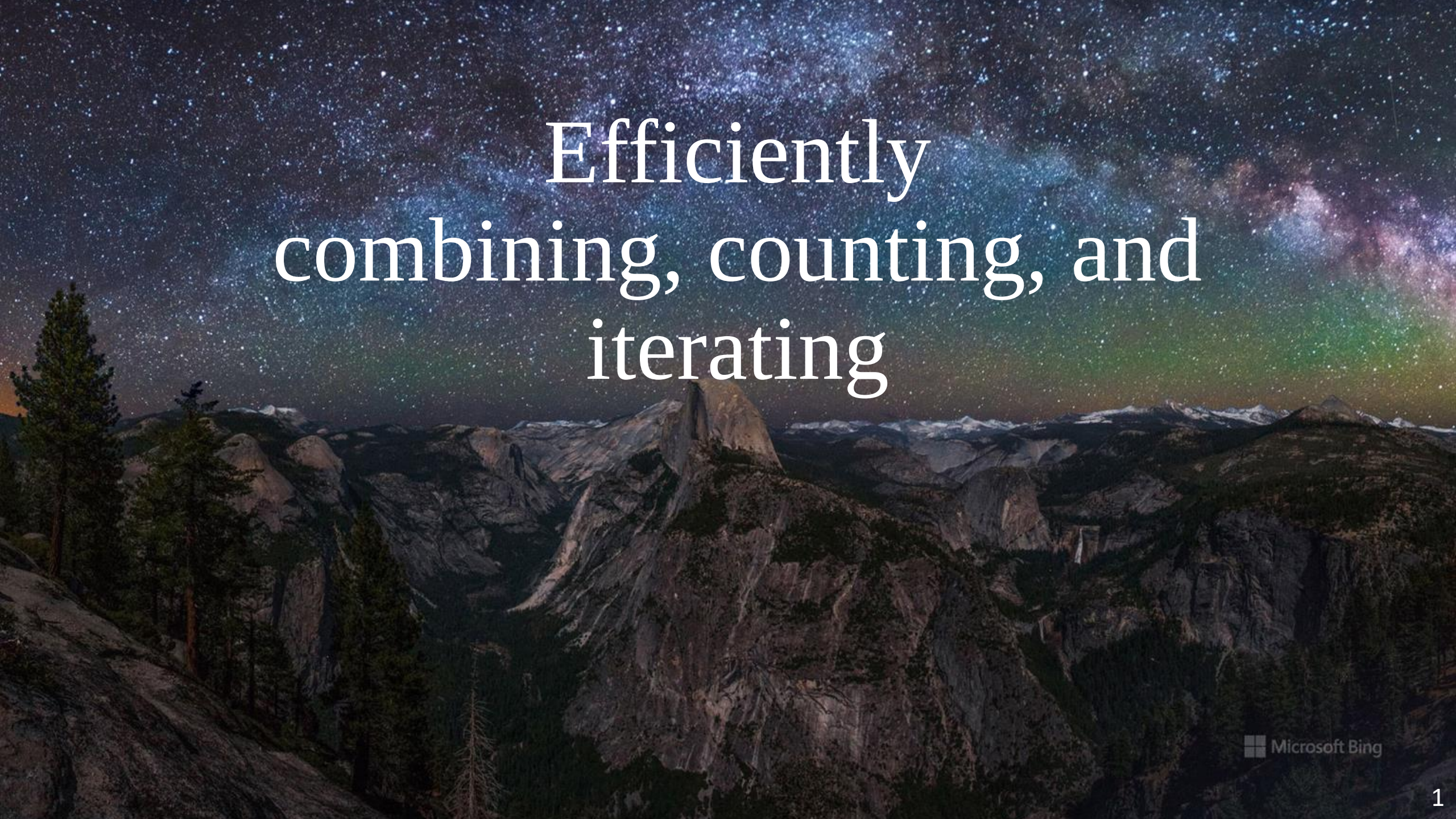

Efficiently
combining, counting, and
iterating
Microsoft Bing

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

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 ,elds

✓ 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

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)
```

Dictionary Name[Key]=Value

```
{'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:

  ✓ Infnite 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')]
```


Set theory
Microsoft Bing

Set theory

- Branch of Mathematics applied to collections of objects
  - ✓ i.e., sets
- Python has built-in set datatype with accompanying methods:

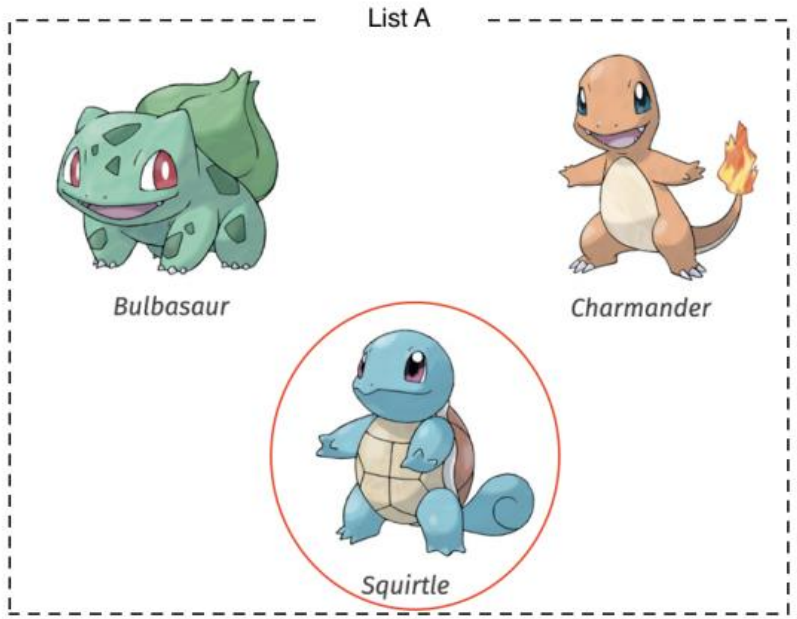
✓ intersection() : all elements that are in both sets
✓ difference() : all elements in one set but not the other
✓ symmetric_difference() : all elements in exactly one set
✓ union() : all elements that are in either set

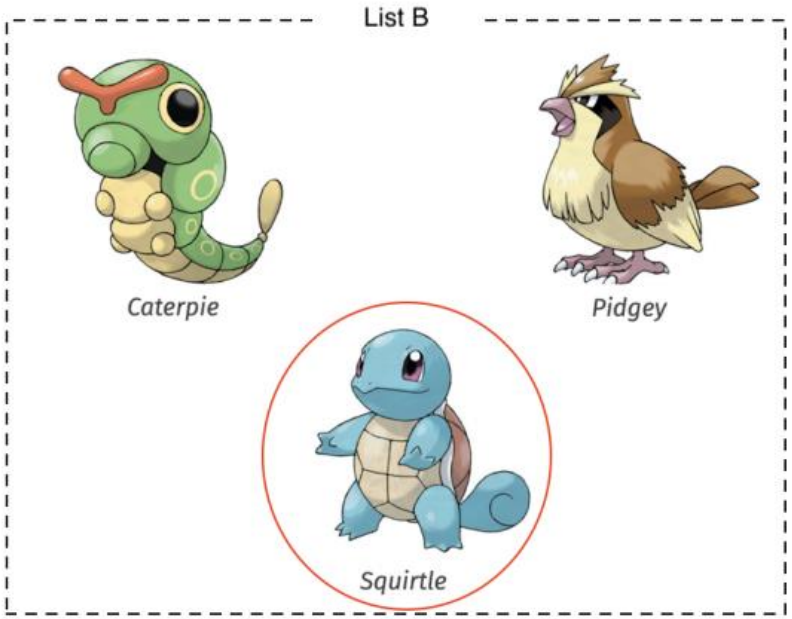
- Fast membership testing

✓ 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']
```

```
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']
```

Comparing objects with set

```
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)
```

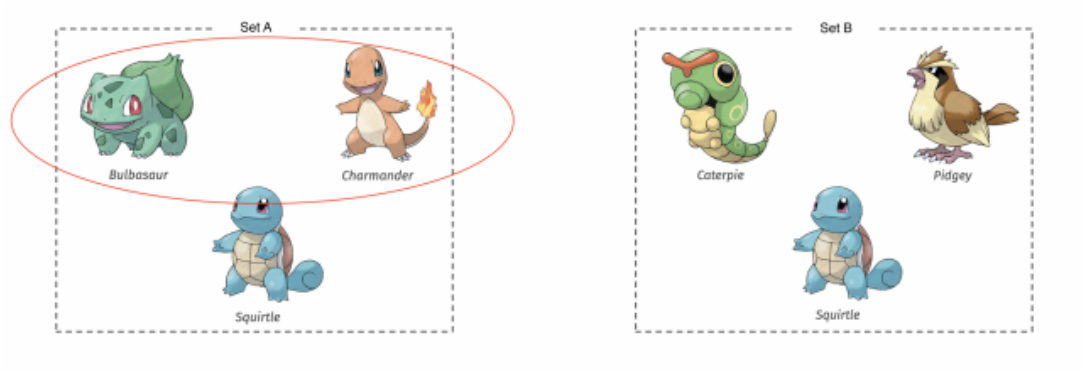
```
137 ns ± 3.01 ns per loop (mean ± std. dev. of 7 runs, 10000000 loops each)
```

Set method: difference

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

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

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

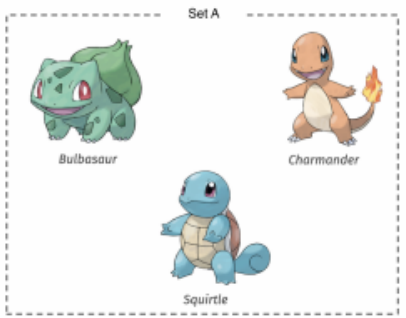


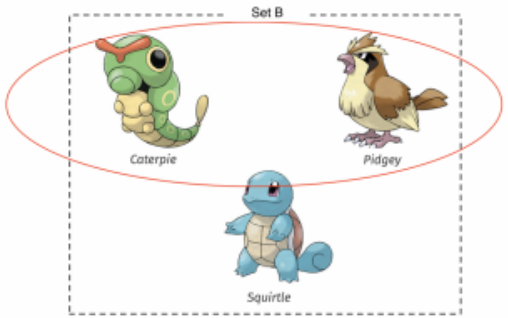
Set method: difference

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

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

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



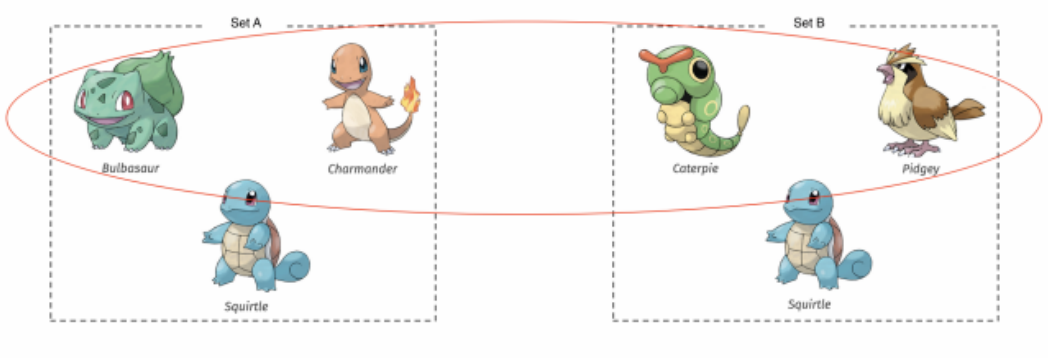


Set method: symmetric difference

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

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

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

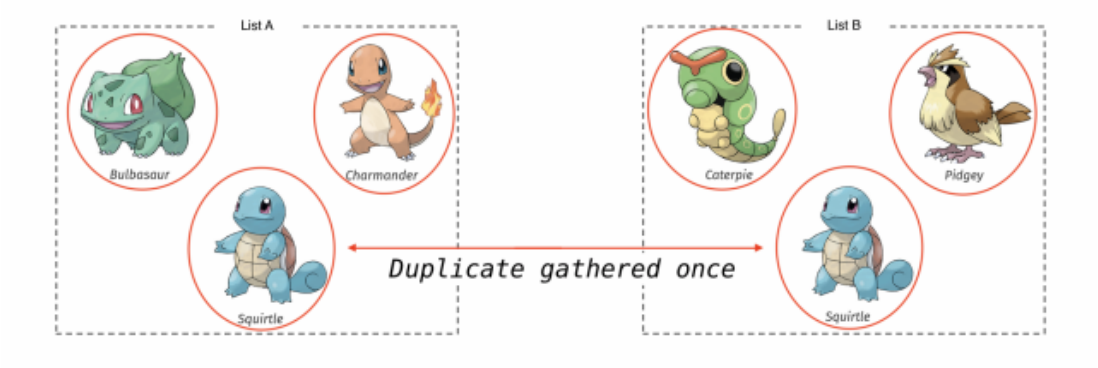


Set method: union

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

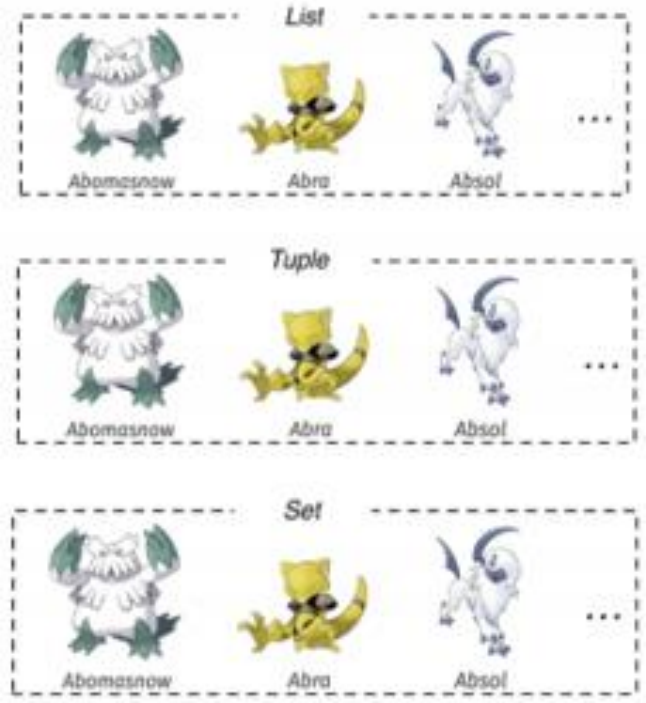
```
set_a.union(set_b)
```

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



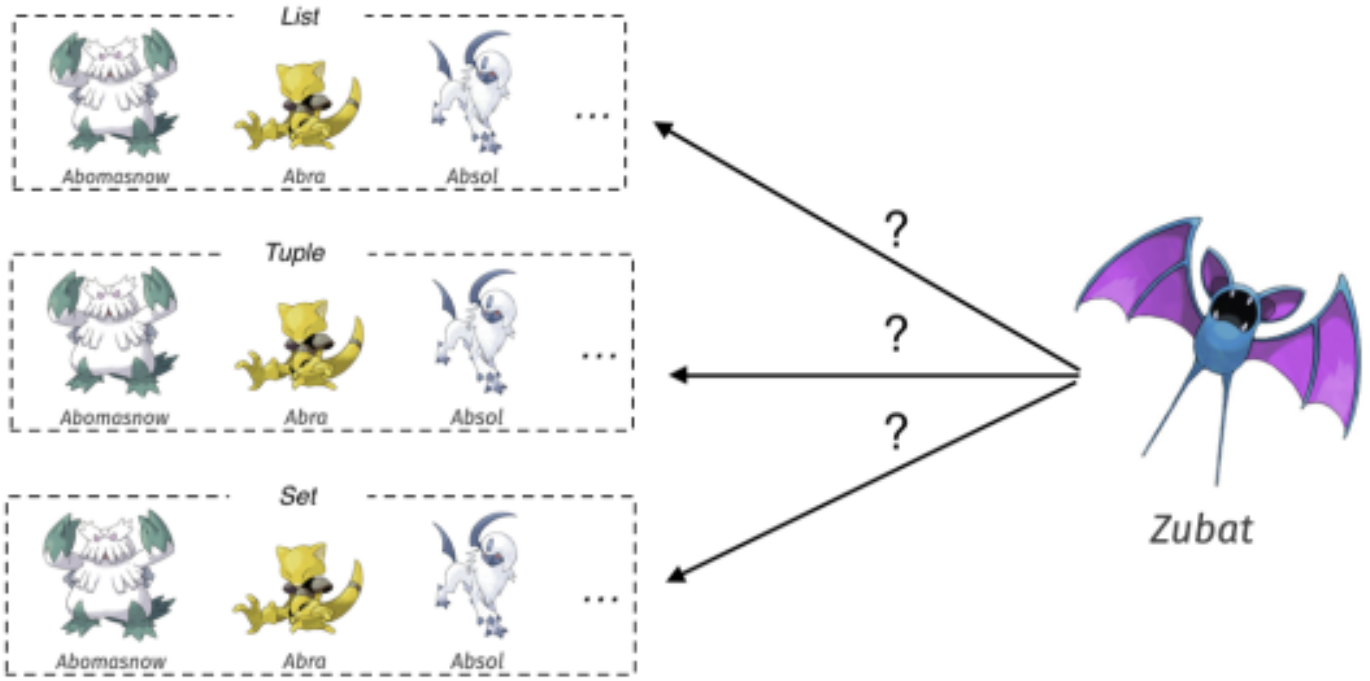
Membership testing with sets

```
# 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', ...}
```



Membership testing with sets

```
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']
```

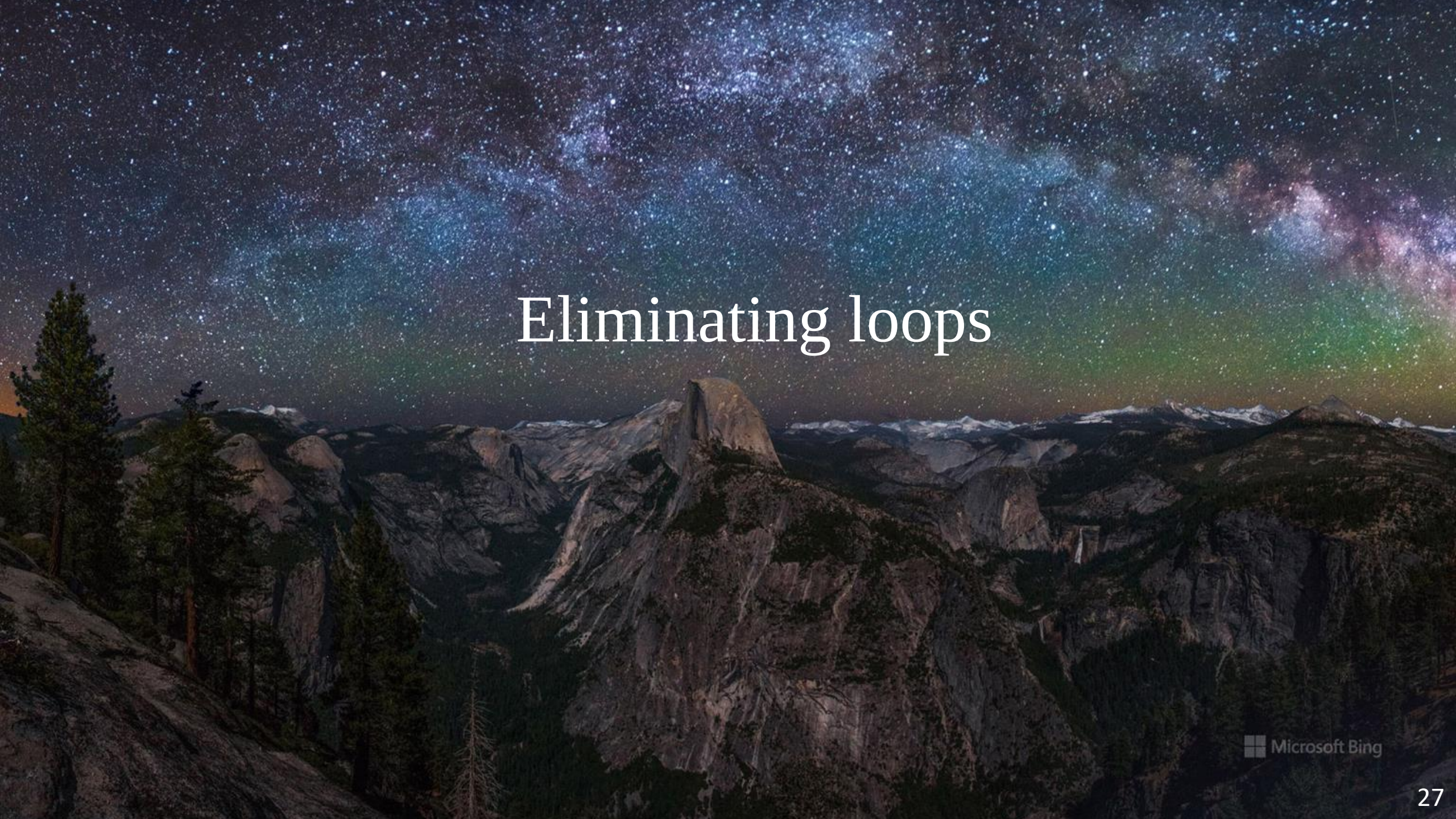
Uniques with sets

```
# 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'}
```


Eliminating loops
Microsoft Bing

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"*

- Effciency gains

List comprehensions

- Collapse for loops for building lists into a single line
- Components
  - ✓ Iterable
  - ✓ Iterator variable (represent members of iterable)
  - ✓ Output expression

Populate a list with a for loop

```
nums = [12, 8, 21, 3, 16]
new_nums = []
for num in nums:
    new_nums.append(num + 1)
print(new_nums)
```

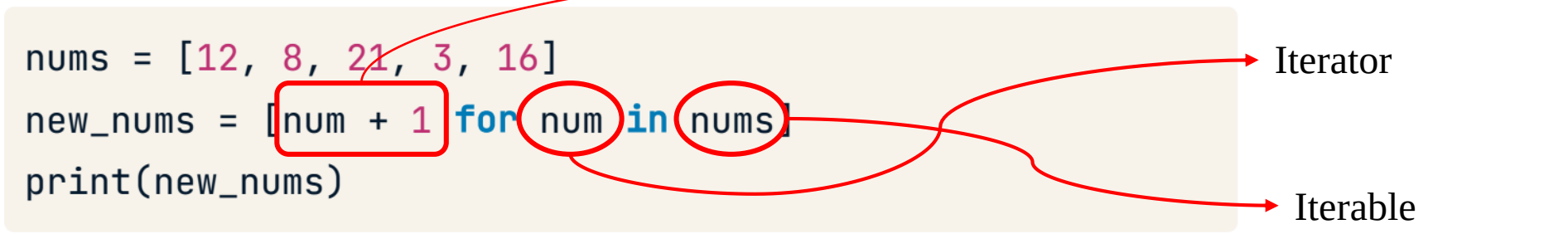
```
[13, 9, 22, 4, 17]
```

Populate a list with a for loop

```
nums = [12, 8, 21, 3, 16]
new_nums = []
for num in nums:
    new_nums.append(num + 1)
print(new_nums)
```

```
[13, 9, 22, 4, 17]
```

A list comprehension




```
[13, 9, 22, 4, 17]
```

Nested loops

??? `[(0, 6), (0, 7), (1, 6), (1, 7)]`

```
pairs_1 = []
for num1 in range(0, 2):
    for num2 in range(6, 8):
        pairs_1.append(num1, num2)
print(pairs_1)
```

```
[(0, 6), (0, 7), (1, 6), (1, 7)]
```

Nested loops

??? `[(0, 6), (0, 7), (1, 6), (1, 7)]`

```
pairs_1 = []
for num1 in range(0, 2):
    for num2 in range(6, 8):
        pairs_1.append(num1, num2)
print(pairs_1)
```

```
[(0, 6), (0, 7), (1, 6), (1, 7)]
```

A list comprehension

```
pairs_2 = [(num1, num2) for num1 in range(0, 2) for num2 in range(6, 8)]
print(pairs_2)
```

```
[(0, 6), (0, 7), (1, 6), (1, 7)]
```

Conditionals in comprehensions

- Conditionals on the iterable

```
[num ** 2 for num in range(10) if num % 2 == 0]
```

```
[0, 4, 16, 36, 64]
```

- Conditionals on the output expression

```
[num ** 2 if num % 2 == 0 else 0 for num in range(10)]
```

```
[0, 0, 4, 0, 16, 0, 36, 0, 64, 0]
```

Re-cap: list comprehensions

- Basic

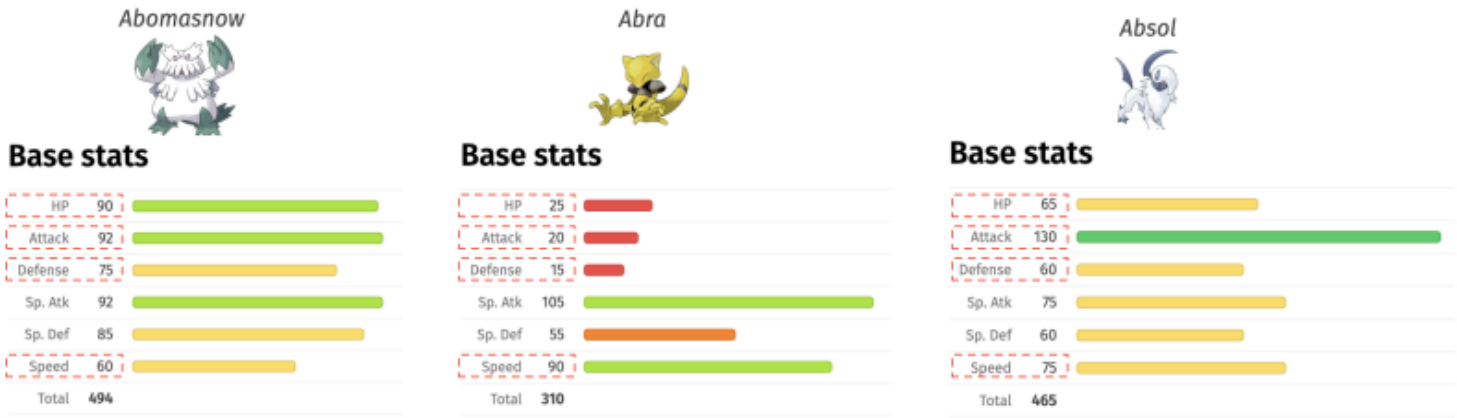
```
[output expression for iterator variable in iterable]
```

- Advanced

```
[output expression +
conditional on output for iterator variable in iterable +
conditional on iterable]
```

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],
    ...
]
```



Eliminating loops with built-ins

```
%%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)
```

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)
```


Writing better loops
Microsoft Bing

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!
```

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!
```

Moving calculations above a loop

```
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)
```

```
%%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], ...]
```

Using holistic conversions

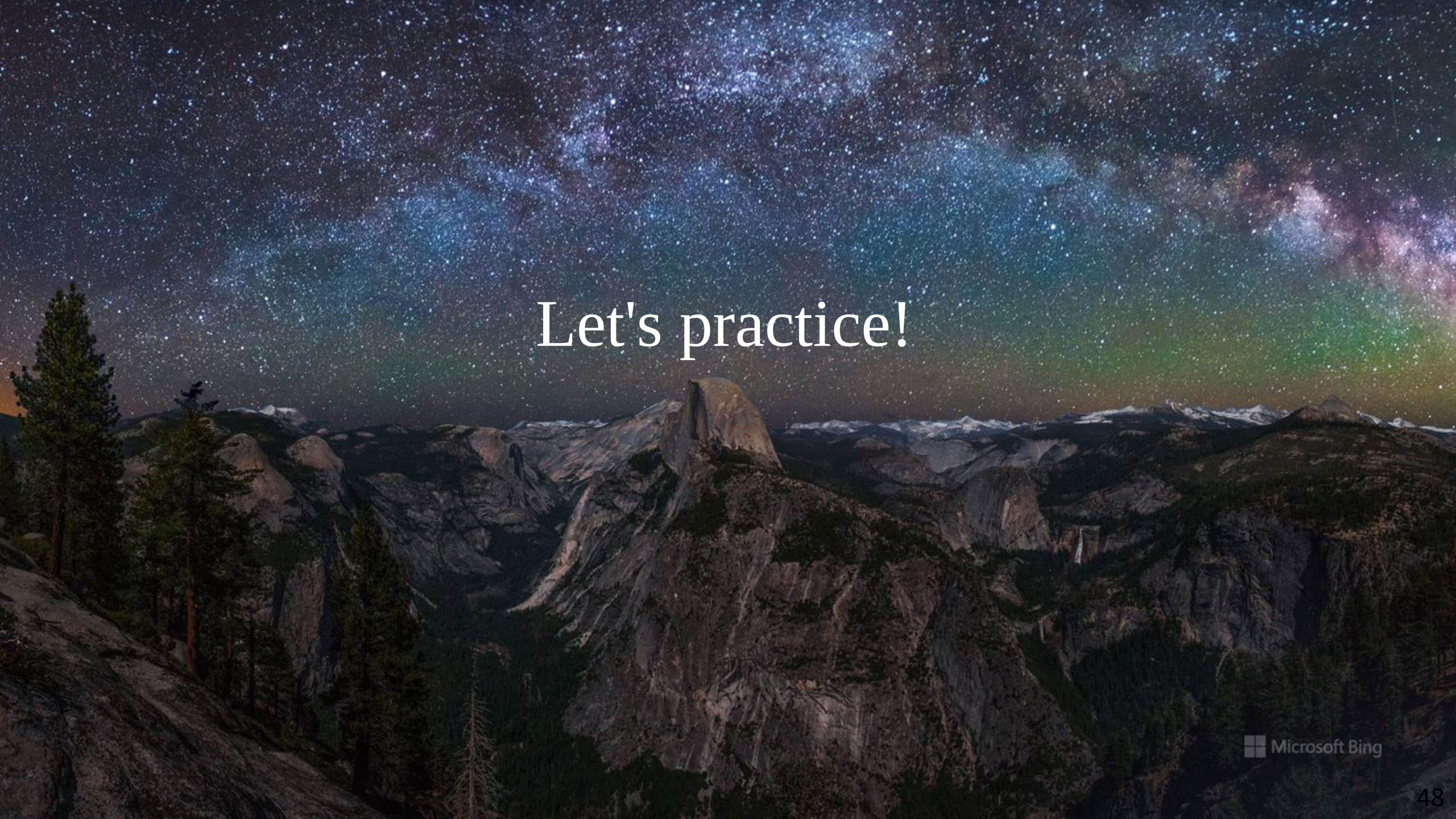
```
%%timeit
poke_data = []
for poke_tuple in zip(names, legend_status, generations):
    poke_list = list(poke_tuple)
    poke_data.append(poke_list)
```

```
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)
```


Let's practice!
Microsoft Bing