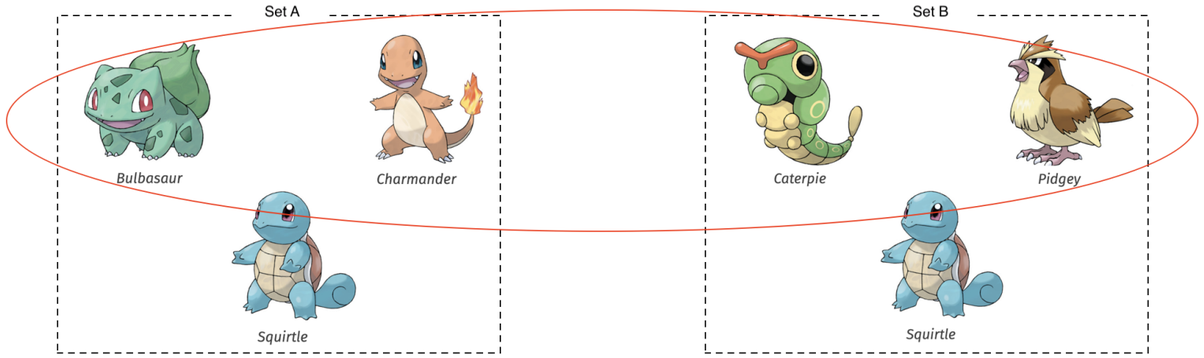


Set method: symmetric difference

```
set_a = {'Bulbasaur', 'Charmander', 'Squirtle'}
set_b = {'Caterpie', 'Pidgey', 'Squirtle'}
```

```
set_a.symmetric_difference(set_b)
```

```
{'Bulbasaur', 'Caterpie', 'Charmander', 'Pidgey'}
```

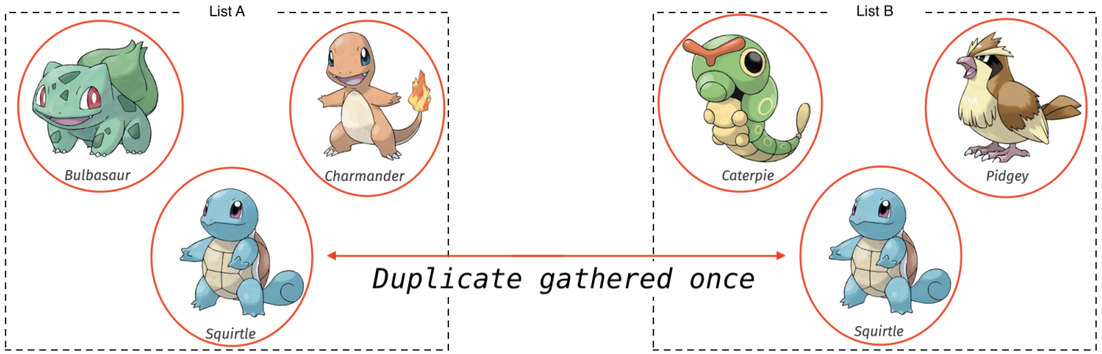


Set method: union

```
set_a = {'Bulbasaur', 'Charmander', 'Squirtle'}
set_b = {'Caterpie', 'Pidgey', 'Squirtle'}
```

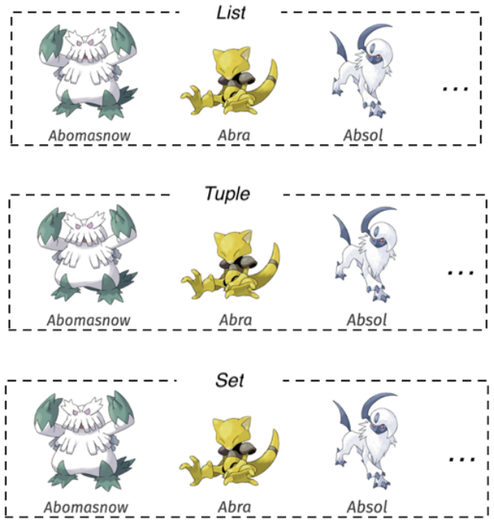
```
set_a.union(set_b)
```

```
{'Bulbasaur', 'Caterpie', 'Charmander', 'Pidgey', 'Squirtle'}
```



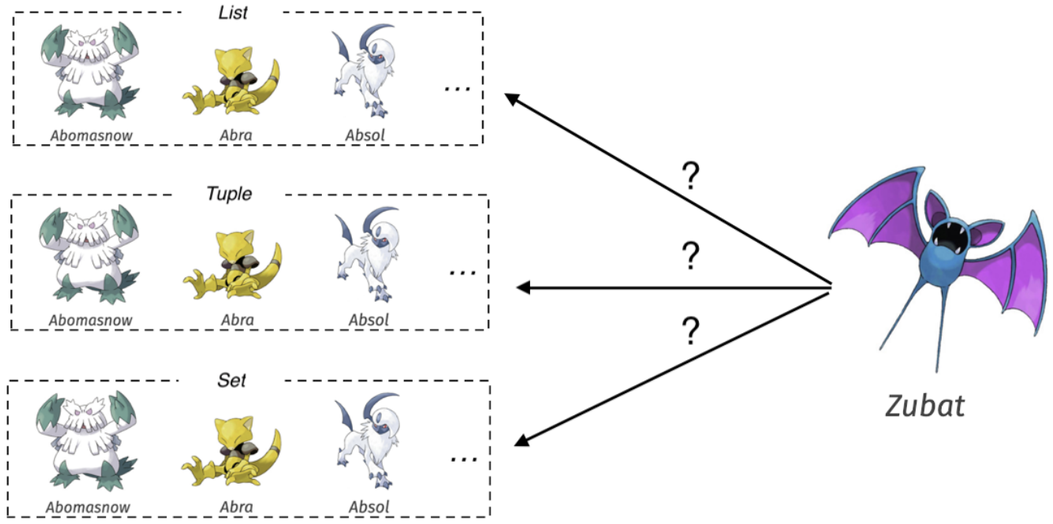
Membership testing with sets

```
# The same 720 total Pokémon in each data structure
names_list  = ['Abomasnow', 'Abra', 'Absol', ...]
names_tuple = ('Abomasnow', 'Abra', 'Absol', ...)
names_set   = {'Abomasnow', 'Abra', 'Absol', ...}
```



Membership testing with sets

```
# The same 720 total Pokémon in each data structure
names_list  = ['Abomasnow', 'Abra', 'Absol', ...]
names_tuple = ('Abomasnow', 'Abra', 'Absol', ...)
names_set   = {'Abomasnow', 'Abra', 'Absol', ...}
```



```
names_list  = ['Abomasnow', 'Abra', 'Absol', ...]
names_tuple = ('Abomasnow', 'Abra', 'Absol', ...)
names_set   = {'Abomasnow', 'Abra', 'Absol', ...}
```

```
%timeit 'Zubat' in names_list
```

```
7.63 µs ± 211 ns per loop (mean ± std. dev. of 7 runs, 100000 loops each)
```

```
%timeit 'Zubat' in names_tuple
```

```
7.6 µs ± 394 ns per loop (mean ± std. dev. of 7 runs, 100000 loops each)
```

```
%timeit 'Zubat' in names_set
```

```
37.5 ns ± 1.37 ns per loop (mean ± std. dev. of 7 runs, 10000000 loops each)
```

Uniques with sets

```
# 720 Pokémon primary types corresponding to each Pokémon
primary_types = ['Grass', 'Psychic', 'Dark', 'Bug', ...]
```

```
unique_types = []

for prim_type in primary_types:
    if prim_type not in unique_types:
        unique_types.append(prim_type)

print(unique_types)
```

```
['Grass', 'Psychic', 'Dark', 'Bug', 'Steel', 'Rock', 'Normal',
 'Water', 'Dragon', 'Electric', 'Poison', 'Fire', 'Fairy', 'Ice',
 'Ground', 'Ghost', 'Fighting', 'Flying']
```

Uniques with sets

```
# 720 Pokémon primary types corresponding to each Pokémon
primary_types = ['Grass', 'Psychic', 'Dark', 'Bug', ...]
```

```
unique_types_set = set(primary_types)
```

```
print(unique_types_set)
```

```
{'Grass', 'Psychic', 'Dark', 'Bug', 'Steel', 'Rock', 'Normal',
 'Water', 'Dragon', 'Electric', 'Poison', 'Fire', 'Fairy', 'Ice',
 'Ground', 'Ghost', 'Fighting', 'Flying'}
```

Let's practice set theory!

WRITING EFFICIENT PYTHON CODE

Eliminating loops

WRITING EFFICIENT PYTHON CODE



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Looping in Python

- Looping patterns:
  - `for` loop: iterate over sequence piece-by-piece
  - `while` loop: repeat loop as long as condition is met
  - "nested" loops: use one loop inside another loop
  - Costly!

Benefits of eliminating loops

- Fewer lines of code
- Better code readability
  - "Flat is better than nested"
- Efficiency gains

Eliminating loops with built-ins

```
# List of HP, Attack, Defense, Speed
poke_stats = [
    [90,  92, 75, 60],
    [25,  20, 15, 90],
    [65, 130, 60, 75],
    ...
]
```

Abomasnow



Base stats

HP	90
Attack	92
Defense	75
Sp. Atk	92
Sp. Def	85
Speed	60
Total	**494**

Abra



Base stats

HP	25
Attack	20
Defense	15
Sp. Atk	105
Sp. Def	55
Speed	90
Total	**310**

Absol



Base stats

HP	65
Attack	130
Defense	60
Sp. Atk	75
Sp. Def	60
Speed	75
Total	**465**

```
# List of HP, Attack, Defense, Speed
poke_stats = [
    [90,  92, 75, 60],
    [25,  20, 15, 90],
    [65, 130, 60, 75],
    ...
]
# For loop approach
totals = []
for row in poke_stats:
    totals.append(sum(row))
# List comprehension
totals_comp = [sum(row) for row in poke_stats]
# Built-in map() function
totals_map = [*map(sum, poke_stats)]
```

```
%%timeit
totals = []
for row in poke_stats:
    totals.append(sum(row))
```

```
140 µs ± 1.94 µs per loop (mean ± std. dev. of 7 runs, 10000 loops each)
```

```
%timeit totals_comp = [sum(row) for row in poke_stats]
```

```
114 µs ± 3.55 µs per loop (mean ± std. dev. of 7 runs, 10000 loops each)
```

```
%timeit totals_map = [*map(sum, poke_stats)]
```

```
95 µs ± 2.94 µs per loop (mean ± std. dev. of 7 runs, 10000 loops each)
```

Eliminating loops with built-in modules

```
poke_types = ['Bug', 'Fire', 'Ghost', 'Grass', 'Water']
```

```
# Nested for loop approach
combos = []
for x in poke_types:
    for y in poke_types:
        if x == y:
            continue
        if ((x,y) not in combos) & ((y,x) not in combos):
            combos.append((x,y))
```

```
# Built-in module approach
from itertools import combinations
combos2 = [*combinations(poke_types, 2)]
```

Eliminate loops with NumPy

```
# Array of HP, Attack, Defense, Speed
import numpy as np

poke_stats = np.array([
    [90,  92, 75, 60],
    [25,  20, 15, 90],
    [65, 130, 60, 75],
    ...
])
```

Eliminate loops with NumPy

```
avgs = []
for row in poke_stats:
    avg = np.mean(row)
    avgs.append(avg)
print(avgs)
```

```
[79.25, 37.5, 82.5, ...]
```

```
avgs_np = poke_stats.mean(axis=1)
print(avgs_np)
```

```
[ 79.25  37.5   82.5  ...]
```

Eliminate loops with NumPy

```
%timeit avgs = poke_stats.mean(axis=1)
```

```
23.1 µs ± 235 ns per loop (mean ± std. dev. of 7 runs, 10000 loops each)
```

```
%%timeit
avgs = []
for row in poke_stats:
    avg = np.mean(row)
    avgs.append(avg)
```

```
5.54 ms ± 224 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

Let's practice!

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Writing better loops

WRITING EFFICIENT PYTHON CODE



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Lesson caveat

- Some of the following loops can be eliminated with techniques covered in previous lessons.
- Examples in this lesson are used for **demonstrative** purposes.



Warning: *For demonstration purposes only*

Writing better loops

- Understand what is being done with each loop iteration
- Move one-time calculations outside (above) the loop
- Use holistic conversions outside (below) the loop
- Anything that is done **once** should be outside the loop

Moving calculations above a loop

```
import numpy as np

names = ['Absol', 'Aron', 'Jynx', 'Natu', 'Onix']
attacks = np.array([130, 70, 50, 50, 45])
for pokemon,attack in zip(names, attacks):
    total_attack_avg = attacks.mean()
    if attack > total_attack_avg:
        print(
            "{}'s attack: {} > average: {}!"
            .format(pokemon, attack, total_attack_avg)
        )
```

```
Absol's attack: 130 > average: 69.0!
Aron's attack: 70 > average: 69.0!
```

```
import numpy as np

names = ['Absol', 'Aron', 'Jynx', 'Natu', 'Onix']
attacks = np.array([130, 70, 50, 50, 45])
# Calculate total average once (outside the loop)
total_attack_avg = attacks.mean()
for pokemon,attack in zip(names, attacks):

    if attack > total_attack_avg:
        print(
            "{}'s attack: {} > average: {}!"
            .format(pokemon, attack, total_attack_avg)
        )
```

```
Absol's attack: 130 > average: 69.0!
Aron's attack: 70 > average: 69.0!
```

Moving calculations above a loop

```
%%timeit
for pokemon,attack in zip(names, attacks):

    total_attack_avg = attacks.mean()

    if attack > total_attack_avg:
        print(
            "{}'s attack: {} > average: {}!"
            .format(pokemon, attack, total_attack_avg)
        )
```

```
74.9 µs ± 3.42 µs per loop (mean ± std. dev. of 7 runs, 10000 loops each)
```

Moving calculations above a loop

```
%%timeit
# Calculate total average once (outside the loop)
total_attack_avg = attacks.mean()

for pokemon,attack in zip(names, attacks):

    if attack > total_attack_avg:
        print(
            "{}'s attack: {} > average: {}!"
            .format(pokemon, attack, total_attack_avg)
        )
```

```
37.5 µs ± 281 ns per loop (mean ± std. dev. of 7 runs, 10000 loops each)
```

Using holistic conversions

```
names = ['Pikachu', 'Squirtle', 'Articuno', ...]
legend_status = [False, False, True, ...]
generations = [1, 1, 1, ...]
poke_data = []
for poke_tuple in zip(names, legend_status, generations):
    poke_list = list(poke_tuple)
    poke_data.append(poke_list)
print(poke_data)
```

```
[['Pikachu', False, 1], ['Squirtle', False, 1], ['Articuno', True, 1], ...]
```

Using holistic conversions

```
names = ['Pikachu', 'Squirtle', 'Articuno', ...]
legend_status = [False, False, True, ...]
generations = [1, 1, 1, ...]
poke_data_tuples = []
for poke_tuple in zip(names, legend_status, generations):
    poke_data_tuples.append(poke_tuple)
poke_data = [*map(list, poke_data_tuples)]
print(poke_data)
```

```
[['Pikachu', False, 1], ['Squirtle', False, 1], ['Articuno', True, 1], ...]
```

```
%%timeit
poke_data = []
for poke_tuple in zip(names, legend_status, generations):
    poke_list = list(poke_tuple)
    poke_data.append(poke_list)
```

```
261 µs ± 23.2 µs per loop (mean ± std. dev. of 7 runs, 1000 loops each)
```

```
%%timeit
poke_data_tuples = []
for poke_tuple in zip(names, legend_status, generations):
    poke_data_tuples.append(poke_tuple)

poke_data = [*map(list, poke_data_tuples)]
```

```
224 µs ± 1.67 µs per loop (mean ± std. dev. of 7 runs, 1000 loops each)
```

Time for some practice!

WRITING EFFICIENT PYTHON CODE