# Review of pandas DataFrames

PANDAS FOUNDATIONS

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# pandas DataFrames

- Example: DataFrame of Apple Stock data

| Date | Open | High | Low | Close | Volume | Adj Close |
|---|---|---|---|---|---|---|
| 2014-09-16 | 99.80 | 101.26 | 98.89 | 100.86 | 66818200 | 100.86 |
| 2014-09-15 | 102.81 | 103.05 | 101.44 | 101.63 | 61216500 | 101.63 |
| 2014-09-12 | 101.21 | 102.19 | 101.08 | 101.66 | 62626100 | 101.66 |
| ... | ... | ... | ... | ... | ... | ... |

# Indexes and columns

```
import pandas as pd
type(AAPL)
```

```
pandas.core.frame.DataFrame
```

```
AAPL.shape
```

```
(8514, 6)
```

```
AAPL.columns
```

```
Index(['Open', 'High', 'Low', 'Close', 'Volume', 'Adj Close'], dtype='object')
```

```
type(AAPL.columns)
```

```
pandas.indexes.base.Index
```

# Indexes and columns

```
AAPL.index
```

```
DatetimeIndex(['2014-09-16', '2014-09-15', '2014-09-12',
               '2014-09-11', '2014-09-10', '2014-09-09',
               '2014-09-08', '2014-09-05', '2014-09-04',
               '2014-09-03',
               ...
               '1980-12-26', '1980-12-24', '1980-12-23',
               '1980-12-22', '1980-12-19', '1980-12-18',
               '1980-12-17', '1980-12-16', '1980-12-15',
               '1980-12-12'],
              dtype='datetime64[ns]', name='Date', length=8514,
              freq=None)
```

```
type(AAPL.index)
```

```
pandas.tseries.index.DatetimeIndex
```

# Slicing

```
AAPL.iloc[:5,:]
```

```
              Open    High     Low   Close     Volume  Adj Close
Date
2014-09-16   99.80  101.26   98.89  100.86   66818200     100.86
2014-09-15  102.81  103.05  101.44  101.63   61216500     101.63
2014-09-12  101.21  102.19  101.08  101.66   62626100     101.66
2014-09-11  100.41  101.44   99.62  101.43   62353100     101.43
2014-09-10   98.01  101.11   97.76  101.00  100741900     101.00
```

```
AAPL.iloc[-5:,:]
```

```
             Open   High    Low  Close     Volume  Adj Close
Date
1980-12-18  26.63  26.75  26.63  26.63   18362400       0.41
1980-12-17  25.87  26.00  25.87  25.87   21610400       0.40
1980-12-16  25.37  25.37  25.25  25.25   26432000       0.39
1980-12-15  27.38  27.38  27.25  27.25   43971200       0.42
1980-12-12  28.75  28.87  28.75  28.75  117258400       0.45
```

# head()

```
AAPL.head(5)
```

```
              Open    High     Low   Close     Volume  Adj Close
Date
2014-09-16   99.80  101.26   98.89  100.86   66818200     100.86
2014-09-15  102.81  103.05  101.44  101.63   61216500     101.63
2014-09-12  101.21  102.19  101.08  101.66   62626100     101.66
2014-09-11  100.41  101.44   99.62  101.43   62353100     101.43
2014-09-10   98.01  101.11   97.76  101.00  100741900     101.00
```

```
AAPL.head(2)
```

```
              Open    High     Low   Close    Volume  Adj Close
Date
2014-09-16   99.80  101.26   98.89  100.86  66818200     100.86
2014-09-15  102.81  103.05  101.44  101.63  61216500     101.63
```

# tail()

```
AAPL.tail()
```

```
             Open   High    Low  Close     Volume  Adj Close
Date
1980-12-18  26.63  26.75  26.63  26.63   18362400       0.41
1980-12-17  25.87  26.00  25.87  25.87   21610400       0.40
1980-12-16  25.37  25.37  25.25  25.25   26432000       0.39
1980-12-15  27.38  27.38  27.25  27.25   43971200       0.42
1980-12-12  28.75  28.87  28.75  28.75  117258400       0.45
```

```
AAPL.tail(3)
```

```
             Open   High    Low  Close     Volume  Adj Close
Date
1980-12-16  25.37  25.37  25.25  25.25   26432000       0.39
1980-12-15  27.38  27.38  27.25  27.25   43971200       0.42
1980-12-12  28.75  28.87  28.75  28.75  117258400       0.45
```

# info()

```
AAPL.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 8514 entries, 2014-09-16 to 1980-12-12
Data columns (total 6 columns):
Open          8514 non-null float64
High          8514 non-null float64
Low           8514 non-null float64
Close         8514 non-null float64
Volume        8514 non-null int64
Adj Close     8514 non-null float64
dtypes: float64(5), int64(1)
memory usage: 465.6 KB
```

# Broadcasting

- Assigning scalar value to column slice broadcasts value to each row.

```
import numpy as np
AAPL.iloc[::3, -1] = np.nan
```

```
AAPL.head(6)
```

```
             Open    High     Low   Close     Volume  Adj Close
Date
2014-09-16   99.80  101.26   98.89  100.86   66818200        NaN
2014-09-15  102.81  103.05  101.44  101.63   61216500     101.63
2014-09-12  101.21  102.19  101.08  101.66   62626100     101.66
2014-09-11  100.41  101.44   99.62  101.43   62353100        NaN
2014-09-10   98.01  101.11   97.76  101.00  100741900     101.00
2014-09-09   99.08  103.08   96.14   97.99  189560600      97.99
2014-09-08   99.30   99.31   98.05   98.36   46277800        NaN
```

# Broadcasting

```
AAPL.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 8514 entries, 2014-09-16 to 1980-12-12
Data columns (total 6 columns):
Open         8514 non-null float64
High         8514 non-null float64
Low          8514 non-null float64
Close        8514 non-null float64
Volume       8514 non-null int64
Adj Close    5676 non-null float64
dtypes: float64(5), int64(1)
memory usage: 465.6 KB
```

# Series

```
low = AAPL['Low']
type(low)
```

```
pandas.core.series.Series
```

```
low.head()
```

```
Date
2014-09-16     98.89
2014-09-15    101.44
2014-09-12    101.08
2014-09-11     99.62
2014-09-10     97.76
Name: Low, dtype: float64
```

```
lows = low.values
type(lows)
```

```
numpy.ndarray
```

# Let's practice!

PANDAS FOUNDATIONS

# Building DataFrames from scratch

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# DataFrames from CSV files

```
import pandas as pd
users = pd.read_csv('datasets/users.csv', index_col=0)
print(users)
```

```
  weekday    city  visitors  signups
0     Sun  Austin       139        7
1     Sun  Dallas       237       12
2     Mon  Austin       326        3
3     Mon  Dallas       456        5
```

# DataFrames from dict (1)

```
import pandas as pd
data = {'weekday': ['Sun', 'Sun', 'Mon', 'Mon'],
            'city': ['Austin', 'Dallas', 'Austin', 'Dallas'],
            'visitors': [139, 237, 326, 456],
            'signups': [7, 12, 3, 5]}
users = pd.DataFrame(data)
print(users)
```

```
  weekday    city  visitors  signups
0     Sun  Austin       139        7
1     Sun  Dallas       237       12
2     Mon  Austin       326        3
3     Mon  Dallas       456        5
```

# DataFrames from dict (2)

```
import pandas as pd
cities = ['Austin', 'Dallas', 'Austin', 'Dallas']
signups = [7, 12, 3, 5]
visitors = [139, 237, 326, 456]
weekdays = ['Sun', 'Sun', 'Mon', 'Mon']
list_labels = ['city', 'signups', 'visitors', 'weekday']
list_cols = [cities, signups, visitors, weekdays]
zipped = list(zip(list_labels, list_cols))
```

# DataFrames from dict (3)

```
print(zipped)
```

```
[('city', ['Austin', 'Dallas', 'Austin', 'Dallas']),
('signups', [7, 12, 3, 5]),
('visitors', [139, 237, 326, 456]),
('weekday', ['Sun', 'Sun', 'Mon', 'Mon'])]
```

```
data = dict(zipped)
users = pd.DataFrame(data)
print(users)
```

```
  weekday    city  visitors  signups
0     Sun  Austin       139        7
1     Sun  Dallas       237       12
2     Mon  Austin       326        3
3     Mon  Dallas       456        5
```

# Broadcasting

```
users['fees'] = 0 # Broadcasts to entire column
print(users)
```

```
     city  signups  visitors weekday  fees
0  Austin        7       139     Sun     0
1  Dallas       12       237     Sun     0
2  Austin        3       326     Mon     0
3  Dallas        5       456     Mon     0
```

# Broadcasting with a dict

```
import pandas as pd
heights = [ 59.0, 65.2, 62.9, 65.4, 63.7, 65.7, 64.1 ]
data = {'height': heights, 'sex': 'M'}
results = pd.DataFrame(data)
print(results)
```

```
   height sex
0    59.0   M
1    65.2   M
2    62.9   M
3    65.4   M
4    63.7   M
5    65.7   M
6    64.1   M
```

# Index and columns

```
results.columns = ['height (in)', 'sex']
results.index = ['A', 'B', 'C', 'D', 'E', 'F', 'G']
print(results)
```

```
   height (in) sex
A          59.0   M
B          65.2   M
C          62.9   M
D          65.4   M
E          63.7   M
F          65.7   M
G          64.1   M
```

# Let's practice!

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# Importing & exporting data

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# Original CSV file

- Dataset: Sunspot observations collected from SILSO

```
1818,01,01,1818.004, -1,1
1818,01,02,1818.007, -1,1
1818,01,03,1818.010, -1,1
1818,01,04,1818.012, -1,1
1818,01,05,1818.015, -1,1
1818,01,06,1818.018, -1,1
...
```

[1] Source: SILSO, Daily total sunspot number (http://www.sidc.be/silso/infossntotdaily)

# Datasets from CSV files

```
import pandas as pd
filepath = 'ISSN_D_tot.csv'
sunspots = pd.read_csv(filepath)
sunspots.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 71921 entries, 0 to 71920
Data columns (total 6 columns):
1818        71921 non-null int64
01          71921 non-null int64
01.1        71921 non-null int64
1818.004    71921 non-null float64
 -1         71921 non-null int64
1           71921 non-null int64
dtypes: float64(1), int64(5)
memory usage: 3.3 MB
```

# Datasets from CSV files

```
sunspots.iloc[10:20, :]
```

```
    1818  01  01.1  1818.004   -1  1
10  1818   1    12  1818.034   -1  1
11  1818   1    13  1818.037   22  1
12  1818   1    14  1818.040   -1  1
13  1818   1    15  1818.042   -1  1
14  1818   1    16  1818.045   -1  1
15  1818   1    17  1818.048   46  1
16  1818   1    18  1818.051   59  1
17  1818   1    19  1818.053   63  1
18  1818   1    20  1818.056   -1  1
19  1818   1    21  1818.059   -1  1
```

# Problems

- CSV file has no column headers
  - Columns 0-2: Gregorian date (year, month, day)
  - Column 3: Date as fraction as year
  - Column 4: Daily total sunspot number
  - Column 5: Definitive/provisional indicator (1 or 0)
- Missing values in column 4: indicated by -1
- Dates representation inconvenient

# Using header keyword

```
sunspots = pd.read_csv(filepath, header=None)
sunspots.iloc[10:20, :]
```

```
      0  1   2          3   4  5
10  1818  1  11  1818.031  -1  1
11  1818  1  12  1818.034  -1  1
12  1818  1  13  1818.037  22  1
13  1818  1  14  1818.040  -1  1
14  1818  1  15  1818.042  -1  1
15  1818  1  16  1818.045  -1  1
16  1818  1  17  1818.048  46  1
17  1818  1  18  1818.051  59  1
18  1818  1  19  1818.053  63  1
19  1818  1  20  1818.056  -1  1
```

# Using names keyword

```
col_names = ['year', 'month', 'day', 'dec_date',
                'sunspots', 'definite']
sunspots = pd.read_csv(filepath, header=None,
                           names=col_names)
sunspots.iloc[10:20, :]
```

| | year | month | day | dec_date | sunspots | definite |
|---|---|---|---|---|---|---|
| 10 | 1818 | 1 | 11 | 1818.031 | -1 | 1 |
| 11 | 1818 | 1 | 12 | 1818.034 | -1 | 1 |
| 12 | 1818 | 1 | 13 | 1818.037 | 22 | 1 |
| 13 | 1818 | 1 | 14 | 1818.040 | -1 | 1 |
| 14 | 1818 | 1 | 15 | 1818.042 | -1 | 1 |
| 15 | 1818 | 1 | 16 | 1818.045 | -1 | 1 |
| 16 | 1818 | 1 | 17 | 1818.048 | 46 | 1 |
| 17 | 1818 | 1 | 18 | 1818.051 | 59 | 1 |
| 18 | 1818 | 1 | 19 | 1818.053 | 63 | 1 |
| 19 | 1818 | 1 | 20 | 1818.056 | -1 | 1 |

# Using na_values keyword (1)

```
sunspots = pd.read_csv(filepath, header=None,
                               names=col_names, na_values='-1')
sunspots.iloc[10:20, :]
```

| | year | month | day | dec_date | sunspots | definite |
|---|---|---|---|---|---|---|
| 10 | 1818 | 1 | 11 | 1818.031 | -1 | 1 |
| 11 | 1818 | 1 | 12 | 1818.034 | -1 | 1 |
| 12 | 1818 | 1 | 13 | 1818.037 | 22 | 1 |
| 13 | 1818 | 1 | 14 | 1818.040 | -1 | 1 |
| 14 | 1818 | 1 | 15 | 1818.042 | -1 | 1 |
| 15 | 1818 | 1 | 16 | 1818.045 | -1 | 1 |
| 16 | 1818 | 1 | 17 | 1818.048 | 46 | 1 |
| 17 | 1818 | 1 | 18 | 1818.051 | 59 | 1 |
| 18 | 1818 | 1 | 19 | 1818.053 | 63 | 1 |
| 19 | 1818 | 1 | 20 | 1818.056 | -1 | 1 |

# Using na_values keyword (2)

```
sunspots = pd.read_csv(filepath, header=None,
                               names=col_names, na_values=' -1')
sunspots.iloc[10:20, :]
```

```
    year  month  day  dec_date  sunspots  definite
10  1818      1   11  1818.031       NaN         1
11  1818      1   12  1818.034       NaN         1
12  1818      1   13  1818.037      22.0         1
13  1818      1   14  1818.040       NaN         1
14  1818      1   15  1818.042       NaN         1
15  1818      1   16  1818.045       NaN         1
16  1818      1   17  1818.048      46.0         1
17  1818      1   18  1818.051      59.0         1
18  1818      1   19  1818.053      63.0         1
19  1818      1   20  1818.056       NaN         1
```

# Using na_values keyword (3)

```
sunspots = pd.read_csv(filepath, header=None,
     names=col_names, na_values={'sunspots':[' -1']})
sunspots.iloc[10:20, :]
```

| | year | month | day | dec_date | sunspots | definite |
|---|---|---|---|---|---|---|
| 10 | 1818 | 1 | 11 | 1818.031 | NaN | 1 |
| 11 | 1818 | 1 | 12 | 1818.034 | NaN | 1 |
| 12 | 1818 | 1 | 13 | 1818.037 | 22.0 | 1 |
| 13 | 1818 | 1 | 14 | 1818.040 | NaN | 1 |
| 14 | 1818 | 1 | 15 | 1818.042 | NaN | 1 |
| 15 | 1818 | 1 | 16 | 1818.045 | NaN | 1 |
| 16 | 1818 | 1 | 17 | 1818.048 | 46.0 | 1 |
| 17 | 1818 | 1 | 18 | 1818.051 | 59.0 | 1 |
| 18 | 1818 | 1 | 19 | 1818.053 | 63.0 | 1 |
| 19 | 1818 | 1 | 20 | 1818.056 | NaN | 1 |

# Using parse_dates keyword

```
sunspots = pd.read_csv(filepath, header=None,
     names=col_names, na_values={'sunspots':[' -1']},
     parse_dates=[[0, 1, 2]])
sunspots.iloc[10:20, :]
```

| | year_month_day | dec_date | sunspots | definite |
|---|---|---|---|---|
| 10 | 1818-01-11 | 1818.031 | NaN | 1 |
| 11 | 1818-01-12 | 1818.034 | NaN | 1 |
| 12 | 1818-01-13 | 1818.037 | 22.0 | 1 |
| 13 | 1818-01-14 | 1818.040 | NaN | 1 |
| 14 | 1818-01-15 | 1818.042 | NaN | 1 |
| 15 | 1818-01-16 | 1818.045 | NaN | 1 |
| 16 | 1818-01-17 | 1818.048 | 46.0 | 1 |
| 17 | 1818-01-18 | 1818.051 | 59.0 | 1 |
| 18 | 1818-01-19 | 1818.053 | 63.0 | 1 |
| 19 | 1818-01-20 | 1818.056 | NaN | 1 |

# Inspecting DataFrame

```
sunspots.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 71922 entries, 0 to 71921
Data columns (total 4 columns):
year_month_day    71922 non-null datetime64[ns]
dec_date          71922 non-null float64
sunspots          68675 non-null float64
definite          71922 non-null int64
dtypes: datetime64[ns](1), float64(2), int64(1)
memory usage: 2.2 MB
```

# Using dates as index

```
sunspots.index = sunspots['year_month_day']
sunspots.index.name = 'date'
sunspots.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 71922 entries, 1818-01-01 to 2014-11-30
Data columns (total 4 columns):
year_month_day    71922 non-null datetime64[ns]
dec_date          71922 non-null float64
sunspots          68675 non-null float64
definite          71922 non-null int64
dtypes: datetime64[ns](1), float64(2), int64(1)
memory usage: 2.7 MB
```

# Trimming redundant columns

```
cols = ['sunspots', 'definite']
sunspots = sunspots[cols]
sunspots.iloc[10:20, :]
```

```
            sunspots  definite
date
1818-01-11       NaN         1
1818-01-12       NaN         1
1818-01-13      22.0         1
1818-01-14       NaN         1
1818-01-15       NaN         1
1818-01-16       NaN         1
1818-01-17      46.0         1
1818-01-18      59.0         1
1818-01-19      63.0         1
1818-01-20       NaN         1
```

# Writing files

```
out_csv = 'sunspots.csv'
sunspots.to_csv(out_csv)

out_tsv = 'sunspots.tsv'
sunspots.to_csv(out_tsv, sep='\t')

out_xlsx = 'sunspots.xlsx'
sunspots.to_excel(out_xlsx)
```

# Let's practice!

PANDAS FOUNDATIONS

# Plotting with pandas

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# AAPL stock data

```
import pandas as pd
import matplotlib.pyplot as plt
aapl = pd.read_csv('aapl.csv', index_col='date',
                   parse_dates=True)
aapl.head(6)
```

```
            adj_close   close    high     low    open    volume
date
2000-03-01      31.68  130.31  132.06  118.50  118.56  38478000
2000-03-02      29.66  122.00  127.94  120.69  127.00  11136800
2000-03-03      31.12  128.00  128.23  120.00  124.87  11565200
2000-03-06      30.56  125.69  129.13  125.00  126.00   7520000
2000-03-07      29.87  122.87  127.44  121.12  126.44   9767600
2000-03-08      29.66  122.00  123.94  118.56  122.87   9690800
```

# Plotting arrays (matplotlib)

```
close_arr = aapl['close'].values
type(close_arr)
```

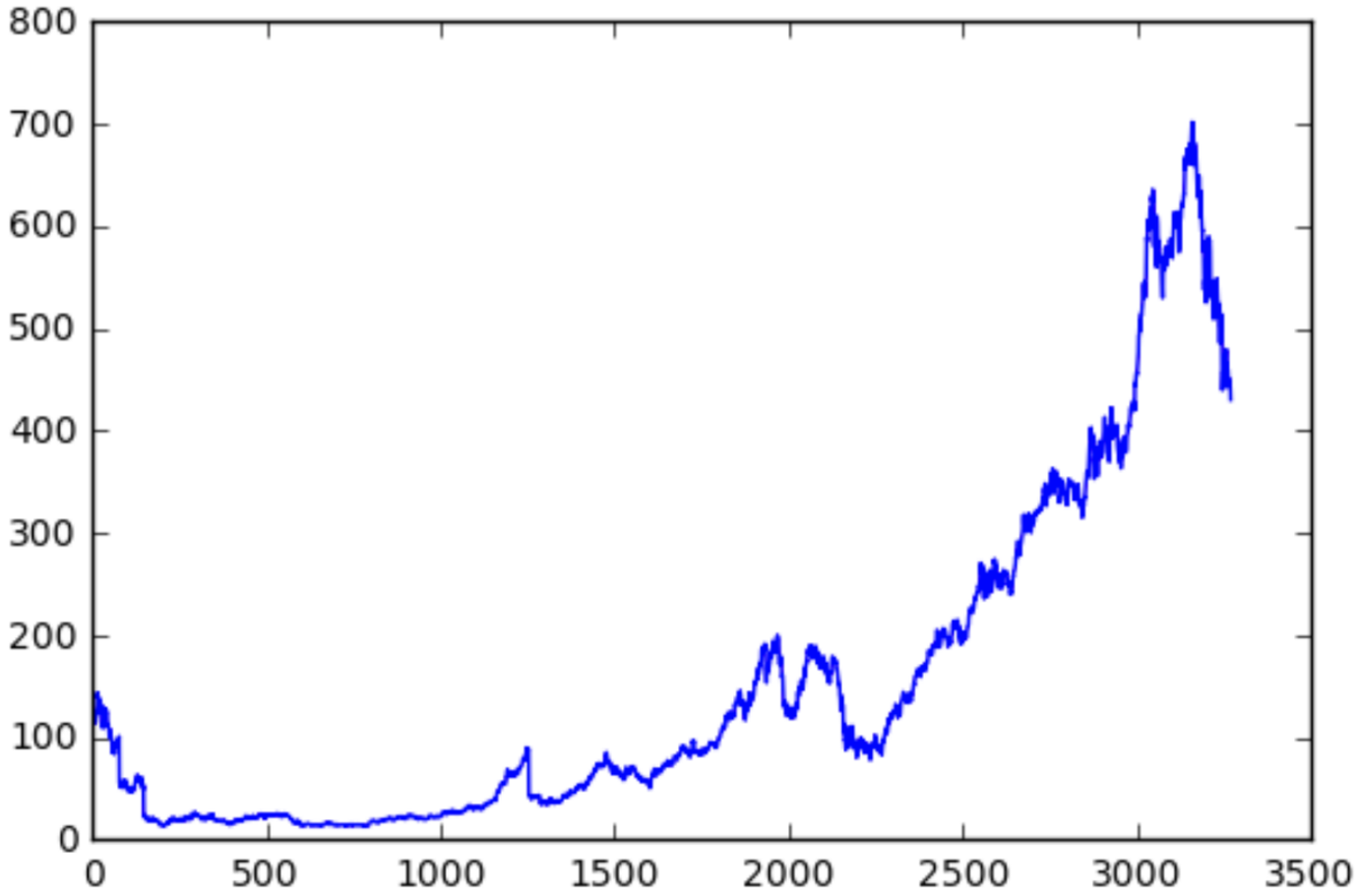
```
numpy.ndarray
```

```
plt.plot(close_arr)
```

```
[<matplotlib.lines.Line2D at 0x115550358>]
```

```
plt.show()
```

# Plotting arrays (matplotlib)



# Plotting Series (matplotlib)

```
close_series = aapl['close']
type(close_series)
```

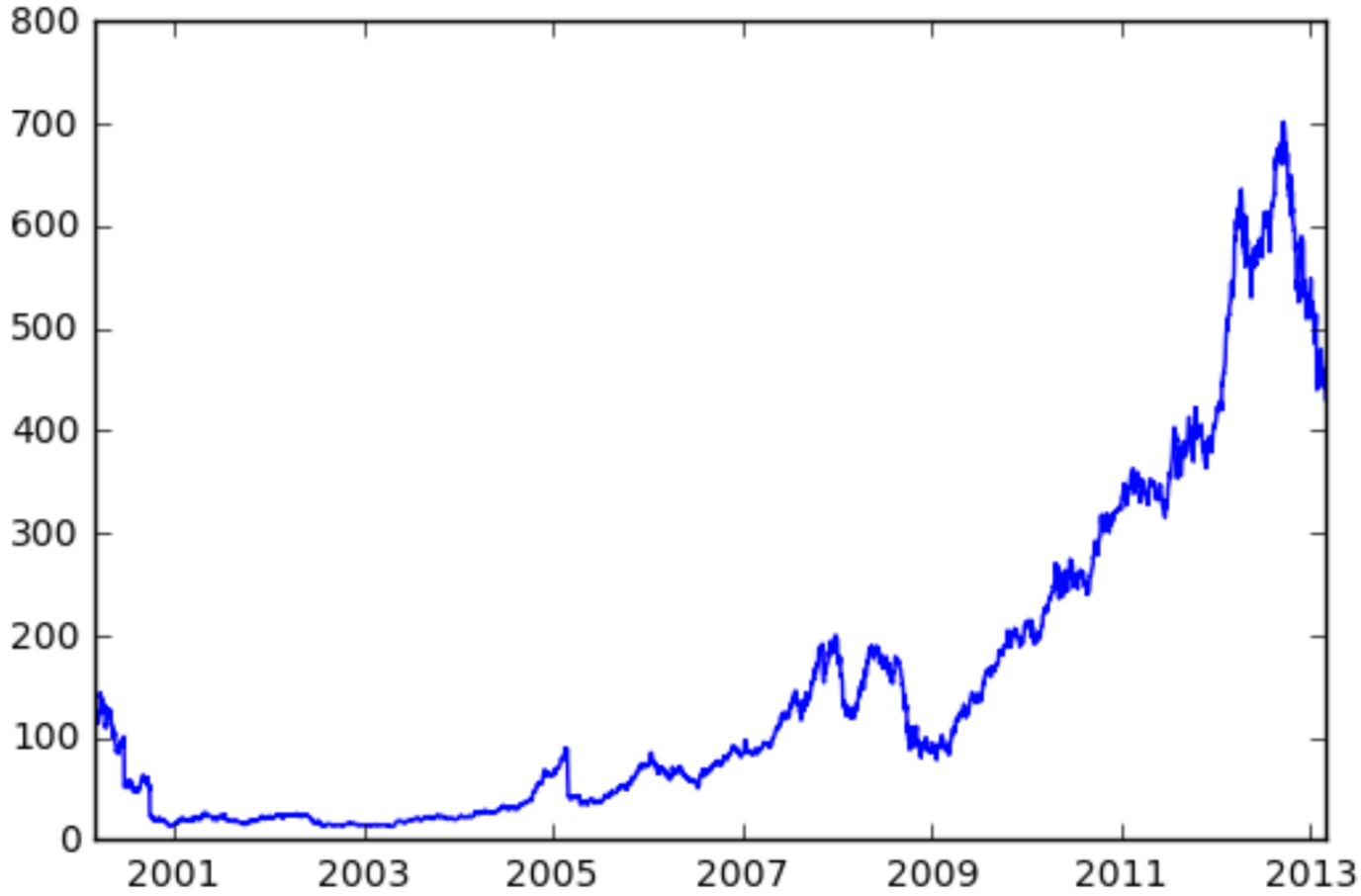
```
pandas.core.series.Series
```

```
plt.plot(close_series)
```

```
[<matplotlib.lines.Line2D at 0x11801cd30>]
```

```
plt.show()
```

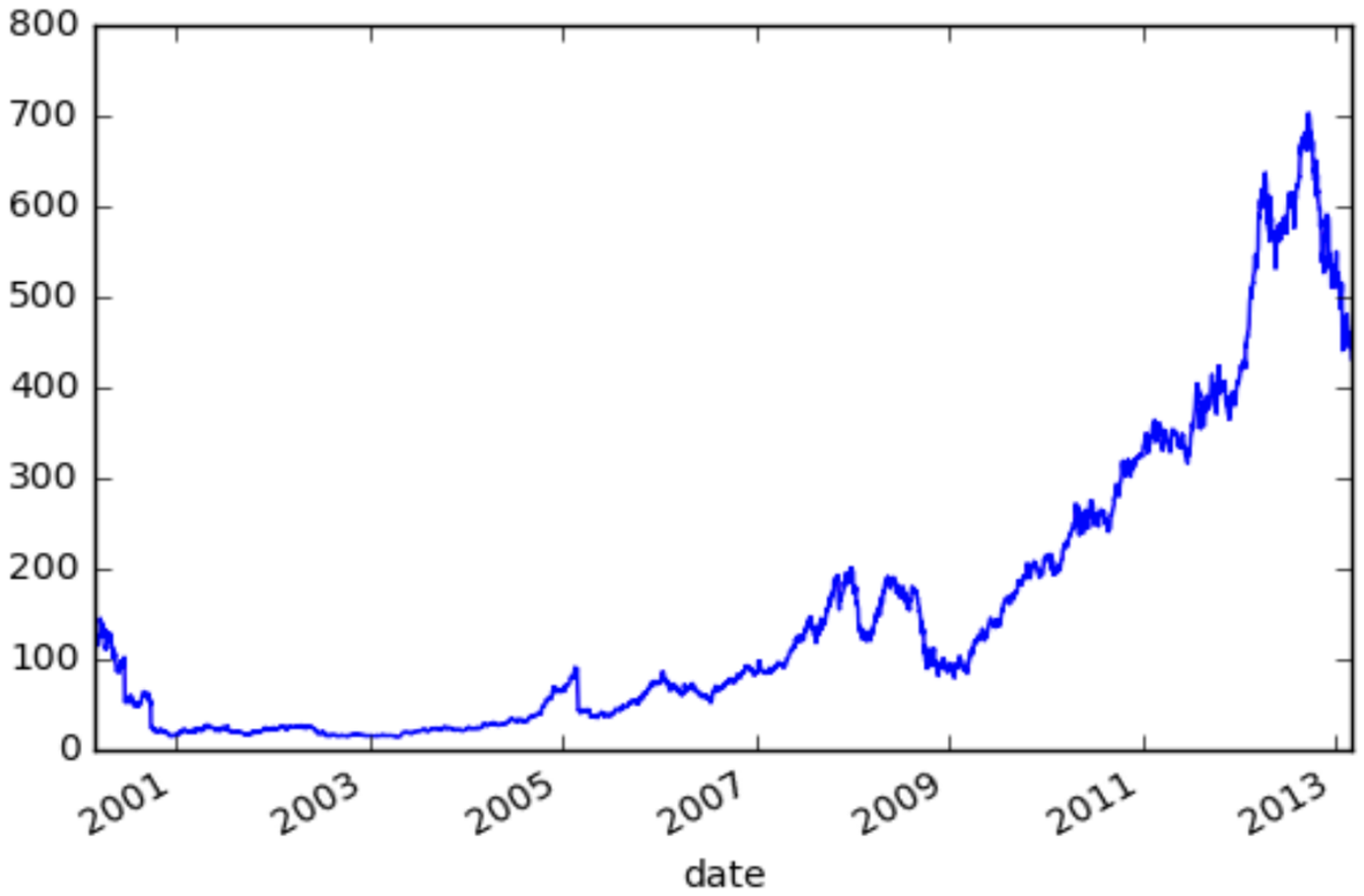
# Plotting Series (matplotlib)



# Plotting Series (pandas)

```
close_series.plot()  # plots Series directly
plt.show()
```

# Plotting Series (pandas)



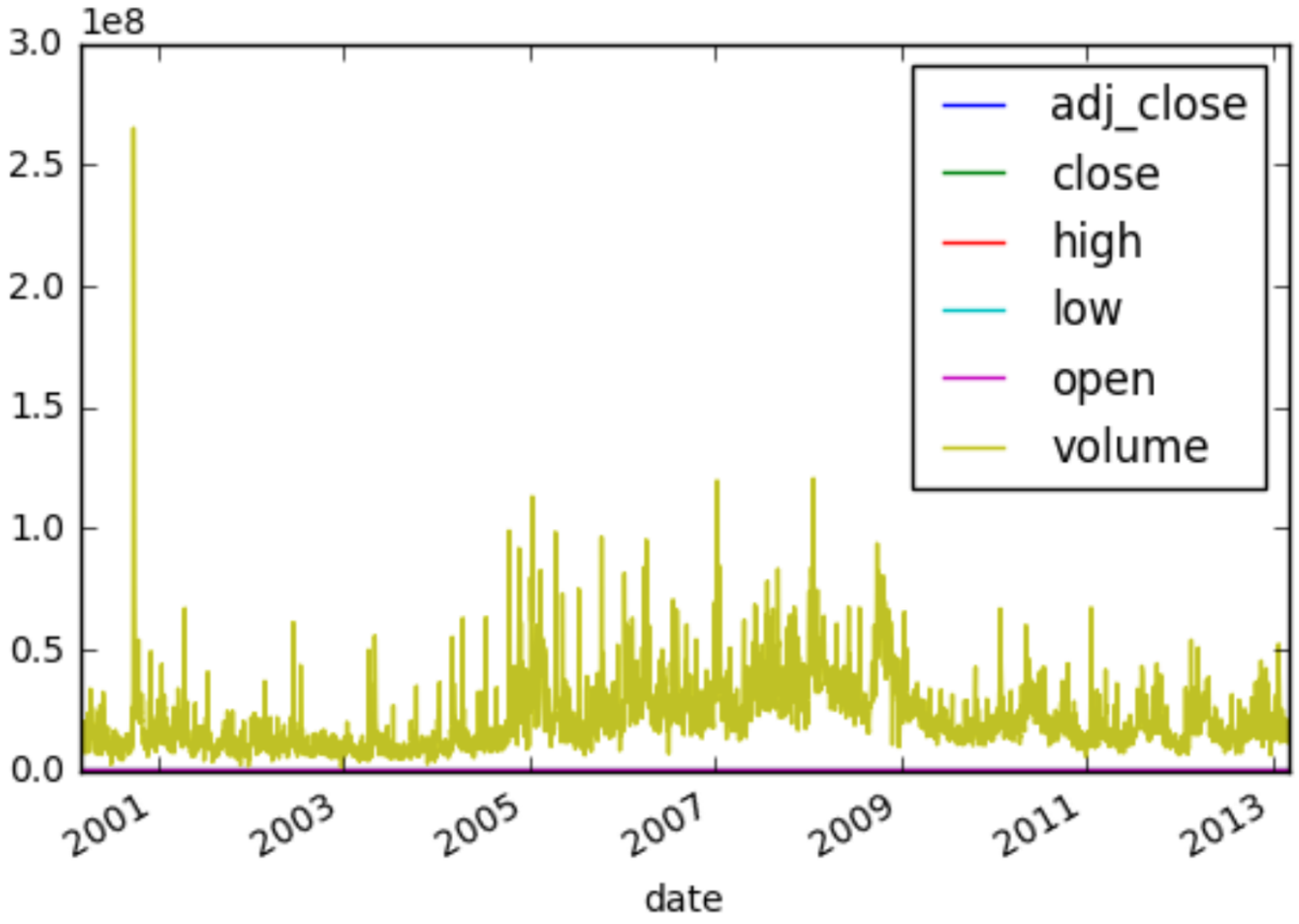
# Plotting DataFrames (pandas)

```
aapl.plot()  # plots all Series at once
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x118039b38>
```

```
plt.show()
```

# Plotting DataFrames (pandas)



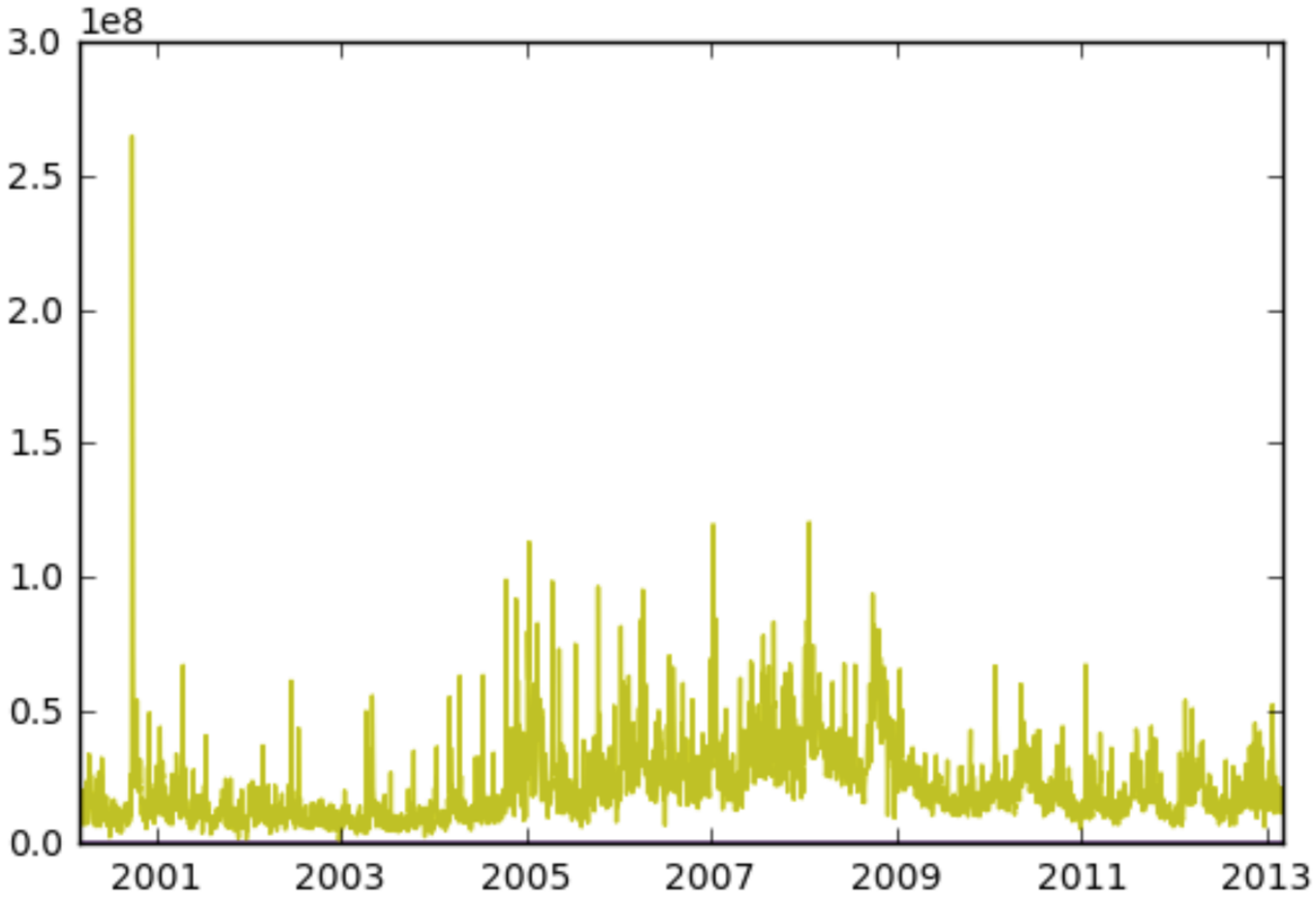
# Plotting DataFrames (matplotlib)

```
plt.plot(aapl) # plots all columns at once
```

```
<matplotlib.lines.Line2D at 0x1156290f0>,
<matplotlib.lines.Line2D at 0x1156525f8>,
<matplotlib.lines.Line2D at 0x1156527f0>,
<matplotlib.lines.Line2D at 0x1156529e8>,
<matplotlib.lines.Line2D at 0x115652be0>,
<matplotlib.lines.Line2D at 0x115652dd8>
```

```
plt.show()
```

# Plotting DataFrames (matplotlib)



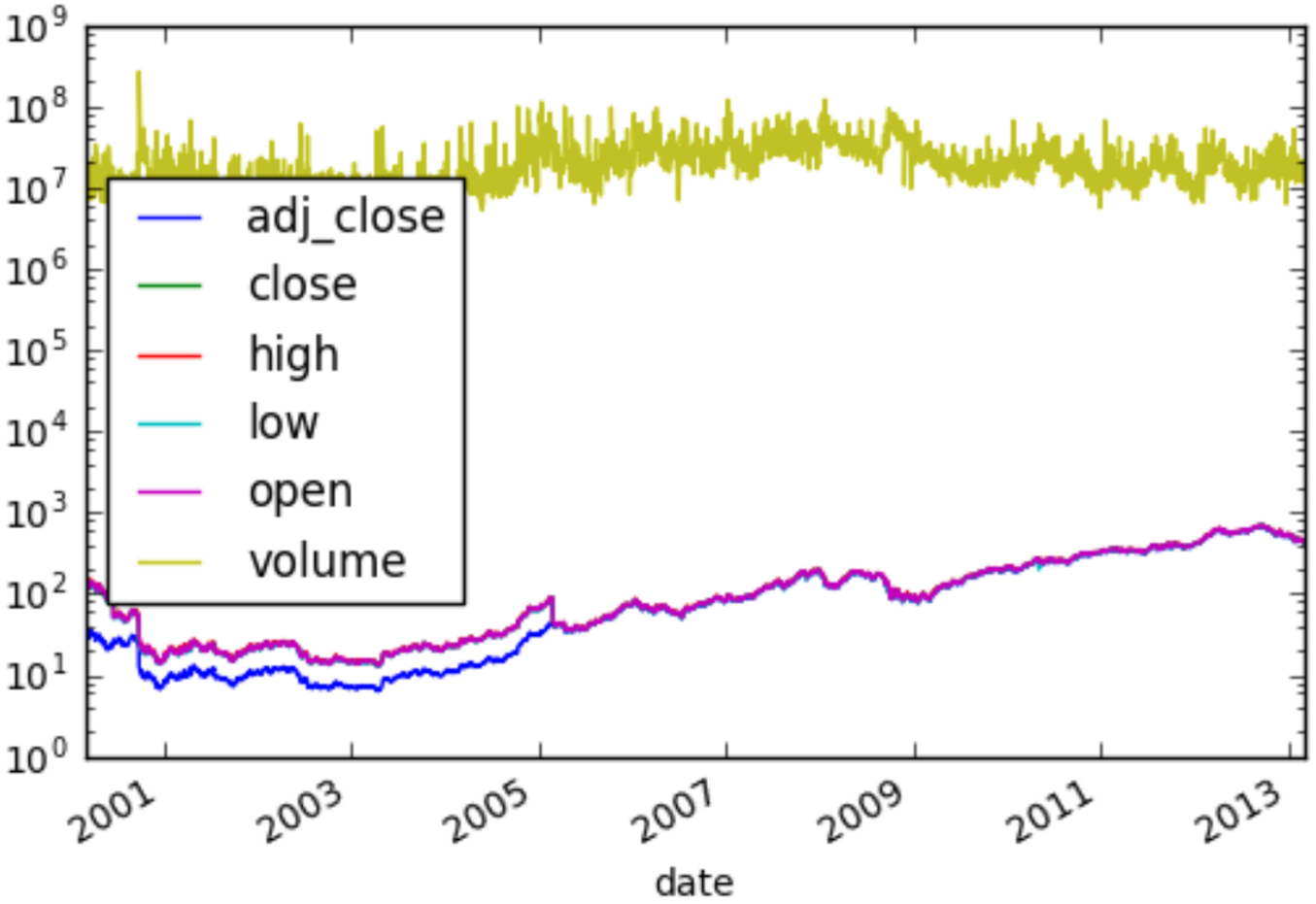
# Fixing scales

```
aapl.plot()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x118afe048>
```

```
plt.yscale('log') # logarithmic scale on vertical axis
plt.show()
```

# Fixing scales



# Customizing plots

```
aapl['open'].plot(color='b', style='.-', legend=True)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x11a17db38>
```

```
aapl['close'].plot(color='r', style='.', legend=True)
```

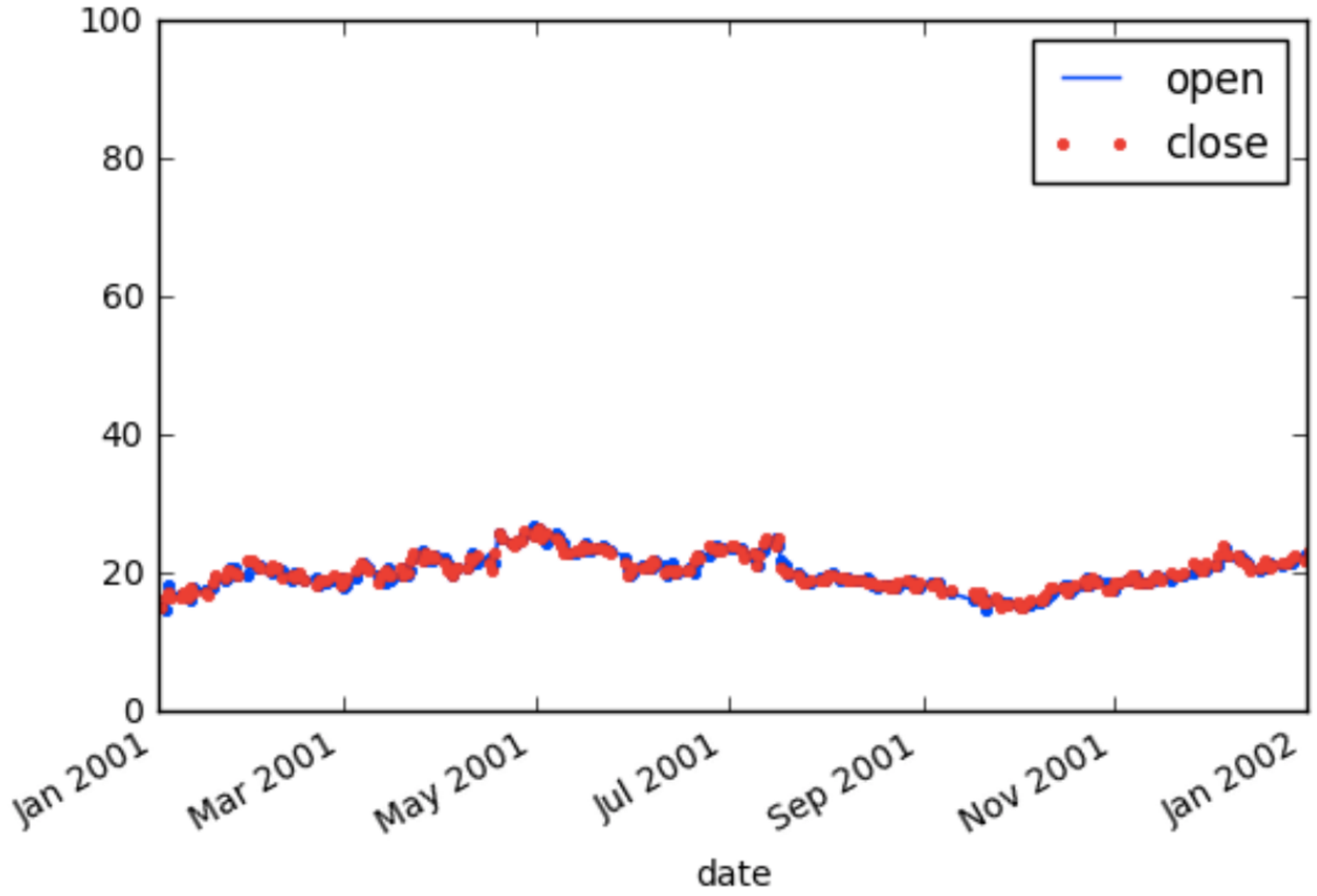
```
<matplotlib.axes._subplots.AxesSubplot at 0x11a17db38>
```

```
plt.axis(('2001', '2002', 0, 100))
```

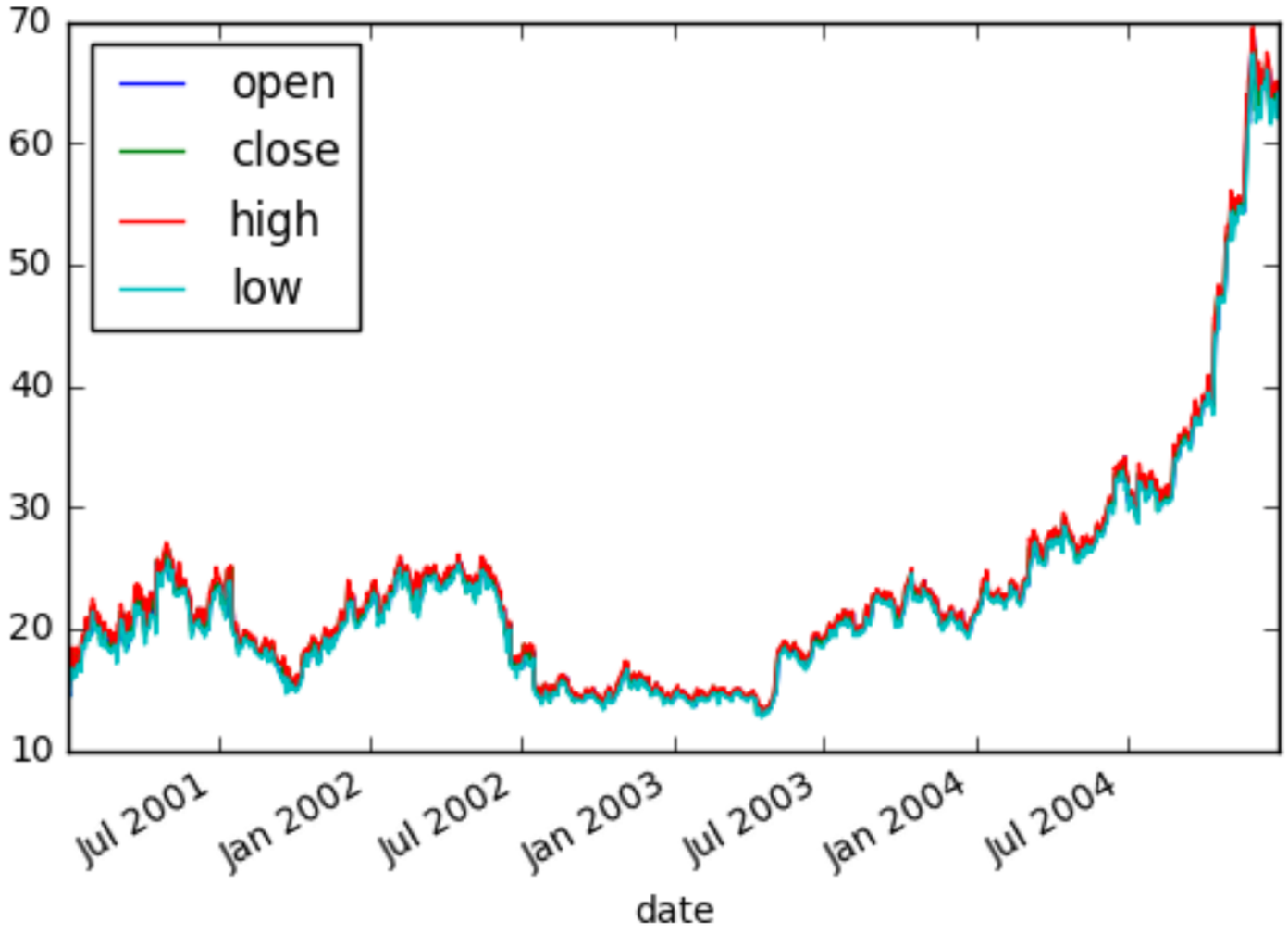
```
'2001', '2002', 0, 100)
```

```
plt.show()
```

# Customizing plots



# Saving plots



# Saving plots

```
aapl.loc['2001':'2004',['open', 'close', 'high',
                'low']].plot()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x11ab42978>
```

```
plt.savefig('aapl.png')
plt.savefig('aapl.jpg')
plt.savefig('aapl.pdf')
plt.show()
```

# Let's practice!

PANDAS FOUNDATIONS