Lesson 02: Data Structures

Data Science with Python – BSc Course

Data Science Program

BSc Course

45 Minutes

Previously: Variables and Types

L01: You stored one value in one variable: `price = 185.50`

Problem: You have 500 stock prices. A single variable won't cut it.

Solution: Data structures – containers that hold multiple values at once.

From single values to organized collections of data

Learning Objectives

After this lesson, you will be able to:

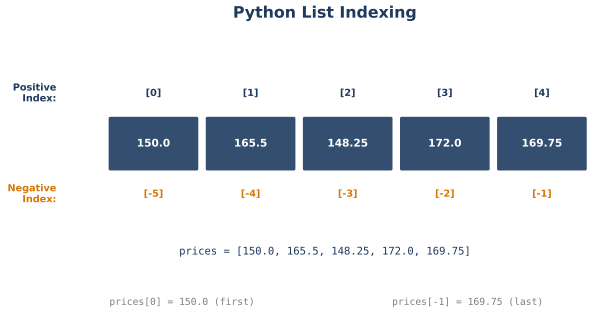
- **Create** lists and access elements by index
- **Slice** lists to extract sub-sequences
- **Build** dictionaries for key-value data storage
- **Choose** the right structure for each use case
- **Apply** list comprehensions for efficient processing

Finance Application: Store portfolios as dictionaries, price histories as lists.

Data structures are containers for organizing information

Lists: Ordered Sequences

A list is an ordered collection of items, accessed by position



Access: `prices[0]` → first — `prices[-1]` → last — `prices[2]` → third

Indexing starts at 0, not 1. Negative indices count from the end.

Creating and Modifying Lists

Creating Lists:

```
# From literal values
prices = [150, 165, 148, 172]
# Empty list
signals = []
# Mixed types (allowed but rare)
info = ["AAPL", 185.5, True]
# From range
days = list(range(1, 6))
# [1, 2, 3, 4, 5]
```

Modifying Lists:

```
prices = [150, 165, 148]
# Change element
prices[0] = 155
# Add to end
prices.append(172)
# Insert at position
prices.insert(1, 160)
# Remove by value
prices.remove(148)
```

Lists are mutable – you can change, add, and remove elements

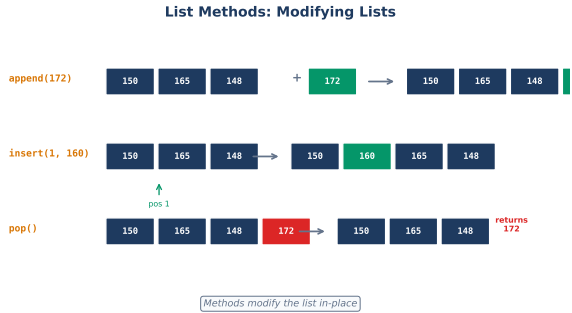
Slicing: Extracting Sub-Sequences

Syntax: `list[start:end:step]` – end index is **exclusive**

More: `prices[0:3]` → first 3 — `prices[::2]` → every 2nd — `prices[::-1]` → reversed

Slicing creates a new list – the original is unchanged

Essential List Methods



Key distinction: `sort()` modifies in place; `sorted()` returns a new list

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Methods modify the list in-place (except sorted() which returns new list)

Useful List Operations

Aggregation:

```
prices = [150, 165, 148, 172]
len(prices)   # 4
sum(prices)   # 635
min(prices)   # 148
max(prices)   # 172
```

Membership Test:

```
172 in prices    # True
200 in prices    # False
```

Sorting:

```
prices.sort()
# [148, 150, 165, 172]
prices.sort(reverse=True)
# [172, 165, 150, 148]
```

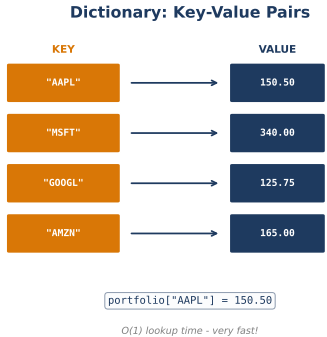
Counting:

```
grades = ["A", "B", "A", "C"]
grades.count("A")  # 2
grades.index("B")  # 1
```

Built-in functions (len, sum, min, max) work on any sequence

Dictionaries: Key-Value Pairs

A dictionary maps unique keys to values – like a phone book



Methods: `.keys()` – all keys — `.values()` – all values — `.items()` – pairs

Dictionaries provide O(1) lookup – instant access by key

Working with Dictionaries

Creating:

```
stock = {
    "ticker":  "AAPL",
    "price":  185.50,
    "shares":  100
}
```

Accessing:

```
stock["price"]    # 185.50
stock.get("sector", "N/A")
# "N/A" (safe access)
```

Modifying:

```
# Update value
stock["price"] = 190.00
# Add new key
stock["sector"] = "Tech"
# Remove key
del stock["shares"]
```

Check Membership:

```
"ticker" in stock  # True
"volume" in stock  # False
```

Use .get() for safe access – avoids KeyError on missing keys

Tuples: Immutable Sequences

Creating Tuples:

```
# Parentheses (optional)
coords = (40.71, -74.01)
# Without parentheses
trade = "AAPL", 185.50, 100
# Single element (note comma)
singleton = (42,)
```

Accessing:

`coords[0]` → 40.71
`trade[-1]` → 100

Why Tuples?

- **Immutable** – cannot be changed after creation
- Safer: prevents accidental modification
- Faster than lists (slight performance edge)
- Can be dictionary keys (lists cannot)

Unpacking:

```
ticker, price, shares = trade
# ticker = "AAPL"
# price = 185.50
# shares = 100
```

Use tuples for data that should not change (coordinates, dates, records)

Sets: Unique Collections

Creating Sets:

```
tickers = {"AAPL", "MSFT", "AAPL"}
# {"AAPL", "MSFT"} -- no duplicates!

# From list
unique = set([1, 2, 2, 3, 3])
# {1, 2, 3}
```

Set Operations:

`A | B` – union
`A & B` – intersection
`A - B` – difference

Finance Use Case:

```
portfolio = {"AAPL", "MSFT", "GOOGL"}
sp500 = {"AAPL", "MSFT", "AMZN"}

# Stocks in both
overlap = portfolio & sp500
# {"AAPL", "MSFT"}

# Only in portfolio
unique_to_me = portfolio - sp500
# {"GOOGL"}
```

Key property: Unordered, no duplicates

Sets: fast membership testing and duplicate removal

Checkpoint: Which Structure?

Q1: Store 252 daily closing prices in order?
(a) dict (b) **list** (c) set (d) tuple

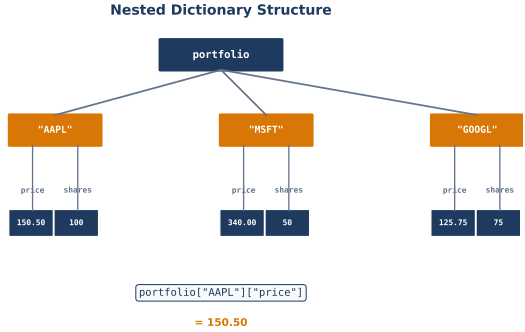
Q2: Map ticker symbols to company names?
(a) list (b) **dict** (c) tuple (d) set

Q3: Find unique sectors in your portfolio?
(a) list (b) dict (c) tuple (d) **set**

Q4: Store an (x, y) coordinate that should never change?
(a) list (b) dict (c) **tuple** (d) set

Choosing the right structure is a key skill – it affects performance and clarity

Nested Data Structures



Real data is hierarchical: portfolios contain stocks, stocks have attributes

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Nested structures model complex financial data naturally

Building Nested Structures

Portfolio Structure:

```
portfolio = {
  "AAPL":  {"price":  185.5,
            "shares":  100},
  "MSFT":  {"price":  340.0,
            "shares":  50}
}
```

Accessing:

`portfolio["AAPL"]["price"]`
→ `185.5`

List of Dicts:

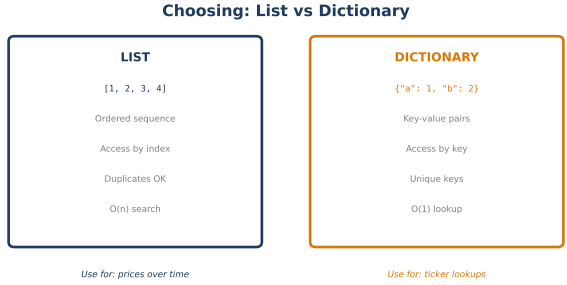
```
trades = [
  {"ticker":  "AAPL",
   "action":  "BUY",
   "shares":  50},
  {"ticker":  "MSFT",
   "action":  "SELL",
   "shares":  30}
]
```

Accessing:

`trades[0]["ticker"]` → `"AAPL"`

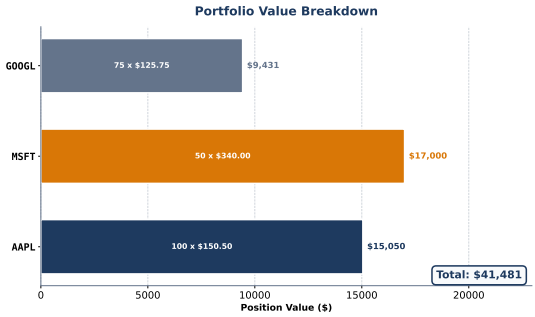
Dict of dicts or list of dicts – choose based on primary access pattern

Choosing the Right Structure



Lists for sequences, dicts for lookups, sets for uniqueness, tuples for immutability

Finance: Portfolio Calculations



Calculate Total Value:

```
portfolio = {
  "AAPL":  {"shares":  100,
            "price":  185.5},
  "MSFT":  {"shares":  50,
            "price":  340.0}
}
total = 0
for t in portfolio:
    s = portfolio[t]["shares"]
    p = portfolio[t]["price"]
    total += s * p
# total = 35,550.00
```

Dictionaries are the natural structure for portfolio data

Finance: Price History Analysis

Price History as List:

```
prices = [150.0, 152.5, 148.0,
          155.0, 160.0]
# Basic statistics
avg = sum(prices) / len(prices)
# 153.10
high = max(prices)  # 160.0
low = min(prices)   # 148.0
# Price range
spread = high - low  # 12.0
```

Computing Returns:

```
# Daily returns
returns = []
for i in range(1, len(prices)):
    r = (prices[i] - prices[i-1])
        / prices[i-1]
    returns.append(r)
# [0.0167, -0.0295,
#  0.0473, 0.0323]
```

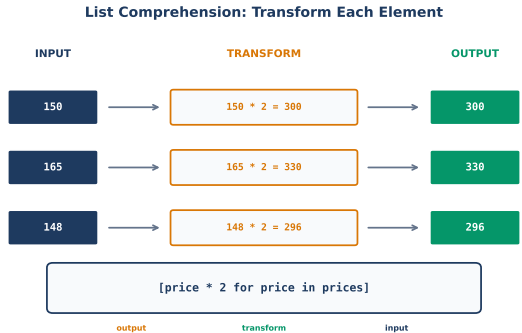
Key pattern:

Returns need consecutive prices – lists preserve order.

Lists maintain insertion order – essential for time series data

List Comprehensions

A concise way to create lists from existing sequences



Syntax: `[expression for item in iterable if condition]`

Comprehensions are more Pythonic and often faster than loops

Comprehension Patterns

Transform:

```
prices = [150, 165, 148, 172]
# Double all prices
doubled = [p * 2 for p in prices]
# [300, 330, 296, 344]
# Convert to returns
base = prices[0]
rets = [(p - base) / base
        for p in prices]
```

Filter:

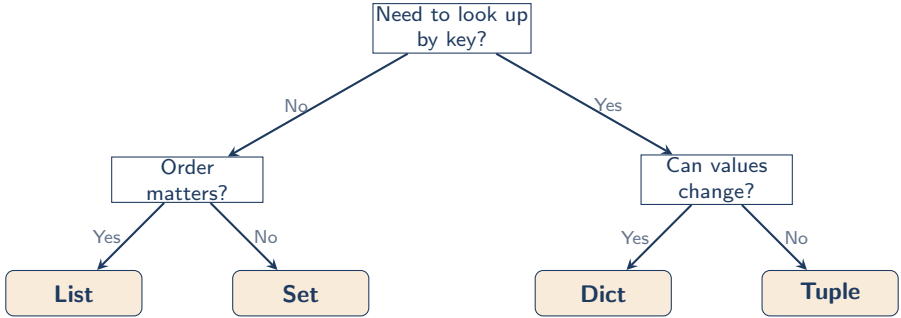
```
# Only prices above 150
high = [p for p in prices
        if p > 150]
# [165, 172]
# Uppercase tickers
tickers = ["aapl", "msft"]
upper = [t.upper()
         for t in tickers]
# ["AAPL", "MSFT"]
```

Traditional loop (equivalent but longer):

```
high = []
for p in prices:
    if p > 150:
        high.append(p)
```

Use comprehensions when the logic fits one line; use loops for complex logic

Data Structure Decision Guide



Structure	Ordered?	Mutable?	Duplicates?
List	Yes	Yes	Yes
Tuple	Yes	No	Yes
Dict	Yes (3.7+)	Yes	Keys: No
Set	No	Yes	No

Pick the simplest structure that meets your needs

Hands-on Exercise (25 min)

Build a portfolio tracker:

1. Create a list of tickers: `tickers = ["AAPL", "MSFT", "GOOGL", "AMZN"]`
2. Create a dict with shares owned: `shares = {"AAPL": 50, "MSFT": 30, ...}`
3. Create a dict with current prices
4. Calculate portfolio value using list comprehension: `values = [shares[t] * prices[t] for t in tickers]`
5. Find total portfolio value: `sum(values)`
6. Filter stocks worth more than $5000

Save your work – we add control flow next lesson

Organizing Data: Complete

List	Dict	Tuple
Ordered, mutable	Key-value pairs	Immutable
prices, tickers	portfolios, lookups	coordinates, records

Comprehensions: `[x*2 for x in prices if x > 150]`

Next: Make your code think and repeat with control flow

You can now store and organize any data – next we process it

Lesson Summary

Key Takeaways:

- Lists store ordered sequences, accessed by index starting at 0
- Dictionaries map keys to values for instant lookups
- Tuples are immutable lists – use for data that shouldn't change
- Sets provide uniqueness and fast membership testing
- List comprehensions create lists concisely: `[expr for x in seq]`
- Choose structure based on access pattern and mutability needs

Next Lesson: Control Flow – if/else decisions and loops for repetition.

Data structures + control flow = the core of programming logic