datascience Documentation

Release 0.17.6

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CONTENTS

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The `datascience` package was written for use in Berkeley's DS 8 course and contains useful functionality for investigating and graphically displaying data.

CHAPTER

ONE

START HERE: DATASCIENCE TUTORIAL

This is a brief introduction to the functionality in `datascience`. For a complete reference guide, please see *Tables (datascience.tables)*.

For other useful tutorials and examples, see:

- The textbook introduction to Tables
- Example notebooks

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1.1 Getting Started

The most important functionality in the package is is the `Table` class, which is the structure used to represent columns of data. First, load the class:

```
In [1]: from datascience import Table
```

In the IPython notebook, type `Table.` followed by the TAB-key to see a list of members.

Note that for the Data Science 8 class we also import additional packages and settings for all assignments and labs. This is so that plots and other available packages mirror the ones in the textbook more closely. The exact code we use is:

```
# HIDDEN

import matplotlib
```

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```
matplotlib.use('Agg')
from datascience import Table
%matplotlib inline
import matplotlib.pyplot as plt
import numpy as np
plt.style.use('fivethirtyeight')
```

In particular, the lines involving `matplotlib` allow for plotting within the IPython notebook.

1.2 Creating a Table

A Table is a sequence of labeled columns of data.

A Table can be constructed from scratch by extending an empty table with columns.

```
In [2]: t = Table().with_columns(
   ...:     'letter', ['a', 'b', 'c', 'z'],
   ...:     'count',  [  9,   3,   3,   1],
   ...:     'points', [  1,   2,   2,  10],
   ...: )
   ...:

In [3]: print(t)
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10
```

More often, a table is read from a CSV file (or an Excel spreadsheet). Here's the content of an example file:

```
In [4]: cat sample.csv
x,y,z
1,10,100
2,11,101
3,12,102
```

And this is how we load it in as a `Table` using *read_table()*:

```
In [5]: Table.read_table('sample.csv')
Out[5]:
x    | y    | z
1    | 10   | 100
2    | 11   | 101
3    | 12   | 102
```

CSVs from URLs are also valid inputs to *read_table()*:

```
In [6]: Table.read_table('https://www.inferentialthinking.com/data/sat2014.csv')
Out[6]:
```

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```
State        | Participation Rate | Critical Reading | Math | Writing | Combined
North Dakota | 2.3                | 612              | 620  | 584     | 1816
Illinois     | 4.6                | 599              | 616  | 587     | 1802
Iowa         | 3.1                | 605              | 611  | 578     | 1794
South Dakota | 2.9                | 604              | 609  | 579     | 1792
Minnesota    | 5.9                | 598              | 610  | 578     | 1786
Michigan     | 3.8                | 593              | 610  | 581     | 1784
Wisconsin    | 3.9                | 596              | 608  | 578     | 1782
Missouri     | 4.2                | 595              | 597  | 579     | 1771
Wyoming      | 3.3                | 590              | 599  | 573     | 1762
Kansas       | 5.3                | 591              | 596  | 566     | 1753
... (41 rows omitted)
```

It's also possible to add columns from a dictionary, but this option is discouraged because dictionaries do not preserve column order.

```
In [7]: t = Table().with_columns({
   ...:     'letter': ['a', 'b', 'c', 'z'],
   ...:     'count':  [  9,   3,   3,   1],
   ...:     'points': [  1,   2,   2,  10],
   ...: })
   ...:

In [8]: print(t)
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10
```

1.3 Accessing Values

To access values of columns in the table, use *column()*, which takes a column label or index and returns an array. Alternatively, *columns()* returns a list of columns (arrays).

```
In [9]: t
Out[9]:
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [10]: t.column('letter')
Out[10]:
array(['a', 'b', 'c', 'z'],
      dtype='<U1')
```

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```
In [11]: t.column(1)
Out[11]: array([9, 3, 3, 1])
```

You can use bracket notation as a shorthand for this method:

```
In [12]: t['letter'] # This is a shorthand for t.column('letter')
Out[12]: 
array(['a', 'b', 'c', 'z'],
      dtype='<U1')

In [13]: t[1]        # This is a shorthand for t.column(1)
Out[13]: array([9, 3, 3, 1])
```

To access values by row, *row()* returns a row by index. Alternatively, *rows()* returns an list-like `Rows` object that contains tuple-like `Row` objects.

```
In [14]: t.rows
Out[14]: 
Rows(letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10)

In [15]: t.rows[0]
Out[15]: Row(letter='a', count=9, points=1)

In [16]: t.row(0)
Out[16]: Row(letter='a', count=9, points=1)

In [17]: second = t.rows[1]

In [18]: second
Out[18]: Row(letter='b', count=3, points=2)

In [19]: second[0]
Out[19]: 'b'

In [20]: second[1]
Out[20]: 3
```

To get the number of rows, use *num_rows*.

```
In [21]: t.num_rows
Out[21]: 4
```

1.4 Manipulating Data

Here are some of the most common operations on data. For the rest, see the reference (*Tables (datascience.tables)*).

Adding a column with `with_column()`:

```
In [22]: t
Out[22]:
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [23]: t.with_column('vowel?', ['yes', 'no', 'no', 'no'])
Out[23]:
letter | count | points | vowel?
a      | 9     | 1      | yes
b      | 3     | 2      | no
c      | 3     | 2      | no
z      | 1     | 10     | no

In [24]: t # .with_column returns a new table without modifying the original
Out[24]:
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [25]: t.with_column('2 * count', t['count'] * 2) # A simple way to operate on columns
Out[25]:
letter | count | points | 2 * count
a      | 9     | 1      | 18
b      | 3     | 2      | 6
c      | 3     | 2      | 6
z      | 1     | 10     | 2
```

Selecting columns with `select()`:

```
In [26]: t.select('letter')
Out[26]:
letter
a
b
c
z

In [27]: t.select(['letter', 'points'])
Out[27]:
letter | points
a      | 1
b      | 2
```

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```
c       | 2
z       | 10
```

Renaming columns with `relabeled()`:

```
In [28]: t
Out[28]:
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [29]: t.relabeled('points', 'other name')
Out[29]:
letter | count | other name
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [30]: t
Out[30]:
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [31]: t.relabeled(['letter', 'count', 'points'], ['x', 'y', 'z'])
Out[31]:
x    | y    | z
a    | 9    | 1
b    | 3    | 2
c    | 3    | 2
z    | 1    | 10
```

Selecting out rows by index with `take()` and conditionally with `where()`:

```
In [32]: t
Out[32]:
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [33]: t.take(2) # the third row
Out[33]:
letter | count | points
c      | 3     | 2
```

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```
In [34]: t.take[0:2] # the first and second rows
Out[34]:
letter | count | points
a      | 9     | 1
b      | 3     | 2
```

```
In [35]: t.where('points', 2) # rows where points == 2
Out[35]:
letter | count | points
b      | 3     | 2
c      | 3     | 2

In [36]: t.where(t['count'] < 8) # rows where count < 8
Out[36]:
letter | count | points
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [37]: t['count'] < 8 # .where actually takes in an array of booleans
Out[37]: array([False,  True,  True,  True], dtype=bool)

In [38]: t.where([False, True, True, True]) # same as the last line
Out[38]:
letter | count | points
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10
```

Operate on table data with *sort()*, *group()*, and *pivot()*

```
In [39]: t
Out[39]:
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [40]: t.sort('count')
Out[40]:
letter | count | points
z      | 1     | 10
b      | 3     | 2
c      | 3     | 2
a      | 9     | 1

In [41]: t.sort('letter', descending = True)
Out[41]:
letter | count | points
z      | 1     | 10
c      | 3     | 2
```

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```
b       | 3      | 2
a       | 9      | 1
```

```
# You may pass a reducing function into the collect arg
# Note the renaming of the points column because of the collect arg
In [42]: t.select(['count', 'points']).group('count', collect=sum)
Out[42]:
count | points sum
1     | 10
3     | 4
9     | 1
```

```
In [43]: other_table = Table().with_columns(
   ....:     'mar_status',  ['married', 'married', 'partner', 'partner', 'married'],
   ....:     'empl_status', ['Working as paid', 'Working as paid', 'Not working',
   ....:                     'Not working', 'Not working'],
   ....:     'count',       [1, 1, 1, 1, 1])
   ....:

In [44]: other_table
Out[44]:
mar_status | empl_status     | count
married    | Working as paid | 1
married    | Working as paid | 1
partner    | Not working     | 1
partner    | Not working     | 1
married    | Not working     | 1

In [45]: other_table.pivot('mar_status', 'empl_status', 'count', collect=sum)
Out[45]:
empl_status     | married | partner
Not working     | 1       | 2
Working as paid | 2       | 0
```

1.5 Visualizing Data

We'll start with some data drawn at random from two normal distributions:

```
In [46]: normal_data = Table().with_columns(
   ....:     'data1', np.random.normal(loc = 1, scale = 2, size = 100),
   ....:     'data2', np.random.normal(loc = 4, scale = 3, size = 100))
   ....:

In [47]: normal_data
Out[47]:
data1    | data2
1.04138  | -1.29895
3.1199   | 5.46409
-1.82543 | 3.04532
```

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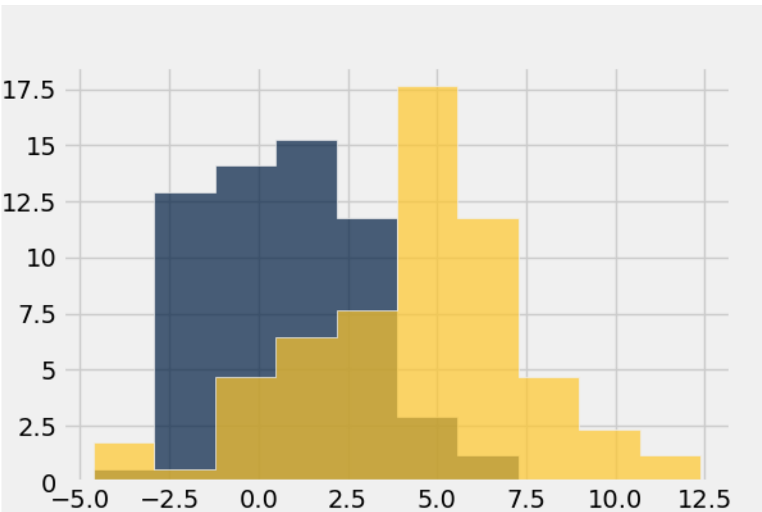
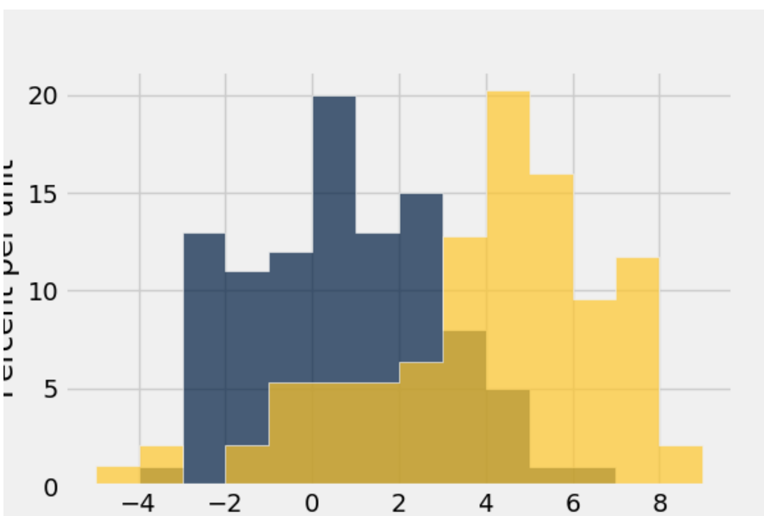
```
-2.41073 | 5.14941
3.77705  | 9.28869
2.97211  | -0.475766
3.41361  | 9.5635
4.28513  | 5.05362
3.58374  | 1.77316
-1.89773 | -1.13326
... (90 rows omitted)
```

Draw histograms with *hist()*:

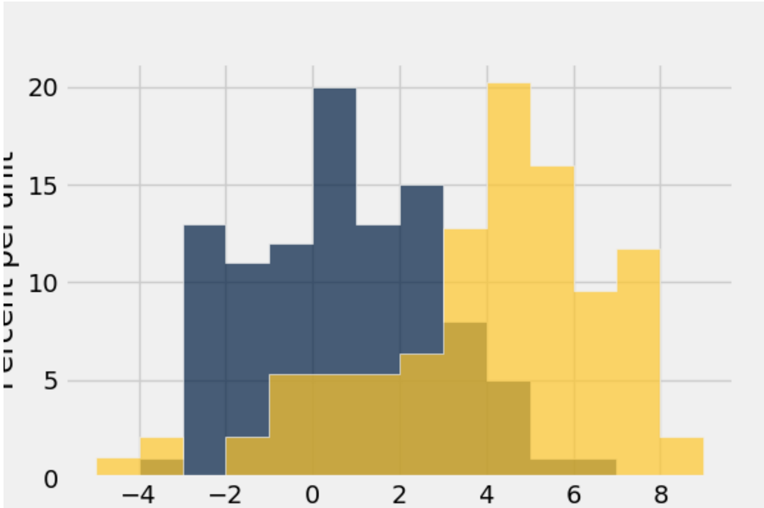
```
In [48]: normal_data.hist()
```




```
In [49]: normal_data.hist(bins = range(-5, 10))
```

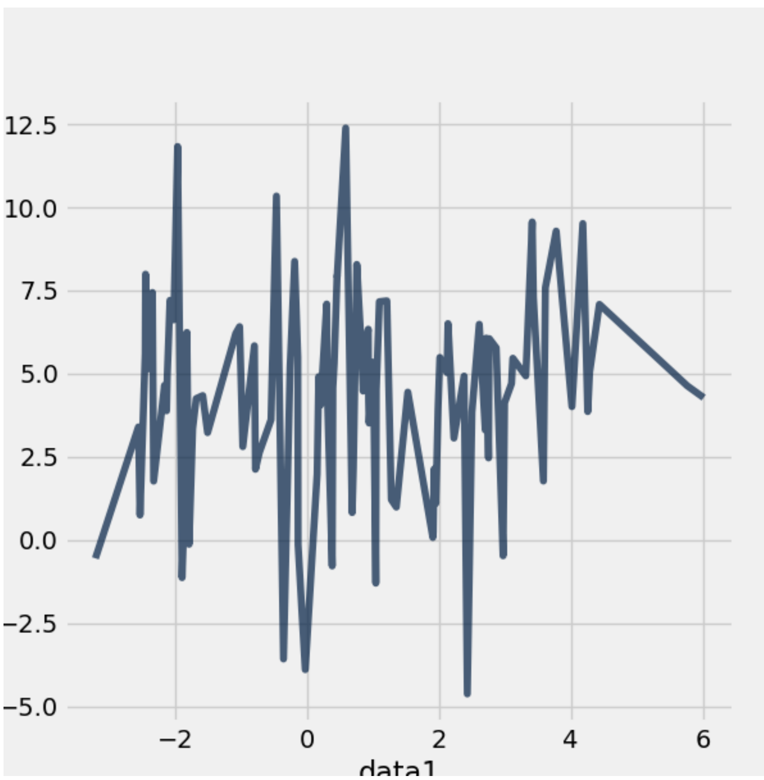



```
In [50]: normal_data.hist(bins = range(-5, 10), overlay = True)
```

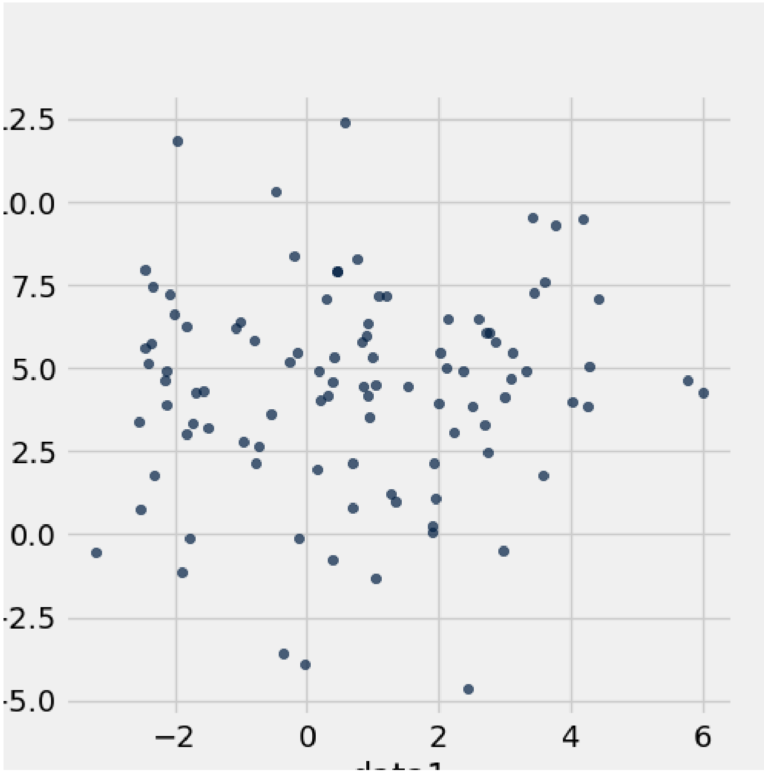


If we treat the normal_data table as a set of x-y points, we can *plot()* and *scatter()*:

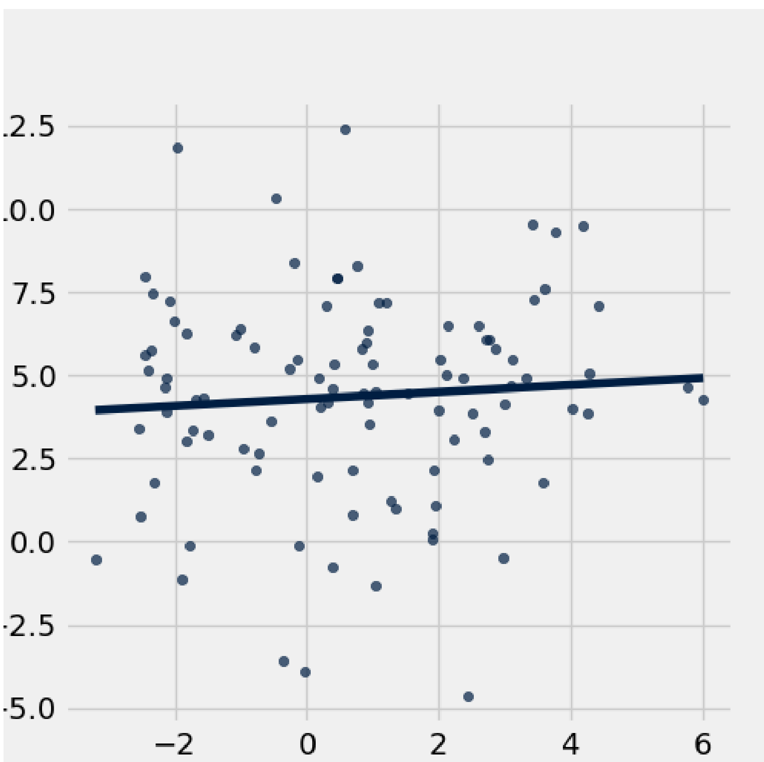
```
In [51]: normal_data.sort('data1').plot('data1') # Sort first to make plot nicer
```




```
In [52]: normal_data.scatter('data1')
```



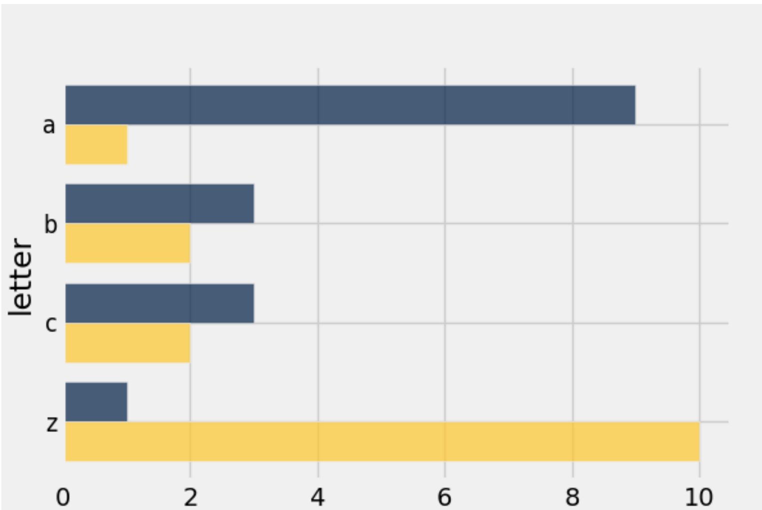

```
In [53]: normal_data.scatter('data1', fit_line = True)
```



Use *barh()* to display categorical data.

```
In [54]: t
Out[54]:
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10

In [55]: t.barh('letter')
```



1.6 Exporting

Exporting to CSV is the most common operation and can be done by first converting to a pandas dataframe with *to_df()*:

```
In [56]: normal_data
Out[56]:
data1     | data2
1.04138   | -1.29895
3.1199    | 5.46409
-1.82543 | 3.04532
-2.41073 | 5.14941
3.77705   | 9.28869
2.97211   | -0.475766
3.41361   | 9.5635
4.28513   | 5.05362
3.58374   | 1.77316
-1.89773 | -1.13326
... (90 rows omitted)

# index = False prevents row numbers from appearing in the resulting CSV
In [57]: normal_data.to_df().to_csv('normal_data.csv', index = False)
```

1.7 An Example

We'll recreate the steps in Chapter 12 of the textbook to see if there is a significant difference in birth weights between smokers and non-smokers using a bootstrap test.

For more examples, check out the TableDemos repo.

From the text:

> The table baby contains data on a random sample of 1,174 mothers and their newborn babies. The column Birth Weight contains the birth weight of the baby, in ounces; Gestational Days is the number of gestational days, that is, the number of days the baby was in the womb. There is also data on maternal age, maternal height, maternal pregnancy weight, and whether or not the mother was a smoker.

```
In [58]: baby = Table.read_table('https://www.inferentialthinking.com/data/baby.csv')

In [59]: baby # Let's take a peek at the table
Out[59]:
Birth Weight | Gestational Days | Maternal Age | Maternal Height | Maternal Pregnancy␣
↪Weight | Maternal Smoker
120          | 284              | 27           | 62              | 100                 ␣
↪     | False
113          | 282              | 33           | 64              | 135                 ␣
↪     | False
128          | 279              | 28           | 64              | 115                 ␣
↪     | True
108          | 282              | 23           | 67              | 125                 ␣
↪     | True
136          | 286              | 25           | 62              | 93                  ␣
↪     | False
138          | 244              | 33           | 62              | 178                 ␣
↪     | False
132          | 245              | 23           | 65              | 140                 ␣
↪     | False
120          | 289              | 25           | 62              | 125                 ␣
↪     | False
143          | 299              | 30           | 66              | 136                 ␣
↪     | True
140          | 351              | 27           | 68              | 120                 ␣
↪     | False
... (1164 rows omitted)

# Select out columns we want.
In [60]: smoker_and_wt = baby.select(['Maternal Smoker', 'Birth Weight'])

In [61]: smoker_and_wt
Out[61]:
Maternal Smoker | Birth Weight
False           | 120
False           | 113
True            | 128
True            | 108
False           | 136
False           | 138
```

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```
False           | 132
False           | 120
True            | 143
False           | 140
... (1164 rows omitted)
```

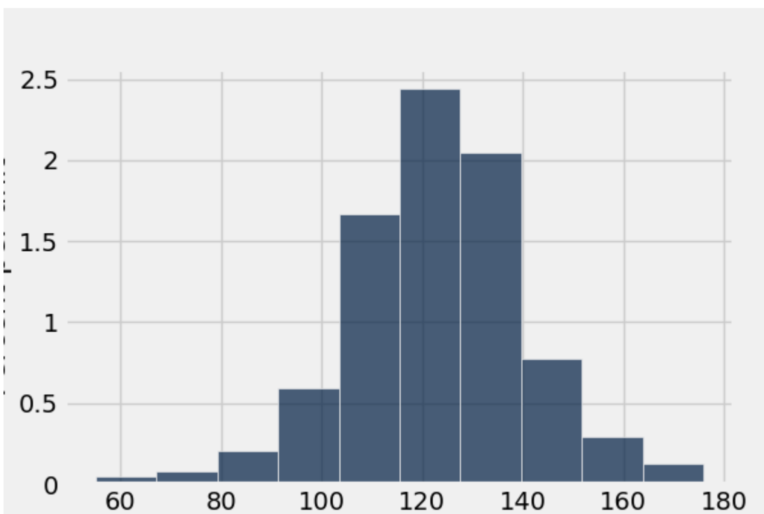
Let's compare the number of smokers to non-smokers.

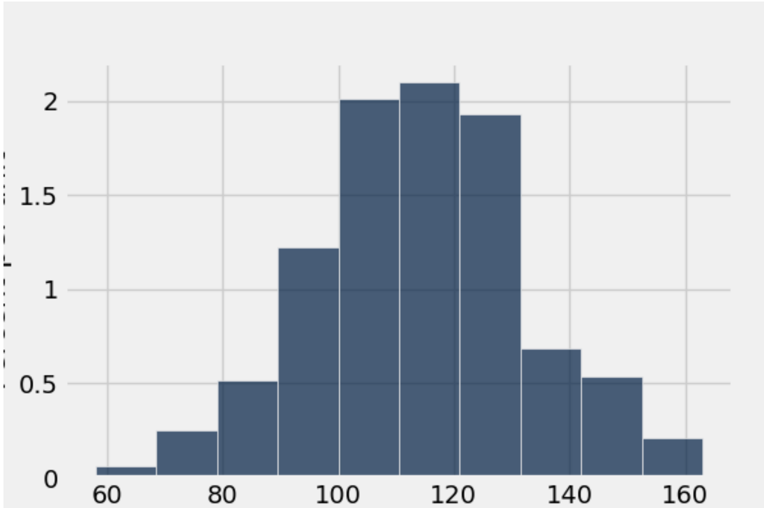
```
In [62]: smoker_and_wt.select('Maternal Smoker').group('Maternal Smoker')
Out[62]:
Maternal Smoker | count
False           | 715
True            | 459
```

We can also compare the distribution of birthweights between smokers and non-smokers.

```
# Non smokers
# We do this by grabbing the rows that correspond to mothers that don't
# smoke, then plotting a histogram of just the birthweights.
In [63]: smoker_and_wt.where('Maternal Smoker', 0).select('Birth Weight').hist()

# Smokers
In [64]: smoker_and_wt.where('Maternal Smoker', 1).select('Birth Weight').hist()
```





What's the difference in mean birth weight of the two categories?

```
In [65]: nonsmoking_mean = smoker_and_wt.where('Maternal Smoker', 0).column('Birth Weight
↪').mean()

In [66]: smoking_mean = smoker_and_wt.where('Maternal Smoker', 1).column('Birth Weight').
↪mean()

In [67]: observed_diff = nonsmoking_mean - smoking_mean

In [68]: observed_diff
Out[68]: 9.266142572024918
```

Let's do the bootstrap test on the two categories.

```
In [69]: num_nonsmokers = smoker_and_wt.where('Maternal Smoker', 0).num_rows

In [70]: def bootstrap_once():
   ....:     """
   ....:     Computes one bootstrapped difference in means.
   ....:     The table.sample method lets us take random samples.
   ....:     We then split according to the number of nonsmokers in the original sample.
   ....:     """
   ....:     resample = smoker_and_wt.sample(with_replacement = True)
   ....:     bootstrap_diff = resample.column('Birth Weight')[:num_nonsmokers].mean() - \
   ....:         resample.column('Birth Weight')[num_nonsmokers:].mean()
   ....:     return bootstrap_diff
   ....:

In [71]: repetitions = 1000

In [72]: bootstrapped_diff_means = np.array(
   ....:     [ bootstrap_once() for _ in range(repetitions) ])
   ....:

In [73]: bootstrapped_diff_means[:10]
Out[73]:
```

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```
array([-1.61099685,  1.33708427,  0.24726602, -0.73273002, -1.07159681,
        0.10865823,  0.6345872 , -1.67601201,  0.49538522,  1.43694867])

In [74]: num_diffs_greater = (abs(bootstrapped_diff_means) > abs(observed_diff)).sum()

In [75]: p_value = num_diffs_greater / len(bootstrapped_diff_means)

In [76]: p_value
Out[76]: 0.0
```

1.8 Drawing Maps

To come.

CHAPTER

TWO

DATA 8 DATASCIENCE REFERENCE

This notebook serves as an interactive, Data 8-friendly reference for the `datascience` library.

2.1 Table Functions and Methods

2.1.1 Table()

Create an empty table, usually to extend with data

```
[29]: new_table = Table()
      new_table
```

```
[29]:
```

```
[30]: type(new_table)
```

```
[30]: datascience.tables.Table
```

2.1.2 Table.read_table()

```
Table.read_table(filename)
```

Creates a table by reading the CSV file named `filename` (a string).

```
[31]: trips = Table.read_table('https://raw.githubusercontent.com/data-8/textbook/gh-pages/
      ↪data/trip.csv')
      trips
```

```
[31]: Trip ID | Duration | Start Date       | Start Station                            | Start␣
      ↪Terminal | End Date         | End Station                              | End Terminal␣
      ↪| Bike # | Subscriber Type | Zip Code
      876419  | 413      | 8/5/2015 8:29    | Civic Center BART (7th at Market)        | 72    ␣
      ↪         | 8/5/2015 8:36    | Townsend at 7th                          | 65           |␣
      ↪269     | Subscriber      | 94518
      459672  | 408      | 9/18/2014 17:11  | Harry Bridges Plaza (Ferry Building)     | 50    ␣
      ↪         | 9/18/2014 17:17  | Embarcadero at Sansome                   | 60           |␣
      ↪429     | Subscriber      | 94111
      903647  | 723      | 8/25/2015 7:26   | San Francisco Caltrain 2 (330 Townsend) | 69    ␣
      ↪         | 8/25/2015 7:38   | Market at 10th                           | 67           |␣
```

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```
↪631    | Subscriber      | 94025
452829  | 409       | 9/15/2014 8:29   | Steuart at Market                          | 74  ␣
↪         | 9/15/2014 8:36   | Market at 4th                            | 76        |␣
↪428    | Subscriber      | 94925
491023  | 224       | 10/9/2014 16:13  | Santa Clara at Almaden                     | 4   ␣
↪         | 10/9/2014 16:17  | San Jose Diridon Caltrain Station        | 2         |␣
↪144    | Subscriber      | 94117
723352  | 519       | 4/13/2015 17:04  | Howard at 2nd                              | 63  ␣
↪         | 4/13/2015 17:12  | San Francisco Caltrain (Townsend at 4th) | 70        |␣
↪629    | Subscriber      | 94061
524499  | 431       | 10/31/2014 16:36 | Townsend at 7th                            | 65  ␣
↪         | 10/31/2014 16:43 | Civic Center BART (7th at Market)        | 72        |␣
↪630    | Subscriber      | 94706
518524  | 389       | 10/28/2014 8:48  | Market at Sansome                          | 77  ␣
↪         | 10/28/2014 8:54  | 2nd at South Park                        | 64        |␣
↪458    | Subscriber      | 94610
710070  | 11460     | 4/2/2015 18:13   | Powell Street BART                         | 39  ␣
↪         | 4/2/2015 21:24   | Powell Street BART                       | 39        |␣
↪375    | Subscriber      | 94107
793149  | 616       | 6/4/2015 5:26    | Embarcadero at Bryant                      | 54  ␣
↪         | 6/4/2015 5:36    | Embarcadero at Sansome                   | 60        |␣
↪289    | Subscriber      | 94105
... (99990 rows omitted)
```

2.1.3 tbl.with_column

```
tbl = Table()
tbl.with_column(name, values)
tbl.with_columns(n1, v1, n2, v2,...)
```

Creates a new table by adding a column with name `name` and values `values` to another table. `name` should be a string and `values` should have as many entries as there are rows in the original table. If `values` is a single value, then every row of that column has the value `values`.

In the examples below, we start with adding a column to the existing table `trips` with `values` being an array we construct from existing tables.

[32]:
```
trips.with_column(
    "Difference in terminal", abs(trips.column("Start Terminal") - trips.column("End␣
↪Terminal"))
)
```

[32]:
```
Trip ID | Duration | Start Date       | Start Station                              | Start␣
↪Terminal | End Date         | End Station                              | End Terminal␣
↪| Bike # | Subscriber Type | Zip Code | Difference in terminal
876419  | 413       | 8/5/2015 8:29    | Civic Center BART (7th at Market)          | 72  ␣
↪         | 8/5/2015 8:36    | Townsend at 7th                          | 65        |␣
↪269    | Subscriber      | 94518    | 7
459672  | 408       | 9/18/2014 17:11  | Harry Bridges Plaza (Ferry Building)       | 50  ␣
↪         | 9/18/2014 17:17  | Embarcadero at Sansome                   | 60        |␣
↪429    | Subscriber      | 94111    | 10
```

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```
903647  | 723       | 8/25/2015 7:26   | San Francisco Caltrain 2 (330 Townsend) | 69    ␣
↪        | 8/25/2015 7:38   | Market at 10th                          | 67       |␣
↪631    | Subscriber       | 94025     | 2
452829  | 409       | 9/15/2014 8:29   | Steuart at Market                       | 74    ␣
↪        | 9/15/2014 8:36   | Market at 4th                           | 76       |␣
↪428    | Subscriber       | 94925     | 2
491023  | 224       | 10/9/2014 16:13  | Santa Clara at Almaden                  | 4     ␣
↪        | 10/9/2014 16:17  | San Jose Diridon Caltrain Station       | 2        |␣
↪144    | Subscriber       | 94117     | 2
723352  | 519       | 4/13/2015 17:04  | Howard at 2nd                           | 63    ␣
↪        | 4/13/2015 17:12  | San Francisco Caltrain (Townsend at 4th) | 70      |␣
↪629    | Subscriber       | 94061     | 7
524499  | 431       | 10/31/2014 16:36 | Townsend at 7th                         | 65    ␣
↪        | 10/31/2014 16:43 | Civic Center BART (7th at Market)       | 72       |␣
↪630    | Subscriber       | 94706     | 7
518524  | 389       | 10/28/2014 8:48  | Market at Sansome                       | 77    ␣
↪        | 10/28/2014 8:54  | 2nd at South Park                       | 64       |␣
↪458    | Subscriber       | 94610     | 13
710070  | 11460     | 4/2/2015 18:13   | Powell Street BART                      | 39    ␣
↪        | 4/2/2015 21:24   | Powell Street BART                      | 39       |␣
↪375    | Subscriber       | 94107     | 0
793149  | 616       | 6/4/2015 5:26    | Embarcadero at Bryant                   | 54    ␣
↪        | 6/4/2015 5:36    | Embarcadero at Sansome                  | 60       |␣
↪289    | Subscriber       | 94105     | 6
... (99990 rows omitted)
```

We can also create a new table by adding two new columns with column name followed by the array values.

[33]:
```
cookies = Table()
cookies = cookies.with_columns(
    "Cookie", make_array("Sugar cookies", "Chocolate chip", "Red velvet", "Oatmeal raisin
↪", "Peanut butter"),
    "Quantity", make_array(10, 15, 15, 10, 5)
)
cookies
```

[33]:
```
Cookie         | Quantity
Sugar cookies  | 10
Chocolate chip | 15
Red velvet     | 15
Oatmeal raisin | 10
Peanut butter  | 5
```

[34]:
```
prices = make_array(1.00, 1.50, 1.75, 1.25, 1.00)
cookies = cookies.with_column("Price ($)", prices)
cookies
```

[34]:
```
Cookie         | Quantity | Price ($)
Sugar cookies  | 10       | 1
Chocolate chip | 15       | 1.5
Red velvet     | 15       | 1.75
Oatmeal raisin | 10       | 1.25
Peanut butter  | 5        | 1
```

In the last examples, we add a new column `Delicious` with one value "yes," and we see every column has the same value.

[35]:
```
cookies.with_column("Delicious", "yes")
```

[35]:
```
Cookie          | Quantity | Price ($) | Delicious
Sugar cookies   | 10       | 1         | yes
Chocolate chip  | 15       | 1.5       | yes
Red velvet      | 15       | 1.75      | yes
Oatmeal raisin  | 10       | 1.25      | yes
Peanut butter   | 5        | 1         | yes
```

2.1.4 `tbl.column()`

```
tbl.column(column_name_or_index)
```

Outputs an array of values of the column `column_name_or_index`. `column_name_or_index` is a string of the column name or number which is the index of the column.

In the examples below, we start with an array of the `Cookie` column from the table `cookies` first by the column name then by using the index of the column.

[36]:
```
cookies.column("Cookie")
```

[36]:
```
array(['Sugar cookies', 'Chocolate chip', 'Red velvet', 'Oatmeal raisin',
       'Peanut butter'], dtype='<U14')
```

[37]:
```
cookies.column(0)
```

[37]:
```
array(['Sugar cookies', 'Chocolate chip', 'Red velvet', 'Oatmeal raisin',
       'Peanut butter'], dtype='<U14')
```

2.1.5 `tbl.num_rows`

Computes the number of rows in a table.

[38]:
```
trips.num_rows
```

[38]:
```
100000
```

[39]:
```
cookies.num_rows
```

[39]:
```
5
```

2.1.6 tbl.num_columns

Computes the number of columns in a table.

[40]:
```
trips.num_columns
```

[40]:
```
11
```

[41]:
```
cookies.num_columns
```

[41]:
```
3
```

2.1.7 tbl.labels

Outputs the column labels in a table.

[42]:
```
trips.labels
```

[42]:
```
('Trip ID',
 'Duration',
 'Start Date',
 'Start Station',
 'Start Terminal',
 'End Date',
 'End Station',
 'End Terminal',
 'Bike #',
 'Subscriber Type',
 'Zip Code')
```

[43]:
```
cookies.labels
```

[43]:
```
('Cookie', 'Quantity', 'Price ($)')
```

2.1.8 tbl.select()

```
tbl.select(col1, col2, ...)
```

Creates a copy of a table with only the selected columns. Each column is the column name as a string or the integer index of the column.

Suppose we want to select the `Trip ID`, `Duration`, `Bike #`, and `Zip Code` columns from the `trips` table.

[44]:
```
trips.select("Trip ID", "Duration", "Bike #", "Zip Code")
```

[44]:
```
Trip ID | Duration | Bike # | Zip Code
876419  | 413      | 269    | 94518
459672  | 408      | 429    | 94111
903647  | 723      | 631    | 94025
452829  | 409      | 428    | 94925
491023  | 224      | 144    | 94117
723352  | 519      | 629    | 94061
524499  | 431      | 630    | 94706
```

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```
518524  | 389       | 458     | 94610
710070  | 11460     | 375     | 94107
793149  | 616       | 289     | 94105
... (99990 rows omitted)
```

Similarly, we can use indexes to select columns. Remember to start indexing at 0.

[45]:
```
trips.select(0, 1, 8, 10).show(5)
```

```
<IPython.core.display.HTML object>
```

2.1.9 `tbl.drop()`

```
tbl.drop(col1, col2, ...)
```

Creates a copy of a table *without* the specified columns. Each column is the column name as a string or integer index.

[46]:
```
cookies.drop("Quantity")
```

[46]:
```
Cookie          | Price ($)
Sugar cookies   | 1
Chocolate chip  | 1.5
Red velvet      | 1.75
Oatmeal raisin  | 1.25
Peanut butter   | 1
```

[47]:
```
trips.drop("End Date", "Subscriber Type")
```

[47]:
```
Trip ID | Duration | Start Date       | Start Station                          | Start␣
↪Terminal | End Station                             | End Terminal | Bike # | Zip Code
876419  | 413      | 8/5/2015 8:29    | Civic Center BART (7th at Market)        | 72      ␣
↪         | Townsend at 7th                          | 65           | 269    | 94518
459672  | 408      | 9/18/2014 17:11  | Harry Bridges Plaza (Ferry Building)     | 50      ␣
↪         | Embarcadero at Sansome                   | 60           | 429    | 94111
903647  | 723      | 8/25/2015 7:26   | San Francisco Caltrain 2 (330 Townsend) | 69      ␣
↪         | Market at 10th                           | 67           | 631    | 94025
452829  | 409      | 9/15/2014 8:29   | Steuart at Market                        | 74      ␣
↪         | Market at 4th                            | 76           | 428    | 94925
491023  | 224      | 10/9/2014 16:13  | Santa Clara at Almaden                   | 4       ␣
↪         | San Jose Diridon Caltrain Station        | 2            | 144    | 94117
723352  | 519      | 4/13/2015 17:04  | Howard at 2nd                            | 63      ␣
↪         | San Francisco Caltrain (Townsend at 4th) | 70           | 629    | 94061
524499  | 431      | 10/31/2014 16:36 | Townsend at 7th                          | 65      ␣
↪         | Civic Center BART (7th at Market)        | 72           | 630    | 94706
518524  | 389      | 10/28/2014 8:48  | Market at Sansome                        | 77      ␣
↪         | 2nd at South Park                        | 64           | 458    | 94610
710070  | 11460    | 4/2/2015 18:13   | Powell Street BART                       | 39      ␣
↪         | Powell Street BART                       | 39           | 375    | 94107
793149  | 616      | 6/4/2015 5:26    | Embarcadero at Bryant                    | 54      ␣
↪         | Embarcadero at Sansome                   | 60           | 289    | 94105
... (99990 rows omitted)
```

[48]:
```
trips.drop(3, 6, 8, 9, 10)
```

[48]:
```
Trip ID | Duration | Start Date      | Start Terminal | End Date        | End Terminal
876419  | 413      | 8/5/2015 8:29   | 72             | 8/5/2015 8:36   | 65
459672  | 408      | 9/18/2014 17:11 | 50             | 9/18/2014 17:17 | 60
903647  | 723      | 8/25/2015 7:26  | 69             | 8/25/2015 7:38  | 67
452829  | 409      | 9/15/2014 8:29  | 74             | 9/15/2014 8:36  | 76
491023  | 224      | 10/9/2014 16:13 | 4              | 10/9/2014 16:17 | 2
723352  | 519      | 4/13/2015 17:04 | 63             | 4/13/2015 17:12 | 70
524499  | 431      | 10/31/2014 16:36 | 65            | 10/31/2014 16:43 | 72
518524  | 389      | 10/28/2014 8:48 | 77             | 10/28/2014 8:54 | 64
710070  | 11460    | 4/2/2015 18:13  | 39             | 4/2/2015 21:24  | 39
793149  | 616      | 6/4/2015 5:26   | 54             | 6/4/2015 5:36   | 60
... (99990 rows omitted)
```

2.1.10 tbl.relabel()

```
tbl.relabel(old_label, new_label)
```

Modifies the table by changing the label of the column named old_label to new_label. old_label can be a string column name or an integer index.

[49]:
```
cookies
```

[49]:
```
Cookie          | Quantity | Price ($)
Sugar cookies   | 10       | 1
Chocolate chip  | 15       | 1.5
Red velvet      | 15       | 1.75
Oatmeal raisin  | 10       | 1.25
Peanut butter   | 5        | 1
```

[50]:
```
cookies.relabel("Quantity", "Amount remaining")
```

[50]:
```
Cookie          | Amount remaining | Price ($)
Sugar cookies   | 10               | 1
Chocolate chip  | 15               | 1.5
Red velvet      | 15               | 1.75
Oatmeal raisin  | 10               | 1.25
Peanut butter   | 5                | 1
```

[51]:
```
cookies.relabel(0, "Type")
```

[51]:
```
Type            | Amount remaining | Price ($)
Sugar cookies   | 10               | 1
Chocolate chip  | 15               | 1.5
Red velvet      | 15               | 1.75
Oatmeal raisin  | 10               | 1.25
Peanut butter   | 5                | 1
```

[52]:
```
cookies
```

[52]:
```
Type            | Amount remaining | Price ($)
Sugar cookies   | 10               | 1
```

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```
Chocolate chip | 15               | 1.5
Red velvet     | 15               | 1.75
Oatmeal raisin | 10               | 1.25
Peanut butter  | 5                | 1
```

2.1.11 `tbl.show()`

```
tbl.show(n)
```

Displays the first `n` rows of a table. If no `n` is provided, displays all rows.

[53]:
```
trips.show(5)
```

```
<IPython.core.display.HTML object>
```

2.1.12 `tbl.sort()`

```
tbl.sort(column_name_or_index, descending=False)
```

Sorts the rows in the table by the values in the column `column_name_or_index` in ascending order by default. Set `descending=True` to sort in descending order. `column_name_or_index` can be a string column label or an integer index.

[54]:
```
cookies
```

[54]:
```
Type           | Amount remaining | Price ($)
Sugar cookies  | 10               | 1
Chocolate chip | 15               | 1.5
Red velvet     | 15               | 1.75
Oatmeal raisin | 10               | 1.25
Peanut butter  | 5                | 1
```

[55]:
```
cookies.sort("Price ($)")
```

[55]:
```
Type           | Amount remaining | Price ($)
Sugar cookies  | 10               | 1
Peanut butter  | 5                | 1
Oatmeal raisin | 10               | 1.25
Chocolate chip | 15               | 1.5
Red velvet     | 15               | 1.75
```

[56]:
```
# sort in descending order
cookies.sort("Amount remaining", descending = True)
```

[56]:
```
Type           | Amount remaining | Price ($)
Red velvet     | 15               | 1.75
Chocolate chip | 15               | 1.5
Oatmeal raisin | 10               | 1.25
Sugar cookies  | 10               | 1
Peanut butter  | 5                | 1
```

[57]:
```
# alphabetical order
cookies.sort(0)
```

[57]:
```
Type            | Amount remaining | Price ($)
Chocolate chip | 15               | 1.5
Oatmeal raisin | 10               | 1.25
Peanut butter  | 5                | 1
Red velvet     | 15               | 1.75
Sugar cookies  | 10               | 1
```

2.1.13 `tbl.where()`

```
tbl.where(column, predicate)
```

Filters the table for rows where the `predicate` is true. `predicate` should be one of the provided `are.<something>` functions. `column` can be a string column label or an integer index. A list of available predicates can be found *below*.

[58]:
```
cookies.where("Amount remaining", are.above(10))
```

[58]:
```
Type            | Amount remaining | Price ($)
Chocolate chip | 15               | 1.5
Red velvet     | 15               | 1.75
```

[59]:
```
cookies.where(0, are.equal_to("Chocolate chip"))
```

[59]:
```
Type            | Amount remaining | Price ($)
Chocolate chip | 15               | 1.5
```

[62]:
```
# if predicate is a value, look for rows where the column == the value
# equivalent to cookies.where(1, are.eual_to(15))
cookies.where(1, 15)
```

[62]:
```
Type            | Amount remaining | Price ($)
Chocolate chip | 15               | 1.5
Red velvet     | 15               | 1.75
```

[63]:
```
cookies.where("Price ($)", are.below(1.25))
```

[63]:
```
Type           | Amount remaining | Price ($)
Sugar cookies | 10               | 1
Peanut butter | 5                | 1
```

2.1.14 `tbl.take()`

```
tbl.take(row_index, ...)
```

Returns a copy of the table with only the specified rows included. Rows are specified by their integer index, so `0` for the first, 1 for the second, etc.

[64]:
```
cookies
```

```
[64]: Type            | Amount remaining | Price ($)
      Sugar cookies   | 10               | 1
      Chocolate chip  | 15               | 1.5
      Red velvet      | 15               | 1.75
      Oatmeal raisin  | 10               | 1.25
      Peanut butter   | 5                | 1
```

```
[65]: cookies.take(0)
```

```
[65]: Type           | Amount remaining | Price ($)
      Sugar cookies  | 10               | 1
```

```
[66]: cookies.take(cookies.num_rows - 1)
```

```
[66]: Type           | Amount remaining | Price ($)
      Peanut butter  | 5                | 1
```

```
[67]: cookies.take(0, 1, 2)
```

```
[67]: Type            | Amount remaining | Price ($)
      Sugar cookies   | 10               | 1
      Chocolate chip  | 15               | 1.5
      Red velvet      | 15               | 1.75
```

2.2 Table Visualizations

```
[68]: actors = Table().read_table("https://github.com/data-8/textbook/raw/gh-pages/data/actors.
      ↪csv")
      actors
```

```
[68]: Actor              | Total Gross | Number of Movies | Average per Movie | #1 Movie         ␣
      ↪               | Gross
      Harrison Ford      | 4871.7      | 41               | 118.8             | Star Wars: The␣
      ↪Force Awakens  | 936.7
      Samuel L. Jackson  | 4772.8      | 69               | 69.2              | The Avengers     ␣
      ↪               | 623.4
      Morgan Freeman     | 4468.3      | 61               | 73.3              | The Dark␣
      ↪Knight               | 534.9
      Tom Hanks          | 4340.8      | 44               | 98.7              | Toy Story 3      ␣
      ↪               | 415
      Robert Downey, Jr. | 3947.3      | 53               | 74.5              | The Avengers     ␣
      ↪               | 623.4
      Eddie Murphy       | 3810.4      | 38               | 100.3             | Shrek 2          ␣
      ↪               | 441.2
      Tom Cruise         | 3587.2      | 36               | 99.6              | War of the␣
      ↪Worlds             | 234.3
      Johnny Depp        | 3368.6      | 45               | 74.9              | Dead Man's␣
      ↪Chest              | 423.3
      Michael Caine      | 3351.5      | 58               | 57.8              | The Dark␣
      ↪Knight               | 534.9
      Scarlett Johansson | 3341.2      | 37               | 90.3              | The Avengers     ␣
```

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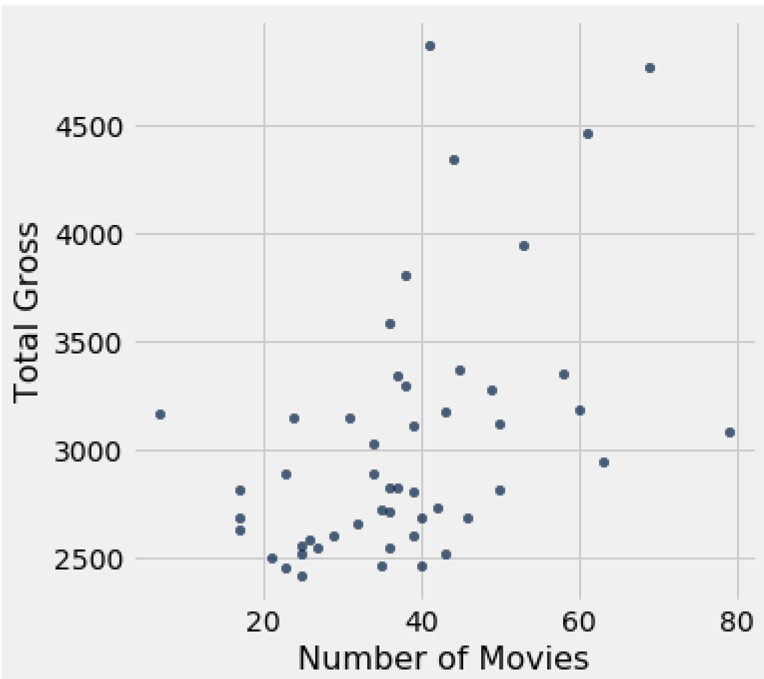
```
↪                 | 623.4
... (40 rows omitted)
```

2.2.1 tbl.scatter()

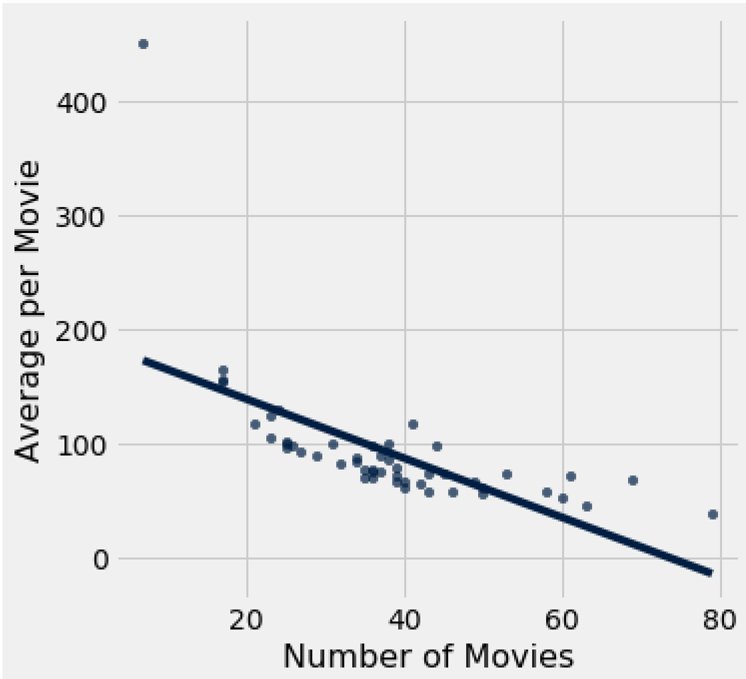
```
tbl.scatter(x_column, y_column, fit_line=False)
```

Creates a scatter plot with x_column on the horizontal axis and y_column on the vertical axis. These labels can be column names as strings or integer indices. Set fit_line=True to include a line of best fit for the data. You can find more examples in the textbook.

[71]:
```
actors.scatter('Number of Movies', 'Total Gross')
```



[73]:
```
actors.scatter(2, 3, fit_line=True)
```



2.2.2 tbl.plot()

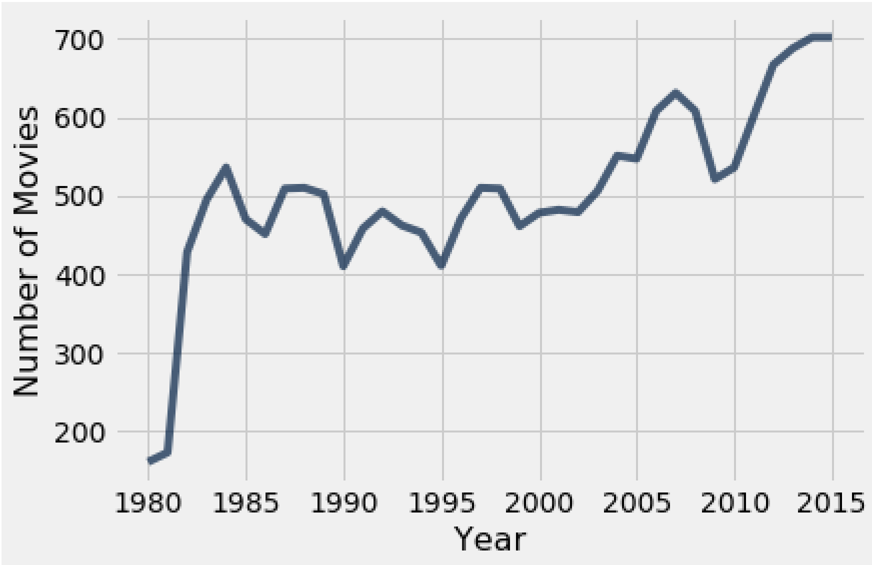
```
tbl.plot(x_column, y_column)
```

Plot a line graph with x_column on the horizontal axis and y_column on the vertical axis. Sorts the table in ascending order by values in x_column first. x_column and y_column can be column names as strings or integer indices.

[74]:
```
movies_by_year = Table.read_table('https://github.com/data-8/textbook/raw/gh-pages/data/
↪movies_by_year.csv')
movies_by_year.show(3)
```

```
<IPython.core.display.HTML object>
```

[75]:
```
movies_by_year.plot('Year', 'Number of Movies')
```

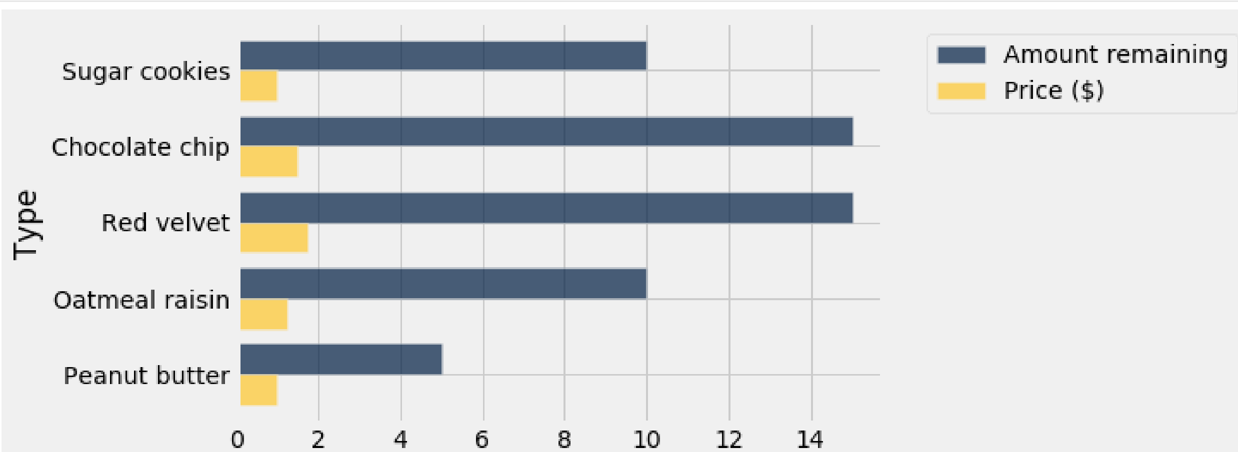


2.2.3 tbl.barh()

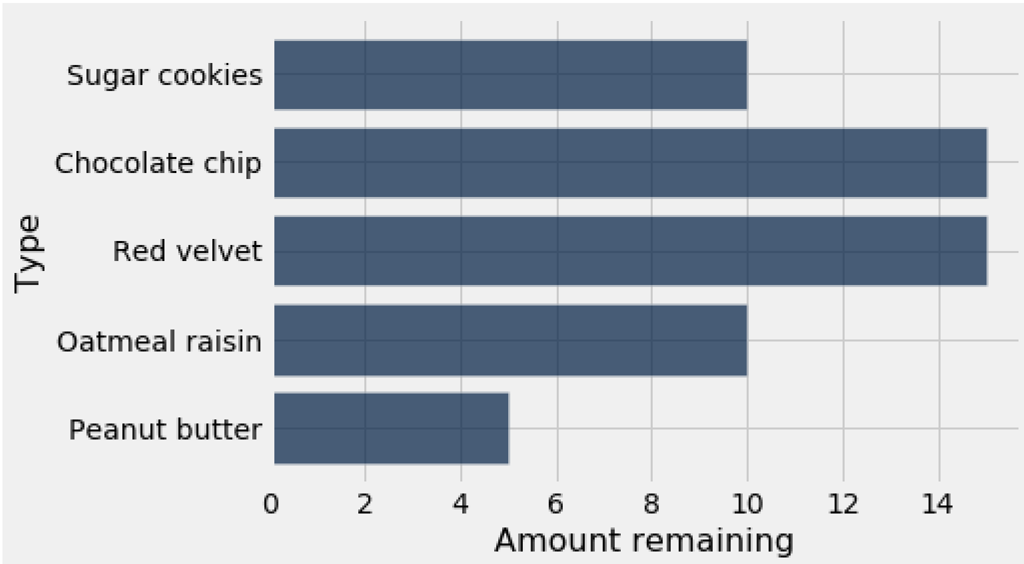
```
tbl.barh(categories)
tbl.barh(categories, values)
```

Plots a horizontal bar chart broken down by `categories` as the bars. If `values` is unspecified, one bar for each column of the table (except `categories`) is plotted. `categories` and `values` can be column names as strings or integer indices.

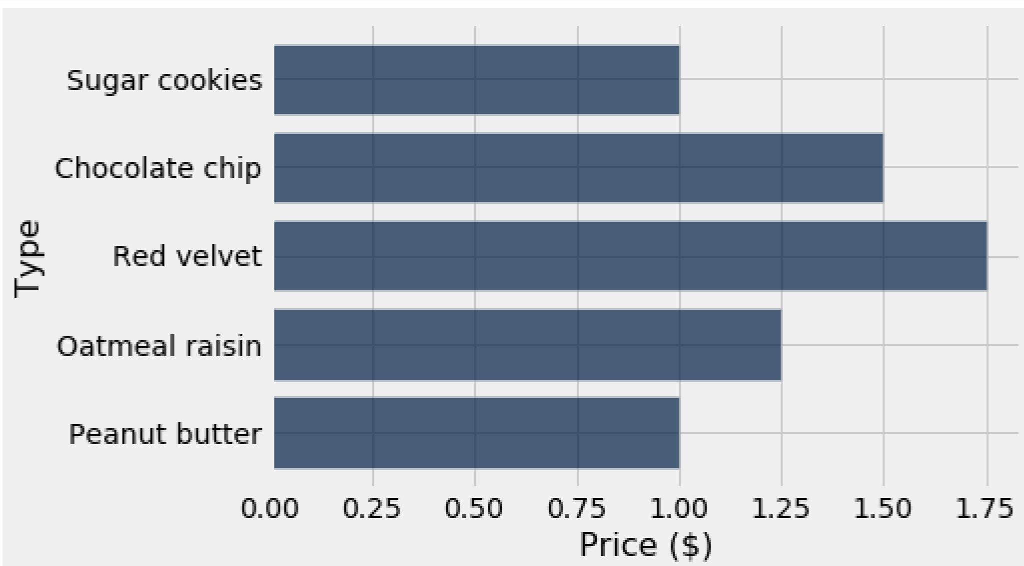
[76]:
```
cookies.barh("Type")
```



[77]:
```
cookies.barh("Type", "Amount remaining")
```




```
[78]: cookies.barh(0, 2)
```

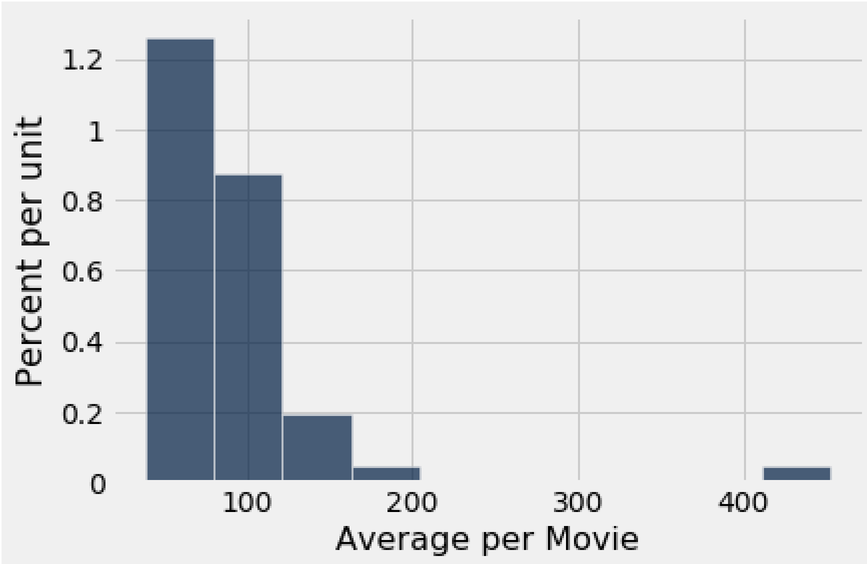


2.2.4 `tbl.hist()`

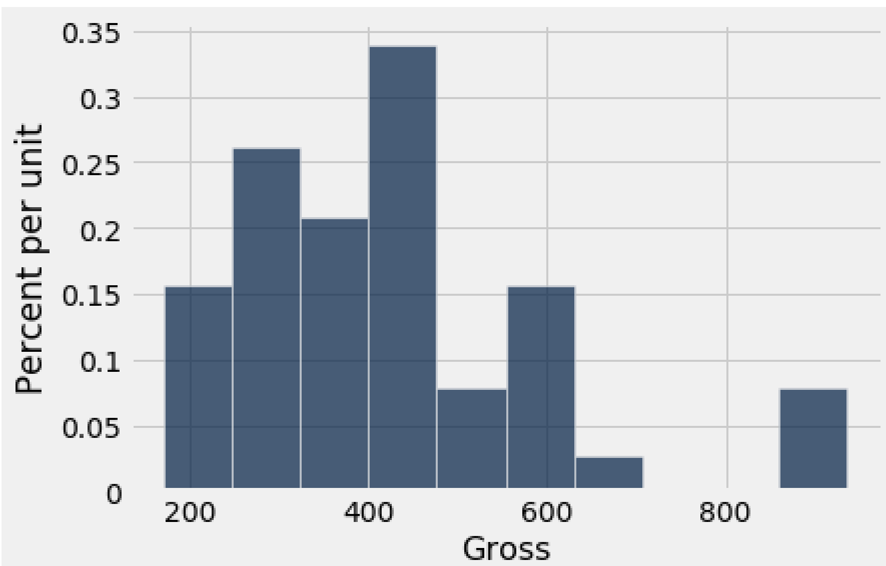
```
tbl.hist(column)
tbl.hist(column, bins=...)
```

Plot a histogram of the values in `column`. Defaults to 10 bins of equal width. If `bins` is specified, it can be a number of bins to use (e.g. `bins=25` will produce a histogram with 25 bins) or an array of values to use as bins (e.g. `bins=make_array(1, 3, 4)` will produce 2 bins: $[1, 3)$ and $[3, 4)$). `column` can be column names as strings or integer indices.

```
[79]: actors.hist(3)
```



[80]:
```
actors.hist("Gross")
```



2.2.5 Table.interactive_plots()

```
Table.interactive_plots()
```

This function will change from static plots like the ones above to interactive plots made with plotly. If a plotting method has a plotly version, that method will be used instead.

[193]:
```
Table.interactive_plots()
actors.scatter("Total Gross", "Gross")
```

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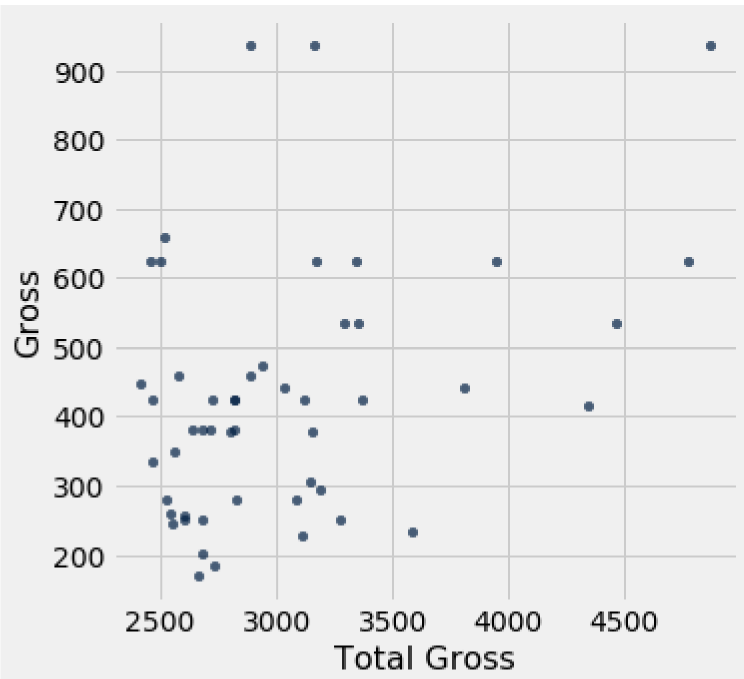
```
Data type cannot be displayed: application/vnd.plotly.v1+json, text/html
```

2.2.6 `Table.static_plots()`

```
Table.static_plots()
```

This function turns off plotly plots.

[194]:
```
Table.static_plots()
actors.scatter("Total Gross", "Gross")
```



2.3 Advanced `Table` Functions

2.3.1 `tbl.apply()`

```
tbl.apply(function, column)
tbl.apply(function, col1, col2, ...)
```

Applies the function `function` to each element of the column `column` and returns the values returned as an array. If `function` takes more than one argument, you can specify multiple columns to use for each argument *in order*.

[65]:
```
actors.apply(np.average, "Number of Movies")
```

[65]:
```
array([41., 69., 61., 44., 53., 38., 36., 45., 58., 37., 38., 49., 60.,
       43.,  7., 31., 24., 50., 39., 79., 34., 63., 23., 34., 37., 36.,
```

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```
       17., 50., 39., 42., 35., 36., 17., 46., 40., 32., 17., 29., 39.,
       26., 25., 36., 27., 43., 25., 21., 40., 35., 23., 25.])
```

[82]:
```
actors
```

[82]:
```
Actor                | Total Gross | Number of Movies | Average per Movie | #1 Movie ␣
↪                | Gross
Harrison Ford        | 4871.7      | 41               | 118.8             | Star Wars: The␣
↪Force Awakens | 936.7
Samuel L. Jackson    | 4772.8      | 69               | 69.2              | The Avengers ␣
↪                | 623.4
Morgan Freeman       | 4468.3      | 61               | 73.3              | The Dark␣
↪Knight              | 534.9
Tom Hanks            | 4340.8      | 44               | 98.7              | Toy Story 3 ␣
↪                | 415
Robert Downey, Jr.   | 3947.3      | 53               | 74.5              | The Avengers ␣
↪                | 623.4
Eddie Murphy         | 3810.4      | 38               | 100.3             | Shrek 2 ␣
↪                | 441.2
Tom Cruise           | 3587.2      | 36               | 99.6              | War of the␣
↪Worlds            | 234.3
Johnny Depp          | 3368.6      | 45               | 74.9              | Dead Man's␣
↪Chest             | 423.3
Michael Caine        | 3351.5      | 58               | 57.8              | The Dark␣
↪Knight              | 534.9
Scarlett Johansson   | 3341.2      | 37               | 90.3              | The Avengers ␣
↪                | 623.4
... (40 rows omitted)
```

The example below calculates the average gross for each movie by actor by applying a function that takes in the value of `Total Gross` and `Number of Movies` and returns their quotient.

[83]:
```
def average_gross(total_gross, num_movies):
    return total_gross / num_movies

actors.apply(average_gross, "Total Gross", "Number of Movies")
```

[83]:
```
array([118.82195122,  69.17101449,  73.25081967,  98.65454545,
        74.47735849, 100.27368421,  99.64444444,  74.85777778,
        57.78448276,  90.3027027 ,  86.68421053,  66.9244898 ,
        53.15666667,  73.8372093 , 451.84285714, 101.62580645,
       131.2125    ,  62.478     ,  79.67435897,  39.00379747,
        89.16764706,  46.70952381, 125.67826087,  84.86470588,
        76.40540541,  78.38888889, 165.63529412,  56.316     ,
        71.86153846,  65.12619048,  77.89428571,  75.425     ,
       157.75882353,  58.28913043,  67.0225    ,  83.15625   ,
       154.96470588,  89.83103448,  66.72564103,  99.25384615,
       102.308     ,  70.82777778,  94.26666667,  58.65348837,
       100.732     , 119.06190476,  61.5925    ,  70.36      ,
       106.86086957,  96.66      ])
```

2.3.2 tbl.group()

```
tbl.group(column_or_columns)
tbl.group(column_or_columns, func)
```

Groups a table by values in `column_or_columns`. If `column_or_columns` is an array, groups by each unique combination of elements in those columns. If `func` is specified, it should be a function that takes in an array of values and returns a single value. If unspecified, this defaults to the count of rows in the set.

```
[84]: trips.group("Start Station")
```

```
[84]: Start Station                      | count
2nd at Folsom                      | 2302
2nd at South Park                  | 2610
2nd at Townsend                    | 3904
5th at Howard                      | 2190
Adobe on Almaden                   | 165
Arena Green / SAP Center           | 176
Beale at Market                    | 2377
Broadway St at Battery St          | 2157
California Ave Caltrain Station    | 127
Castro Street and El Camino Real | 339
... (60 rows omitted)
```

```
[85]: trips.group("Start Station", np.mean).select(0,2)
```

```
[85]: Start Station                      | Duration mean
2nd at Folsom                      | 512.887
2nd at South Park                  | 654.565
2nd at Townsend                    | 755.176
5th at Howard                      | 819.509
Adobe on Almaden                   | 2522.5
Arena Green / SAP Center           | 1999.7
Beale at Market                    | 679.602
Broadway St at Battery St          | 827.753
California Ave Caltrain Station    | 4403.29
Castro Street and El Camino Real | 1221.86
... (60 rows omitted)
```

```
[86]: trips.group("Start Station").sort("count", descending = True)
```

```
[86]: Start Station                                   | count
San Francisco Caltrain (Townsend at 4th)        | 7426
San Francisco Caltrain 2 (330 Townsend)         | 6114
Harry Bridges Plaza (Ferry Building)            | 4795
Temporary Transbay Terminal (Howard at Beale) | 4212
Townsend at 7th                                 | 3925
2nd at Townsend                                 | 3904
Embarcadero at Sansome                          | 3900
Steuart at Market                               | 3872
Market at 10th                                  | 3370
Market at Sansome                               | 3218
... (60 rows omitted)
```

[87]:
```
trips.group(['Start Station', 'End Station'])
```

[87]:
```
Start Station | End Station                      | count
2nd at Folsom | 2nd at Folsom                    | 22
2nd at Folsom | 2nd at South Park                | 84
2nd at Folsom | 2nd at Townsend                  | 123
2nd at Folsom | 5th at Howard                    | 28
2nd at Folsom | Beale at Market                  | 34
2nd at Folsom | Broadway St at Battery St        | 18
2nd at Folsom | Civic Center BART (7th at Market) | 13
2nd at Folsom | Clay at Battery                  | 70
2nd at Folsom | Commercial at Montgomery         | 46
2nd at Folsom | Davis at Jackson                 | 8
... (1616 rows omitted)
```

2.3.3 tbl.pivot()

```
tbl.pivot(col1, col2)
tbl.pivot(col1, col2, values, collect)
```

Creates a pivot table with values in `col1` as columns and values in `col2` as rows. If `values` is unspecified, the values in the cells default to counts. If `values` is specified, it should be the label of a column whose values to pass as an array to `collect`, which should return a single value.

[88]:
```
more_cones = Table().with_columns(
    'Flavor', make_array('strawberry', 'chocolate', 'chocolate', 'strawberry', 'chocolate
↪', 'bubblegum'),
    'Color', make_array('pink', 'light brown', 'dark brown', 'pink', 'dark brown', 'pink
↪'),
    'Price', make_array(3.55, 4.75, 5.25, 5.25, 5.25, 4.75)
)

more_cones
```

[88]:
```
Flavor     | Color       | Price
strawberry | pink        | 3.55
chocolate  | light brown | 4.75
chocolate  | dark brown  | 5.25
strawberry | pink        | 5.25
chocolate  | dark brown  | 5.25
bubblegum  | pink        | 4.75
```

[89]:
```
more_cones.pivot('Flavor', 'Color')
```

[89]:
```
Color       | bubblegum | chocolate | strawberry
dark brown  | 0         | 2         | 0
light brown | 0         | 1         | 0
pink        | 1         | 0         | 2
```

[90]:
```
more_cones.pivot('Flavor', 'Color', values='Price', collect=sum)
```

[90]:
```
Color       | bubblegum | chocolate | strawberry
dark brown  | 0         | 10.5      | 0
```

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```
light brown | 0         | 4.75      | 0
pink        | 4.75      | 0         | 8.8
```

```
[91]: more_cones.pivot(0, 1)
```

```
[91]: Color       | bubblegum | chocolate | strawberry
dark brown  | 0         | 2         | 0
light brown | 0         | 1         | 0
pink        | 1         | 0         | 2
```

2.3.4 `tbl.join()`

```
tbl1.join(col1, tbl2)
tbl1.join(col1, tbl2, col2)
```

Performs a join of `tbl1` on `tbl2` where rows are only included if the value in `col1` is present in *both* join columns. If `col2` is unspecified, it is assumed to be the same label as `col1`.

```
[92]: cones = Table().with_columns(
    'Flavor', make_array('strawberry', 'vanilla', 'chocolate', 'strawberry', 'chocolate
↪'),
    'Price', make_array(3.55, 4.75, 6.55, 5.25, 5.75)
)
cones
```

```
[92]: Flavor     | Price
strawberry | 3.55
vanilla    | 4.75
chocolate  | 6.55
strawberry | 5.25
chocolate  | 5.75
```

```
[95]: ratings = Table().with_columns(
    'Kind', make_array('strawberry', 'chocolate', 'vanilla', 'mint chip'),
    'Stars', make_array(2.5, 3.5, 4, 3)
)
ratings
```

```
[95]: Kind       | Stars
strawberry | 2.5
chocolate  | 3.5
vanilla    | 4
mint chip  | 3
```

```
[97]: # Joins cones on ratings. Note that the mint chip flavor doesn't appear since it's not in␣
↪cones
rated = cones.join('Flavor', ratings, 'Kind')
rated
```

```
[97]: Flavor     | Price | Stars
chocolate  | 6.55  | 3.5
chocolate  | 5.75  | 3.5
```

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```
strawberry | 3.55  | 2.5
strawberry | 5.25  | 2.5
vanilla    | 4.75  | 4
```

2.3.5 tbl.sample()

```
tbl.sample(n, with_replacement=True)
```

Returns a new table with n rows that were randomly sampled from the original table. If with_replacement is true, sampling occurs with replacement. For sampling without replacement, set with_replacement=False.

[98]:
```
# if you rerun this cell, you should get different results since the sample is random
rated.sample(2)
```

[98]:
```
Flavor    | Price | Stars
chocolate | 6.55  | 3.5
chocolate | 6.55  | 3.5
```

Notice how the table below has more rows for certain flavors than the original rated table. This is because we are sampling with replacement, so you get theoretically get 5 of the same flavors!

[99]:
```
sampled_with_replacement = rated.sample(5)
sampled_with_replacement
```

[99]:
```
Flavor     | Price | Stars
strawberry | 5.25  | 2.5
strawberry | 3.55  | 2.5
strawberry | 3.55  | 2.5
chocolate  | 6.55  | 3.5
vanilla    | 4.75  | 4
```

[100]:
```
rated.sample(3, with_replacement = False)
```

[100]:
```
Flavor     | Price | Stars
vanilla    | 4.75  | 4
strawberry | 3.55  | 2.5
chocolate  | 6.55  | 3.5
```

2.4 String Methods

2.4.1 str.split()

```
string.split(separator)
```

Splits the string string into a list on each occurence of the substring separator. The occurences of separator are removed from the resulting list.

For example, the code below splits the string Data 8hiishifun. on the substring hi.

```
[101]: example_string = "Data 8hiishifun."
       example_string.split("hi")
```

```
[101]: ['Data 8', 'is', 'fun.']
```

```
[104]: # split on .
       another_string = "the.secret.message.is.123"
       another_string.split(".")
```

```
[104]: ['the', 'secret', 'message', 'is', '123']
```

2.4.2 str.join()

```
string.join(array)
```

Combines each element of `array` into one string with `string` used to connect each element.

```
[105]: fun_array = make_array("high", "great", "best")
       "est ".join(fun_array)
```

```
[105]: 'highest greatest best'
```

```
[106]: # you can join elements on the empty string to just merge the elements
       some_strings = make_array("some", "list", "of", "strings")
       "".join(some_strings)
```

```
[106]: 'somelistofstrings'
```

2.4.3 str.replace()

```
string.replace(old_string, new_string)
```

Replaces each occurrence of `old_string` in `string` with `new_string`.

```
[107]: berkeley_string = "I saw 5 friends, 10 squirrels, and 20 people flyering on Sproul."
       berkeley_string
```

```
[107]: 'I saw 5 friends, 10 squirrels, and 20 people flyering on Sproul.'
```

```
[108]: berkeley_string.replace("friends", "frisbees")
```

```
[108]: 'I saw 5 frisbees, 10 squirrels, and 20 people flyering on Sproul.'
```

```
[110]: # you can chain calls to .replace() since the return value is also a string
       berkeley_string.replace("friends", "frisbees").replace("flyering on Sproul", "having a␣
       ↪picnic on the Glade")
```

```
[110]: 'I saw 5 frisbees, 10 squirrels, and 20 people having a picnic on the Glade.'
```

2.5 Array Functions and Methods

[111]:
```
example_array = make_array(1, 3, 5, 7, 9)
example_array
```

[111]:
```
array([1, 3, 5, 7, 9])
```

2.5.1 max()

```
max(array)
```

Returns the maximum value of an array.

[112]:
```
max(example_array)
```

[112]:
```
9
```

2.5.2 min()

```
min(array)
```

Returns the minimum value of an array.

[113]:
```
min(example_array)
```

[113]:
```
1
```

2.5.3 sum()

```
sum(array)
```

Returns the sum of values in an array.

[114]:
```
sum(example_array)
```

[114]:
```
25
```

[115]:
```
sum(make_array(1, 2, 0, -10))
```

[115]:
```
-7
```

2.5.4 abs()

```
abs(num)
abs(array)
```

Take the absolute value of number or each number in an array.

```
[118]: abs(-1)
```

```
[118]: 1
```

```
[119]: new_arr = make_array(-3, -1, 5.2, 0.25, -4.9)
       abs(new_arr)
```

```
[119]: array([3.  , 1.  , 5.2 , 0.25, 4.9 ])
```

2.5.5 round(num)

```
round(num)
round(num, d)
np.round(array)
np.round(array, d)
```

Round number or array of numbers to the nearest integer. If d is specified, rounds to d places *after* the decimal. Use np.round to round arrays.

```
[124]: round(3.14159)
```

```
[124]: 3
```

```
[125]: round(3.14159, 3)
```

```
[125]: 3.142
```

```
[130]: np.round(new_arr, 1)
```

```
[130]: array([-3. , -1. ,  5.2,  0.2, -4.9])
```

2.5.6 len()

```
len(array)
```

Returns the length of an array.

```
[131]: len(new_arr)
```

```
[131]: 5
```

2.5.7 make_array()

```
make_array(val1, val2, ...)
```

Creates a new array with the values passed.

[132]:
```
new_array = make_array(25, 16, 9, 4, 1)
new_array
```

[132]:
```
array([25, 16,  9,  4,  1])
```

2.5.8 np.mean

```
np.mean(array)
np.average(array)
```

Returns the mean of the values in an array.

[134]:
```
np.mean(new_array)
```

[134]:
```
11.0
```

[133]:
```
np.average(new_array)
```

[133]:
```
11.0
```

2.5.9 np.std()

```
np.std(array)
```

Returns the standard deviation of the values in an array.

[150]:
```
np.std(new_array)
```

[150]:
```
8.648699324175862
```

2.5.10 np.diff()

```
np.diff(array)
```

Returns an array with the pairwise differences between elements in the input array. The output will have length `len(array) - 1` and will have elements $x_1 - x_0$, $x_2 - x_1$, $x_3 - x_2$, etc.

[135]:
```
np.diff(new_array)
```

[135]:
```
array([-9, -7, -5, -3])
```

[136]:
```
np.diff(make_array(1, 3, 5, 7))
```

[136]:
```
array([2, 2, 2])
```

2.5.11 np.sqrt()

```
np.sqrt(num)
np.sqrt(array)
```

Returns the square root of a number or an array of the square roots of each element in the input array.

[137]:
```
np.sqrt(4)
```

[137]:
```
2.0
```

[138]:
```
np.sqrt(new_array)
```

[138]:
```
array([5., 4., 3., 2., 1.])
```

2.5.12 np.arange()

```
np.arange(stop)
np.arange(start, stop)
np.arange(start, stop, step)
```

Returns an array of integers from `start` to `stop` incrementing by `step`. If `start` is unspecified, it is assumed be 0. If `step` is unspecified, it is assumed to be 1. The upper bound is *exclusive*, meaning that `max(np.arange(10))` is 9.

[139]:
```
np.arange(0, 11)
```

[139]:
```
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10])
```

[140]:
```
np.arange(5)
```

[140]:
```
array([0, 1, 2, 3, 4])
```

[142]:
```
np.arange(0, 102, 2.7)
```

[142]:
```
array([ 0. ,  2.7,  5.4,  8.1, 10.8, 13.5, 16.2, 18.9, 21.6, 24.3, 27. ,
       29.7, 32.4, 35.1, 37.8, 40.5, 43.2, 45.9, 48.6, 51.3, 54. , 56.7,
       59.4, 62.1, 64.8, 67.5, 70.2, 72.9, 75.6, 78.3, 81. , 83.7, 86.4,
       89.1, 91.8, 94.5, 97.2, 99.9])
```

2.5.13 array.item()

```
array.item(num)
```

Returns the item at index `num` in an array (remember Python indices start at 0!).

[143]:
```
np.arange(0, 102, 2).item(1)
```

[143]:
```
2
```

[146]:
```
new_array.item(2)
```

[146]:
```
9
```

[147]:
```
new_array.item(len(new_array) - 1)
```

[147]:
```
1
```

2.5.14 np.random.choice

```
np.random.choice(array)
np.random.choice(array, n, replace=True)
```

Picks one or n of items from an array at random. By default, with replacement (set replace=False for without replacement).

[149]:
```
np.random.choice(new_array)
```

[149]:
```
25
```

[150]:
```
np.random.choice(new_array, 3)
```

[150]:
```
array([ 4,  4, 16])
```

[152]:
```
np.random.choice(np.arange(0, 102, 2), 10, replace=False)
```

[152]:
```
array([ 98,  22,  12,  56,  24,  54, 100,  52,  28,  88])
```

2.5.15 np.count_nonzero()

Returns the number of nonzero elements in an array. Because False values are considered zeros (as integers), this can also give you the number of Trues in an array of boolean valuea.

[153]:
```
another_array = make_array(0, 1, 2, 0, 4, 0, 1, 0, 0)
np.count_nonzero(another_array)
```

[153]:
```
4
```

[159]:
```
bools = make_array(True, False, True, False, False, True, False)
np.count_nonzero(bools)
```

[159]:
```
3
```

2.5.16 np.append()

```
np.append(array, item)
```

Returns a copy of the input array with item (must be the same type as the other entries in the array) appended to the end.

[160]:
```
new_array
```

[160]:
```
array([25, 16,  9,  4,  1])
```

[161]:
```
np.append(new_array, 1000)
```

[161]:
```
array([  25,    16,     9,     4,     1, 1000])
```

2.5.17 percentile()

```
percentile(percent, array)
```

Returns the value corresponding to the specified percentile of an array. `percent` should be in percentage form (i.e. `50` not `0.5`).

[162]:
```
long_array = make_array(1, 1, 1, 2, 2, 2, 3, 3, 3, 4)
long_array
```

[162]:
```
array([1, 1, 1, 2, 2, 2, 3, 3, 3, 4])
```

[163]:
```
percentile(50, long_array)
```

[163]:
```
2
```

[164]:
```
percentile(90, long_array)
```

[164]:
```
3
```

2.6 Table.where Predicates

All of the predicates described below can be negated by preceding the name with `not_`. For example, we can find values *not* equal to a specific value using `are.not_equal_to(value)`.

2.6.1 are.equal_to()

```
tbl.where(column, are.equal_to(value))
```

Filter leaves rows only where the value in `column` is equal to `value`.

[166]:
```
trips.where("Duration", are.equal_to(519))
```

[166]:
```
Trip ID | Duration | Start Date       | Start Station                            |␣
↪Start Terminal | End Date         | End Station                              |␣
↪End Terminal | Bike # | Subscriber Type | Zip Code
723352  | 519      | 4/13/2015 17:04  | Howard at 2nd                            |␣
↪63             | 4/13/2015 17:12  | San Francisco Caltrain (Townsend at 4th)      | 70␣
↪            | 629    | Subscriber      | 94061
824979  | 519      | 6/27/2015 15:02  | Japantown                                |␣
↪9              | 6/27/2015 15:11  | San Jose City Hall                       | 10␣
↪            | 660    | Customer        | nil
439946  | 519      | 9/5/2014 12:38   | Yerba Buena Center of the Arts (3rd @ Howard) |␣
↪68             | 9/5/2014 12:47   | Civic Center BART (7th at Market)        | 72␣
↪            | 452    | Subscriber      | 94105
788261  | 519      | 6/1/2015 9:21    | Powell at Post (Union Square)            |␣
```

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```
↪71             | 6/1/2015 9:30    | Steuart at Market                           | 74␣
↪          | 575    | Subscriber       | 94108
560479  | 519      | 11/28/2014 14:20 | South Van Ness at Market                    |␣
↪66             | 11/28/2014 14:29 | Powell at Post (Union Square)               | 71␣
↪          | 609    | Subscriber       | 94108
653797  | 519      | 2/23/2015 8:47   | Market at 10th                              |␣
↪67             | 2/23/2015 8:55   | Yerba Buena Center of the Arts (3rd @ Howard) | 68␣
↪          | 546    | Subscriber       | 94102
887134  | 519      | 8/12/2015 17:29  | Civic Center BART (7th at Market)           |␣
↪72             | 8/12/2015 17:38  | Mechanics Plaza (Market at Battery)         | 75␣
↪          | 313    | Subscriber       | 94103
482225  | 519      | 10/3/2014 16:41  | Spear at Folsom                             |␣
↪49             | 10/3/2014 16:50  | Broadway St at Battery St                   | 82␣
↪          | 209    | Subscriber       | 94133
681697  | 519      | 3/14/2015 10:19  | Embarcadero at Sansome                      |␣
↪60             | 3/14/2015 10:28  | Harry Bridges Plaza (Ferry Building)        | 50␣
↪          | 368    | Customer         | 95120
912821  | 519      | 8/31/2015 17:00  | Embarcadero at Folsom                       |␣
↪51             | 8/31/2015 17:09  | San Francisco Caltrain (Townsend at 4th)    | 70␣
↪          | 354    | Subscriber       | 94085
... (115 rows omitted)
```

2.6.2 are.above()

```
tbl.where(column, are.above(value))
```

Filter leaves rows only where the value in column is strictly greater than value.

[167]:
```
trips.where("Duration", are.above(1000))
```

[167]:
```
Trip ID | Duration | Start Date      | Start Station            | Start Terminal | End␣
↪Date          | End Station                              | End Terminal | Bike # |␣
↪Subscriber Type | Zip Code
710070  | 11460    | 4/2/2015 18:13  | Powell Street BART       | 39             | 4/2/
↪2015 21:24  | Powell Street BART                       | 39           | 375    |␣
↪Subscriber      | 94107
589964  | 15097    | 1/3/2015 15:22  | Embarcadero at Sansome   | 60             | 1/3/
↪2015 19:33  | Golden Gate at Polk                      | 59           | 599    |␣
↪Customer        | 29225
831509  | 1057     | 7/2/2015 10:14  | 2nd at Folsom            | 62             | 7/2/
↪2015 10:31  | South Van Ness at Market                 | 66           | 631    |␣
↪Subscriber      | 94114
442750  | 6084     | 9/8/2014 13:32  | Embarcadero at Sansome   | 60             | 9/8/
↪2014 15:14  | Embarcadero at Sansome                   | 60           | 368    |␣
↪Customer        | 474454
608714  | 19799    | 1/18/2015 10:07 | University and Emerson   | 35             | 1/18/
↪2015 15:37 | San Francisco Caltrain (Townsend at 4th) | 70          | 686    |␣
↪Customer        | nil
711961  | 1026     | 4/4/2015 7:07   | Davis at Jackson         | 42             | 4/4/
↪2015 7:24   | Harry Bridges Plaza (Ferry Building)     | 50           | 189    |␣
↪Subscriber      | 94111
```

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```
833071   | 2314      | 7/4/2015 11:13  | Market at 4th              | 76             | 7/4/
↪2015 11:52  | Washington at Kearny                    | 46           | 602     |␣
↪Customer        | 94806
570731   | 1218      | 12/8/2014 23:51 | MLK Library                | 11             | 12/9/
↪2014 0:12  | St James Park                          | 13           | 299     |␣
↪Customer        | 95033
853698   | 1048      | 7/20/2015 10:53 | Broadway St at Battery St | 82             | 7/20/
↪2015 11:10 | Embarcadero at Sansome                 | 60           | 636     |␣
↪Customer        | 91436
787510   | 3670      | 5/31/2015 10:47 | Mountain View City Hall    | 27             | 5/31/
↪2015 11:48 | Castro Street and El Camino Real       | 32           | 713     |␣
↪Customer        | 94041
... (11576 rows omitted)
```

2.6.3 are.above_or_equal_to()

```
tbl.where(column, are.above_or_equal_to(value))
```

Filter leaves rows only where the value in column is greater than or equal to value.

[168]:
```
trips.where("Duration", are.above_or_equal_to(1000))
```

[168]:
```
Trip ID | Duration | Start Date      | Start Station              | Start Terminal | End␣
↪Date         | End Station                             | End Terminal | Bike # |␣
↪Subscriber Type | Zip Code
710070   | 11460     | 4/2/2015 18:13  | Powell Street BART         | 39             | 4/2/
↪2015 21:24  | Powell Street BART                      | 39           | 375     |␣
↪Subscriber      | 94107
589964   | 15097     | 1/3/2015 15:22  | Embarcadero at Sansome     | 60             | 1/3/
↪2015 19:33  | Golden Gate at Polk                     | 59           | 599     |␣
↪Customer        | 29225
831509   | 1057      | 7/2/2015 10:14  | 2nd at Folsom              | 62             | 7/2/
↪2015 10:31  | South Van Ness at Market                | 66           | 631     |␣
↪Subscriber      | 94114
442750   | 6084      | 9/8/2014 13:32  | Embarcadero at Sansome     | 60             | 9/8/
↪2014 15:14  | Embarcadero at Sansome                  | 60           | 368     |␣
↪Customer        | 474454
608714   | 19799     | 1/18/2015 10:07 | University and Emerson     | 35             | 1/18/
↪2015 15:37 | San Francisco Caltrain (Townsend at 4th) | 70           | 686     |␣
↪Customer        | nil
711961   | 1026      | 4/4/2015 7:07   | Davis at Jackson           | 42             | 4/4/
↪2015 7:24   | Harry Bridges Plaza (Ferry Building)    | 50           | 189     |␣
↪Subscriber      | 94111
833071   | 2314      | 7/4/2015 11:13  | Market at 4th              | 76             | 7/4/
↪2015 11:52  | Washington at Kearny                    | 46           | 602     |␣
↪Customer        | 94806
570731   | 1218      | 12/8/2014 23:51 | MLK Library                | 11             | 12/9/
↪2014 0:12  | St James Park                          | 13           | 299     |␣
↪Customer        | 95033
853698   | 1048      | 7/20/2015 10:53 | Broadway St at Battery St | 82             | 7/20/
↪2015 11:10 | Embarcadero at Sansome                 | 60           | 636     |␣
```

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```
↪Customer        | 91436
787510  | 3670     | 5/31/2015 10:47 | Mountain View City Hall   | 27            | 5/31/
↪2015 11:48 | Castro Street and El Camino Real         | 32           | 713    |␣
↪Customer        | 94041
... (11597 rows omitted)
```

2.6.4 `are.below()`

```
tbl.where(column, are.below(value))
```

Filter leaves rows only where the value in `column` is strictly less than `value`.

[170]:
```
trips.where("Duration", are.below(100))
```

[170]:
```
Trip ID | Duration | Start Date        | Start Station                                |␣
↪Start Terminal | End Date          | End Station                                  |␣
↪End Terminal | Bike # | Subscriber Type | Zip Code
482797  | 65       | 10/4/2014 7:50    | San Francisco Caltrain (Townsend at 4th)     |␣
↪70             | 10/4/2014 7:52    | San Francisco Caltrain (Townsend at 4th)     | 70␣
↪            | 430    | Subscriber      | 95112
483052  | 81       | 10/4/2014 13:52   | Harry Bridges Plaza (Ferry Building)         |␣
↪50             | 10/4/2014 13:53   | Harry Bridges Plaza (Ferry Building)         | 50␣
↪            | 306    | Customer        | nan
569620  | 84       | 12/8/2014 10:09   | Civic Center BART (7th at Market)            |␣
↪72             | 12/8/2014 10:10   | Civic Center BART (7th at Market)            | 72␣
↪            | 326    | Subscriber      | 94111
502332  | 79       | 10/16/2014 17:26 | Beale at Market                              |␣
↪56             | 10/16/2014 17:27 | Temporary Transbay Terminal (Howard at Beale) | 55␣
↪            | 613    | Subscriber      | 94602
604012  | 76       | 1/14/2015 15:18   | Davis at Jackson                             |␣
↪42             | 1/14/2015 15:19   | Broadway St at Battery St                    | 82␣
↪            | 601    | Subscriber      | 94107
704918  | 70       | 3/30/2015 22:51   | Broadway St at Battery St                    |␣
↪82             | 3/30/2015 22:52   | Broadway St at Battery St                    | 82␣
↪            | 394    | Subscriber      | 94107
513458  | 83       | 10/24/2014 8:50   | 2nd at Folsom                                |␣
↪62             | 10/24/2014 8:51   | Howard at 2nd                                | 63␣
↪            | 569    | Subscriber      | 94107
696725  | 94       | 3/25/2015 8:47    | Post at Kearny                               |␣
↪47             | 3/25/2015 8:49    | Washington at Kearny                         | 46␣
↪            | 516    | Subscriber      | 94109
829817  | 86       | 7/1/2015 9:27     | Market at Sansome                            |␣
↪77             | 7/1/2015 9:28     | 2nd at South Park                            | 64␣
↪            | 292    | Subscriber      | 94538
745895  | 73       | 4/29/2015 13:05   | Yerba Buena Center of the Arts (3rd @ Howard) |␣
↪68             | 4/29/2015 13:06   | Yerba Buena Center of the Arts (3rd @ Howard) | 68␣
↪            | 380    | Subscriber      | 94947
... (403 rows omitted)
```

2.6.5 are.below_or_equal_to()

```
tbl.where(column, are.below_or_equal_to(value))
```

Filter leaves rows only where the value in `column` is less than or equal to `value`.

[171]:
```
trips.where("Duration", are.below_or_equal_to(100))
```

[171]:
```
Trip ID | Duration | Start Date       | Start Station                           | Start␣
↪Terminal | End Date        | End Station                             | End␣
↪Terminal | Bike # | Subscriber Type | Zip Code
482797  | 65       | 10/4/2014 7:50   | San Francisco Caltrain (Townsend at 4th) | 70      ␣
↪          | 10/4/2014 7:52   | San Francisco Caltrain (Townsend at 4th)      | 70      ␣
↪     | 430    | Subscriber      | 95112
483052  | 81       | 10/4/2014 13:52  | Harry Bridges Plaza (Ferry Building)     | 50      ␣
↪          | 10/4/2014 13:53  | Harry Bridges Plaza (Ferry Building)          | 50      ␣
↪     | 306    | Customer        | nan
569620  | 84       | 12/8/2014 10:09  | Civic Center BART (7th at Market)        | 72      ␣
↪          | 12/8/2014 10:10  | Civic Center BART (7th at Market)             | 72      ␣
↪     | 326    | Subscriber      | 94111
502332  | 79       | 10/16/2014 17:26 | Beale at Market                          | 56      ␣
↪          | 10/16/2014 17:27 | Temporary Transbay Terminal (Howard at Beale) | 55      ␣
↪     | 613    | Subscriber      | 94602
604012  | 76       | 1/14/2015 15:18  | Davis at Jackson                         | 42      ␣
↪          | 1/14/2015 15:19  | Broadway St at Battery St                     | 82      ␣
↪     | 601    | Subscriber      | 94107
704918  | 70       | 3/30/2015 22:51  | Broadway St at Battery St                | 82      ␣
↪          | 3/30/2015 22:52  | Broadway St at Battery St                     | 82      ␣
↪     | 394    | Subscriber      | 94107
513458  | 83       | 10/24/2014 8:50  | 2nd at Folsom                            | 62      ␣
↪          | 10/24/2014 8:51  | Howard at 2nd                                 | 63      ␣
↪     | 569    | Subscriber      | 94107
696725  | 94       | 3/25/2015 8:47   | Post at Kearny                           | 47      ␣
↪          | 3/25/2015 8:49   | Washington at Kearny                          | 46      ␣
↪     | 516    | Subscriber      | 94109
808199  | 100      | 6/15/2015 20:57  | Post at Kearny                           | 47      ␣
↪          | 6/15/2015 20:58  | 2nd at South Park                             | 64      ␣
↪     | 537    | Subscriber      | 94107
829817  | 86       | 7/1/2015 9:27    | Market at Sansome                        | 77      ␣
↪          | 7/1/2015 9:28    | 2nd at South Park                             | 64      ␣
↪     | 292    | Subscriber      | 94538
... (430 rows omitted)
```

2.6.6 are.between()

```
tbl.where(column, are.between(x, y))
```

Filter leaves rows only where the value in `column` is greather than or equal to `x` and less than `y` (i.e. in the interval $[x, y)$).

[172]:
```
trips.where("Duration", are.between(100, 200))
```

[172]:
```
Trip ID | Duration | Start Date        | Start Station                                 |␣
↪Start Terminal | End Date          | End Station                      | End␣
↪Terminal | Bike # | Subscriber Type | Zip Code
437830  | 151      | 9/4/2014 9:13     | Grant Avenue at Columbus Avenue               |␣
↪73             | 9/4/2014 9:15     | Commercial at Montgomery         | 45          ␣
↪ | 306    | Subscriber      | 94104
436255  | 195      | 9/3/2014 11:53    | 2nd at Folsom                                 |␣
↪62             | 9/3/2014 11:57    | Spear at Folsom                  | 49          ␣
↪ | 403    | Subscriber      | 94107
585884  | 151      | 12/26/2014 13:34 | Broadway St at Battery St                      |␣
↪82             | 12/26/2014 13:37 | Harry Bridges Plaza (Ferry Building) | 50      ␣
↪ | 576    | Subscriber      | 94107
548322  | 191      | 11/17/2014 20:10 | Yerba Buena Center of the Arts (3rd @ Howard) |␣
↪68             | 11/17/2014 20:13 | Market at Sansome                | 77          ␣
↪ | 29     | Subscriber      | 94705
594999  | 185      | 1/7/2015 17:53    | San Antonio Caltrain Station                  |␣
↪29             | 1/7/2015 17:56    | San Antonio Shopping Center      | 31          ␣
↪ | 176    | Subscriber      | 94040
468534  | 194      | 9/24/2014 19:08   | Mechanics Plaza (Market at Battery)           |␣
↪75             | 9/24/2014 19:11   | Harry Bridges Plaza (Ferry Building) | 50      ␣
↪ | 443    | Subscriber      | 94107
873710  | 169      | 8/3/2015 17:20    | Broadway St at Battery St                     |␣
↪82             | 8/3/2015 17:23    | Embarcadero at Sansome           | 60          ␣
↪ | 532    | Subscriber      | 94114
853087  | 168      | 7/20/2015 7:27    | Temporary Transbay Terminal (Howard at Beale) |␣
↪55             | 7/20/2015 7:30    | 2nd at Folsom                    | 62          ␣
↪ | 418    | Subscriber      | 94602
863019  | 162      | 7/27/2015 8:31    | Temporary Transbay Terminal (Howard at Beale) |␣
↪55             | 7/27/2015 8:34    | Mechanics Plaza (Market at Battery) | 75       ␣
↪ | 504    | Subscriber      | 94111
883134  | 173      | 8/10/2015 15:11   | Embarcadero at Folsom                         |␣
↪51             | 8/10/2015 15:14   | Beale at Market                  | 56          ␣
↪ | 363    | Subscriber      | 94117
... (5083 rows omitted)
```

2.6.7 `are.between_or_equal_to()`

```
tbl.where(column, are.between_or_equal_to(x, y))
```

Filter leaves rows only where the value in `column` is between or equal to `x` and `y` (i.e. in the interval $[x, y]$).

[173]:
```
trips.where("Duration", are.between_or_equal_to(100, 200))
```

[173]:
```
Trip ID | Duration | Start Date        | Start Station                                 |␣
↪Start Terminal | End Date          | End Station                      | End␣
↪Terminal | Bike # | Subscriber Type | Zip Code
437830  | 151      | 9/4/2014 9:13     | Grant Avenue at Columbus Avenue               |␣
↪73             | 9/4/2014 9:15     | Commercial at Montgomery         | 45          ␣
↪ | 306    | Subscriber      | 94104
436255  | 195      | 9/3/2014 11:53    | 2nd at Folsom                                 |␣
↪62             | 9/3/2014 11:57    | Spear at Folsom                  | 49          ␣
↪ | 403    | Subscriber      | 94107
```

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```
585884  | 151       | 12/26/2014 13:34 | Broadway St at Battery St                       |␣
↪82              | 12/26/2014 13:37 | Harry Bridges Plaza (Ferry Building) | 50             ␣
↪ | 576    | Subscriber       | 94107
548322  | 191       | 11/17/2014 20:10 | Yerba Buena Center of the Arts (3rd @ Howard) |␣
↪68              | 11/17/2014 20:13 | Market at Sansome                    | 77             ␣
↪ | 29     | Subscriber       | 94705
903735  | 200       | 8/25/2015 7:59   | Temporary Transbay Terminal (Howard at Beale) |␣
↪55              | 8/25/2015 8:02   | Steuart at Market                    | 74             ␣
↪ | 453    | Subscriber       | 94501
594999  | 185       | 1/7/2015 17:53   | San Antonio Caltrain Station                  |␣
↪29              | 1/7/2015 17:56   | San Antonio Shopping Center          | 31             ␣
↪ | 176    | Subscriber       | 94040
468534  | 194       | 9/24/2014 19:08  | Mechanics Plaza (Market at Battery)           |␣
↪75              | 9/24/2014 19:11  | Harry Bridges Plaza (Ferry Building) | 50             ␣
↪ | 443    | Subscriber       | 94107
873710  | 169       | 8/3/2015 17:20   | Broadway St at Battery St                     |␣
↪82              | 8/3/2015 17:23   | Embarcadero at Sansome               | 60             ␣
↪ | 532    | Subscriber       | 94114
853087  | 168       | 7/20/2015 7:27   | Temporary Transbay Terminal (Howard at Beale) |␣
↪55              | 7/20/2015 7:30   | 2nd at Folsom                        | 62             ␣
↪ | 418    | Subscriber       | 94602
863019  | 162       | 7/27/2015 8:31   | Temporary Transbay Terminal (Howard at Beale) |␣
↪55              | 7/27/2015 8:34   | Mechanics Plaza (Market at Battery)  | 75             ␣
↪ | 504    | Subscriber       | 94111
... (5180 rows omitted)
```

2.6.8 are.contained_in()

```
tbl.where(column, are.contained_in(string_or_array))
```

Filter leaves rows only where the value in `column` is a substring of `string_or_array` if it is a string or an element of `string_or_array` if it is an array

```
[176]: trips.where("Start Station", are.contained_in("2nd at Folsom San Antonio Caltrain Station
↪"))
```

```
[176]: Trip ID | Duration | Start Date       | Start Station                   | Start Terminal |␣
↪End Date         | End Station                               | End Terminal | Bike
↪# | Subscriber Type | Zip Code
436255  | 195       | 9/3/2014 11:53   | 2nd at Folsom                   | 62             | 9/
↪3/2014 11:57   | Spear at Folsom                           | 49           | 403    ␣
↪| Subscriber       | 94107
831509  | 1057      | 7/2/2015 10:14   | 2nd at Folsom                   | 62             | 7/
↪2/2015 10:31   | South Van Ness at Market                  | 66           | 631    ␣
↪| Subscriber       | 94114
877160  | 306       | 8/5/2015 16:33   | 2nd at Folsom                   | 62             | 8/
↪5/2015 16:39   | Beale at Market                           | 56           | 527    ␣
↪| Subscriber       | 94602
768619  | 840       | 5/15/2015 11:35  | 2nd at Folsom                   | 62             | 5/
↪15/2015 11:49  | Market at 10th                            | 67           | 604    ␣
↪| Subscriber       | 94903
```

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```
594999  | 185      | 1/7/2015 17:53  | San Antonio Caltrain Station | 29            | 1/
↪7/2015 17:56  | San Antonio Shopping Center                  | 31           | 176     ␣
↪| Subscriber      | 94040
701211  | 252      | 3/27/2015 16:26 | 2nd at Folsom                | 62            | 3/
↪27/2015 16:30 | Spear at Folsom                              | 49           | 405     ␣
↪| Subscriber      | 94105
487432  | 561      | 10/7/2014 17:48 | 2nd at Folsom                | 62            |␣
↪10/7/2014 17:58 | Commercial at Montgomery                   | 45           | 342     ␣
↪ | Subscriber      | 94107
610970  | 808      | 1/20/2015 13:28 | 2nd at Folsom                | 62            | 1/
↪20/2015 13:42 | Harry Bridges Plaza (Ferry Building)         | 50           | 310     ␣
↪| Subscriber      | 94025
753668  | 196      | 5/5/2015 11:48  | 2nd at Folsom                | 62            | 5/
↪5/2015 11:52  | Temporary Transbay Terminal (Howard at Beale) | 55           | 533     ␣
↪| Subscriber      | 94973
466551  | 222      | 9/23/2014 18:12 | 2nd at Folsom                | 62            | 9/
↪23/2014 18:16 | 2nd at Townsend                              | 61           | 620     ␣
↪| Subscriber      | 94107
... (2578 rows omitted)
```

[178]:
```
trips.where("Start Terminal", are.contained_in(make_array(62, 29)))
```

[178]:
```
Trip ID | Duration | Start Date      | Start Station                | Start Terminal |␣
↪End Date        | End Station                                  | End Terminal | Bike
↪# | Subscriber Type | Zip Code
436255  | 195      | 9/3/2014 11:53  | 2nd at Folsom                | 62            | 9/
↪3/2014 11:57  | Spear at Folsom                              | 49           | 403     ␣
↪| Subscriber      | 94107
831509  | 1057     | 7/2/2015 10:14  | 2nd at Folsom                | 62            | 7/
↪2/2015 10:31  | South Van Ness at Market                     | 66           | 631     ␣
↪| Subscriber      | 94114
877160  | 306      | 8/5/2015 16:33  | 2nd at Folsom                | 62            | 8/
↪5/2015 16:39  | Beale at Market                              | 56           | 527     ␣
↪| Subscriber      | 94602
768619  | 840      | 5/15/2015 11:35 | 2nd at Folsom                | 62            | 5/
↪15/2015 11:49 | Market at 10th                               | 67           | 604     ␣
↪| Subscriber      | 94903
594999  | 185      | 1/7/2015 17:53  | San Antonio Caltrain Station | 29            | 1/
↪7/2015 17:56  | San Antonio Shopping Center                  | 31           | 176     ␣
↪| Subscriber      | 94040
701211  | 252      | 3/27/2015 16:26 | 2nd at Folsom                | 62            | 3/
↪27/2015 16:30 | Spear at Folsom                              | 49           | 405     ␣
↪| Subscriber      | 94105
487432  | 561      | 10/7/2014 17:48 | 2nd at Folsom                | 62            |␣
↪10/7/2014 17:58 | Commercial at Montgomery                   | 45           | 342     ␣
↪ | Subscriber      | 94107
610970  | 808      | 1/20/2015 13:28 | 2nd at Folsom                | 62            | 1/
↪20/2015 13:42 | Harry Bridges Plaza (Ferry Building)         | 50           | 310     ␣
↪| Subscriber      | 94025
753668  | 196      | 5/5/2015 11:48  | 2nd at Folsom                | 62            | 5/
↪5/2015 11:52  | Temporary Transbay Terminal (Howard at Beale) | 55           | 533     ␣
↪| Subscriber      | 94973
```

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```
466551  | 222      | 9/23/2014 18:12 | 2nd at Folsom                        | 62              | 9/
↪23/2014 18:16 | 2nd at Townsend                        | 61            | 620    ␣
↪| Subscriber      | 94107
... (2578 rows omitted)
```

2.6.9 are.containing()

```
tbl.where(column, are.containing(value))
```

Filter leaves rows only where the value in `column` contains the substring `value`.

[180]:
```
trips.where("End Station", are.containing("at"))
```

[180]:
```
Trip ID | Duration | Start Date      | Start Station                           | Start␣
↪Terminal | End Date        | End Station                           | End Terminal␣
↪| Bike # | Subscriber Type | Zip Code
876419  | 413      | 8/5/2015 8:29    | Civic Center BART (7th at Market)       | 72     ␣
↪         | 8/5/2015 8:36    | Townsend at 7th                       | 65            |␣
↪269    | Subscriber      | 94518
459672  | 408      | 9/18/2014 17:11  | Harry Bridges Plaza (Ferry Building)    | 50     ␣
↪         | 9/18/2014 17:17  | Embarcadero at Sansome                | 60            |␣
↪429    | Subscriber      | 94111
903647  | 723      | 8/25/2015 7:26   | San Francisco Caltrain 2 (330 Townsend) | 69     ␣
↪         | 8/25/2015 7:38   | Market at 10th                        | 67            |␣
↪631    | Subscriber      | 94025
452829  | 409      | 9/15/2014 8:29   | Steuart at Market                       | 74     ␣
↪         | 9/15/2014 8:36   | Market at 4th                         | 76            |␣
↪428    | Subscriber      | 94925
491023  | 224      | 10/9/2014 16:13  | Santa Clara at Almaden                  | 4      ␣
↪         | 10/9/2014 16:17  | San Jose Diridon Caltrain Station     | 2             |␣
↪144    | Subscriber      | 94117
723352  | 519      | 4/13/2015 17:04  | Howard at 2nd                           | 63     ␣
↪         | 4/13/2015 17:12  | San Francisco Caltrain (Townsend at 4th) | 70         |␣
↪629    | Subscriber      | 94061
524499  | 431      | 10/31/2014 16:36 | Townsend at 7th                         | 65     ␣
↪         | 10/31/2014 16:43 | Civic Center BART (7th at Market)     | 72            |␣
↪630    | Subscriber      | 94706
518524  | 389      | 10/28/2014 8:48  | Market at Sansome                       | 77     ␣
↪         | 10/28/2014 8:54  | 2nd at South Park                     | 64            |␣
↪458    | Subscriber      | 94610
793149  | 616      | 6/4/2015 5:26    | Embarcadero at Bryant                   | 54     ␣
↪         | 6/4/2015 5:36    | Embarcadero at Sansome                | 60            |␣
↪289    | Subscriber      | 94105
681771  | 895      | 3/14/2015 11:46  | Market at 10th                          | 67     ␣
↪         | 3/14/2015 12:01  | Market at 4th                         | 76            |␣
↪416    | Subscriber      | 94107
... (78805 rows omitted)
```

2.6.10 are.strictly_between()

```
tbl.where(column, are.strictly_between(x, y))
```

Filter leaves rows only where the value in column is strictly greater than x and less than y (i.e. in the interval (x, y)).

```
[181]: trips.where("Duration", are.strictly_between(100, 200))
```

```
[181]: Trip ID | Duration | Start Date       | Start Station                              |␣
↪Start Terminal | End Date         | End Station                            | End␣
↪Terminal | Bike # | Subscriber Type | Zip Code
437830  | 151      | 9/4/2014 9:13    | Grant Avenue at Columbus Avenue            |␣
↪73             | 9/4/2014 9:15    | Commercial at Montgomery               | 45         ␣
↪ | 306    | Subscriber      | 94104
436255  | 195      | 9/3/2014 11:53   | 2nd at Folsom                              |␣
↪62             | 9/3/2014 11:57   | Spear at Folsom                        | 49         ␣
↪ | 403    | Subscriber      | 94107
585884  | 151      | 12/26/2014 13:34 | Broadway St at Battery St                  |␣
↪82             | 12/26/2014 13:37 | Harry Bridges Plaza (Ferry Building) | 50         ␣
↪ | 576    | Subscriber      | 94107
548322  | 191      | 11/17/2014 20:10 | Yerba Buena Center of the Arts (3rd @ Howard) |␣
↪68             | 11/17/2014 20:13 | Market at Sansome                      | 77         ␣
↪ | 29     | Subscriber      | 94705
594999  | 185      | 1/7/2015 17:53   | San Antonio Caltrain Station               |␣
↪29             | 1/7/2015 17:56   | San Antonio Shopping Center            | 31         ␣
↪ | 176    | Subscriber      | 94040
468534  | 194      | 9/24/2014 19:08  | Mechanics Plaza (Market at Battery)        |␣
↪75             | 9/24/2014 19:11  | Harry Bridges Plaza (Ferry Building) | 50         ␣
↪ | 443    | Subscriber      | 94107
873710  | 169      | 8/3/2015 17:20   | Broadway St at Battery St                  |␣
↪82             | 8/3/2015 17:23   | Embarcadero at Sansome                 | 60         ␣
↪ | 532    | Subscriber      | 94114
853087  | 168      | 7/20/2015 7:27   | Temporary Transbay Terminal (Howard at Beale) |␣
↪55             | 7/20/2015 7:30   | 2nd at Folsom                          | 62         ␣
↪ | 418    | Subscriber      | 94602
863019  | 162      | 7/27/2015 8:31   | Temporary Transbay Terminal (Howard at Beale) |␣
↪55             | 7/27/2015 8:34   | Mechanics Plaza (Market at Battery)   | 75         ␣
↪ | 504    | Subscriber      | 94111
883134  | 173      | 8/10/2015 15:11  | Embarcadero at Folsom                      |␣
↪51             | 8/10/2015 15:14  | Beale at Market                        | 56         ␣
↪ | 363    | Subscriber      | 94117
... (5056 rows omitted)
```

2.7 Miscellaneous Functions

2.7.1 sample_proportions()

```
sample_proportions(sample_size, model_proportions)
```

Samples sample_size objects from the distribution specified by model_proportions. sample_size should be an integer, model_proportions an array of probabilities that sum up to 1. It returns an array with the same size as `model_proportions`. Each item in the array corresponds to the proportion of times it was sampled out of the `sample_size` times.

[182]:
```
sample_proportions(100, [.5, .3, .2])
```

[182]:
```
array([0.32, 0.32, 0.36])
```

2.7.2 minimize()

```
minimize(function)
```

This function returns an array of values that minimize `function`. `function` should be a function that takes in a certain number of arguments and returns a number. The array returned by `minimize` is structured such that if each value in the array was passed into function as arguments, it would minimize the output value of function.

[190]:
```
def f(x, y):
    return 0.47 * x**2 + 1.23 * np.log(y)

minimize(f)
```

[190]:
```
array([ 5.17585792, -0.58835469])
```

CHAPTER

THREE

REFERENCE

3.1 Tables (datascience.tables)

Summary of methods for Table. Click a method to see its documentation.

One note about reading the method signatures for this page: each method is listed with its arguments. However, optional arguments are specified in brackets. That is, a method that's documented like

`Table.foo` (first_arg, second_arg[, some_other_arg, fourth_arg])

means that the `Table.foo` method must be called with first_arg and second_arg and optionally some_other_arg and fourth_arg. That means the following are valid ways to call `Table.foo`:

```
some_table.foo(1, 2)
some_table.foo(1, 2, 'hello')
some_table.foo(1, 2, 'hello', 'world')
some_table.foo(1, 2, some_other_arg='hello')
```

But these are not valid:

```
some_table.foo(1) # Missing arg
some_table.foo(1, 2[, 'hi']) # SyntaxError
some_table.foo(1, 2[, 'hello', 'world']) # SyntaxError
```

If that syntax is confusing, you can click the method name itself to get to the details page for that method. That page will have a more straightforward syntax.

Creation

Table.__init__([labels, formatter])	Create an empty table with column labels.
Table.from_records(records)	Create a table from a sequence of records (dicts with fixed keys).
Table.from_columns_dict(columns)	Create a table from a mapping of column labels to column values.
Table.read_table(filepath_or_buffer, *args, ...)	Read a table from a file or web address.
Table.from_df(df[, keep_index])	Convert a Pandas DataFrame into a Table.
Table.from_array(arr)	Convert a structured NumPy array into a Table.

3.1.1 datascience.tables.Table.__init__

`Table.__init__`(*labels=None*, *formatter=<datascience.formats.Formatter object>*)

Create an empty table with column labels.

```
>>> tiles = Table(make_array('letter', 'count', 'points'))
>>> tiles
letter | count | points
```

Args:

`labels` (list of strings): The column labels.

`formatter` (Formatter): An instance of `Formatter` that
formats the columns' values.

3.1.2 datascience.tables.Table.from_records

classmethod `Table.from_records`(*records*)

Create a table from a sequence of records (dicts with fixed keys).

Args:

records: A list of dictionaries with same keys.

Returns:

If the list is empty, it will return an empty table. Otherwise, it will return a table with the dictionary's keys as the column name, and the corresponding data. If the dictionaries do not have identical keys, the keys of the first dictionary in the list is used.

Example:

```
>>> t = Table().from_records([
...     {'column1':'data1','column2':1},
...     {'column1':'data2','column2':2},
...     {'column1':'data3','column2':3}
... ])
>>> t
column1 | column2
data1   | 1
data2   | 2
data3   | 3
```

3.1.3 datascience.tables.Table.from_columns_dict

classmethod `Table.from_columns_dict`(*columns*)

Create a table from a mapping of column labels to column values. [Deprecated]

3.1.4 datascience.tables.Table.read_table

classmethod `Table.read_table`(*filepath_or_buffer*, **args*, ***vargs*)

Read a table from a file or web address.

Args:

filepath_or_buffer – string or file handle / StringIO; The string
could be a URL. Valid URL schemes include http, ftp, s3, and file.

Returns:
a table read from argument

Example:

```
>>> Table.read_table('https://www.inferentialthinking.com/data/sat2014.csv')
State        | Participation Rate | Critical Reading | Math | Writing | Combined
North Dakota | 2.3                | 612              | 620  | 584     | 1816
Illinois     | 4.6                | 599              | 616  | 587     | 1802
Iowa         | 3.1                | 605              | 611  | 578     | 1794
South Dakota | 2.9                | 604              | 609  | 579     | 1792
Minnesota    | 5.9                | 598              | 610  | 578     | 1786
Michigan     | 3.8                | 593              | 610  | 581     | 1784
Wisconsin    | 3.9                | 596              | 608  | 578     | 1782
Missouri     | 4.2                | 595              | 597  | 579     | 1771
Wyoming      | 3.3                | 590              | 599  | 573     | 1762
Kansas       | 5.3                | 591              | 596  | 566     | 1753
... (41 rows omitted)
```

3.1.5 datascience.tables.Table.from_df

classmethod `Table.from_df`(*df*, *keep_index=False*)

Convert a Pandas DataFrame into a Table.

Args:

df – Pandas DataFrame utilized for creation of Table

keep_index – keeps the index of the DataFrame and turns it into a column called *index* in the new Table

Returns:
a table from Pandas Dataframe in argument

Example:

```
>>> sample_DF = pandas.DataFrame(
...             data = zip([1,2,3],['a','b','c'],['data1','data2','data3']),
...             columns = ['column1','column2','column3']
...             )
```

```
>>> sample_DF
   column1 column2 column3
0        1       a   data1
```

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```
1         2        b    data2
2         3        c    data3
```

```
>>> t = Table().from_df(sample_DF)
```

```
>>> t
column1 | column2 | column3
1       | a       | data1
2       | b       | data2
3       | c       | data3
```

3.1.6 datascience.tables.Table.from_array

classmethod Table.**from_array**(*arr*)

Convert a structured NumPy array into a Table.

Args:

arr – A structured NumPy array

Returns:

A table with the field names as the column names and the corresponding data.

Example:

```
>>> arr = np.array([
...       ('A',1), ('B',2)],
...       dtype=[('Name', 'U10'), ('Number', 'i4')]
...       )
```

```
>>> arr
array([('A', 1), ('B', 2)], dtype=[('Name', '<U10'), ('Number', '<i4')])
```

```
>>> t = Table().from_array(arr)
```

```
>>> t
Name | Number
A    | 1
B    | 2
```

Extension (does not modify original table)

Table.with_column(label, values[, formatter])	Return a new table with an additional or replaced column.
Table.with_columns(*labels_and_values, ...)	Return a table with additional or replaced columns.
Table.with_row(row)	Return a table with an additional row.
Table.with_rows(rows)	Return a table with additional rows.
Table.relabeled(label, new_label)	Return a new table with `label` specifying column label(s) replaced by corresponding `new_label`.

3.1.7 datascience.tables.Table.with_column

Table.**with_column**(*label*, *values*, *formatter=None*)

Return a new table with an additional or replaced column.

Args:

label (str): The column label. If an existing label is used,
the existing column will be replaced in the new table.

values (single value or sequence): If a single value, every
value in the new column is values. If sequence of values, new column takes on values in values.

formatter (single value): Specifies formatter for the new column. Defaults to no formatter.

Raises:

ValueError: If

- label is not a valid column name
- if label is not of type (str)
- **values is a list/array that does not have the same**
  length as the number of rows in the table.

Returns:
copy of original table with new or replaced column

```
>>> alphabet = Table().with_column('letter', make_array('c','d'))
>>> alphabet = alphabet.with_column('count', make_array(2, 4))
>>> alphabet
letter | count
c      | 2
d      | 4
>>> alphabet.with_column('permutes', make_array('a', 'g'))
letter | count | permutes
c      | 2     | a
d      | 4     | g
>>> alphabet
letter | count
c      | 2
d      | 4
>>> alphabet.with_column('count', 1)
letter | count
c      | 1
d      | 1
>>> alphabet.with_column(1, make_array(1, 2))
Traceback (most recent call last):
    ...
ValueError: The column label must be a string, but a int was given
>>> alphabet.with_column('bad_col', make_array(1))
Traceback (most recent call last):
    ...
ValueError: Column length mismatch. New column does not have the same number of
↪rows as table.
```

3.1.8 datascience.tables.Table.with_columns

`Table.with_columns(*labels_and_values, **formatter)`

Return a table with additional or replaced columns.

Args:

`labels_and_values`: An alternating list of labels and values
or a list of label-value pairs. If one of the labels is in existing table, then every value in the corresponding column is set to that value. If label has only a single value (`int`), every row of corresponding column takes on that value.

''formatter'' (single Formatter value): A single formatter value
that will be applied to all columns being added using this function call.

Raises:

`ValueError`: If

- **any label in `labels_and_values` is not a valid column**
name, i.e if label is not of type (str).
- **if any value in `labels_and_values` is a list/array and**
does not have the same length as the number of rows in the table.

`AssertionError`:

- **'incorrect columns format', if passed more than one sequence**
(iterables) for `labels_and_values`.
- **'even length sequence required' if missing a pair in**
label-value pairs.

Returns:
Copy of original table with new or replaced columns. Columns added in order of labels. Equivalent to `with_column(label, value)` when passed only one label-value pair.

```
>>> players = Table().with_columns('player_id',
...     make_array(110234, 110235), 'wOBA', make_array(.354, .236))
>>> players
player_id | wOBA
110234    | 0.354
110235    | 0.236
>>> players = players.with_columns('salaries', 'N/A', 'season', 2016)
>>> players
player_id | wOBA  | salaries | season
110234    | 0.354 | N/A      | 2016
110235    | 0.236 | N/A      | 2016
>>> salaries = Table().with_column('salary',
...     make_array(500000, 15500000))
>>> players.with_columns('salaries', salaries.column('salary'),
...     'bonus', make_array(6, 1), formatter=_formats.CurrencyFormatter)
player_id | wOBA  | salaries    | season | bonus
110234    | 0.354 | $500,000    | 2016   | $6
110235    | 0.236 | $15,500,000 | 2016   | $1
>>> players.with_columns(2, make_array('$600,000', '$20,000,000'))
Traceback (most recent call last):
    ...
```

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```
ValueError: The column label must be a string, but a int was given
>>> players.with_columns('salaries', make_array('$600,000'))
Traceback (most recent call last):
    ...
ValueError: Column length mismatch. New column does not have the same number of␣
↪rows as table.
```

3.1.9 datascience.tables.Table.with_row

`Table.with_row(row)`

Return a table with an additional row.

Args:

`row` (sequence): A value for each column.

Raises:

`ValueError`: If the row length differs from the column count.

```
>>> tiles = Table(make_array('letter', 'count', 'points'))
>>> tiles.with_row(['c', 2, 3]).with_row(['d', 4, 2])
letter | count | points
c      | 2     | 3
d      | 4     | 2
```

3.1.10 datascience.tables.Table.with_rows

`Table.with_rows(rows)`

Return a table with additional rows.

Args:

`rows` (sequence of sequences): Each row has a value per column.

If `rows` is a 2-d array, its shape must be (_, n) for n columns.

Raises:

`ValueError`: If a row length differs from the column count.

```
>>> tiles = Table(make_array('letter', 'count', 'points'))
>>> tiles.with_rows(make_array(make_array('c', 2, 3),
...     make_array('d', 4, 2)))
letter | count | points
c      | 2     | 3
d      | 4     | 2
```

3.1.11 datascience.tables.Table.relabeled

Table.**relabeled**(*label*, *new_label*)

Return a new table with label specifying column label(s) replaced by corresponding new_label.

Args:

label – (str or array of str) The label(s) of
columns to be changed.

new_label – (str or array of str): The new label(s) of
columns to be changed. Same number of elements as label.

Raises:

ValueError – if label does not exist in
table, or if the label and new_label are not not of equal length. Also, raised if label and/or new_label are not str.

Returns:
New table with new_label in place of label.

```
>>> tiles = Table().with_columns('letter', make_array('c', 'd'),
...     'count', make_array(2, 4))
>>> tiles
letter | count
c      | 2
d      | 4
>>> tiles.relabeled('count', 'number')
letter | number
c      | 2
d      | 4
>>> tiles  # original table unmodified
letter | count
c      | 2
d      | 4
>>> tiles.relabeled(make_array('letter', 'count'),
...   make_array('column1', 'column2'))
column1 | column2
c       | 2
d       | 4
>>> tiles.relabeled(make_array('letter', 'number'),
...  make_array('column1', 'column2'))
Traceback (most recent call last):
    ...
ValueError: Invalid labels. Column labels must already exist in table in order to␣
↪be replaced.
```

Accessing values

Table.num_columns	Number of columns.
Table.columns	Return a tuple of columns, each with the values in that column.
Table.column(index_or_label)	Return the values of a column as an array.
Table.num_rows	Computes the number of rows in a table
Table.rows	Return a view of all rows.
Table.row(index)	Return a row.
Table.labels	Return a tuple of column labels.
Table.first(label)	Return the zeroth item in a column.
Table.last(label)	Return the last item in a column.
Table.values	Return data in *self* as a numpy array.
Table.column_index(label)	Return the index of a column by looking up its label.
Table.apply(fn, *column_or_columns)	Apply `fn` to each element or elements of `column_or_columns`.

3.1.12 datascience.tables.Table.num_columns

property Table.**num_columns**

Number of columns.

3.1.13 datascience.tables.Table.columns

property Table.**columns**

Return a tuple of columns, each with the values in that column.

Returns:
tuple of columns

Example:

```
>>> t = Table().with_columns({
...     'letter': ['a', 'b', 'c', 'z'],
...     'count':  [  9,   3,   3,   1],
...     'points': [  1,   2,   2,  10],
... })
>>> t.columns
(array(['a', 'b', 'c', 'z'], dtype='<U1'),
array([9, 3, 3, 1]),
array([ 1,  2,  2, 10]))
```

3.1.14 datascience.tables.Table.column

Table.**column**(*index_or_label*)

Return the values of a column as an array.

table.column(label) is equivalent to table[label].

```
>>> tiles = Table().with_columns(
...     'letter', make_array('c', 'd'),
```

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```
...     'count',  make_array(2, 4),
... )
```

```
>>> list(tiles.column('letter'))
['c', 'd']
>>> tiles.column(1)
array([2, 4])
```

Args:
label (int or str): The index or label of a column

Returns:
An instance of `numpy.array`.

Raises:
`ValueError`: When the `index_or_label` is not in the table.

3.1.15 datascience.tables.Table.num_rows

property `Table.num_rows`

Computes the number of rows in a table

Returns:
integer value stating number of rows

Example:

```
>>> t = Table().with_columns({
...     'letter': ['a', 'b', 'c', 'z'],
...     'count':  [  9,   3,   3,   1],
...     'points': [  1,   2,   2,  10],
... })
>>> t.num_rows
4
```

3.1.16 datascience.tables.Table.rows

property `Table.rows`

Return a view of all rows.

Returns:
list-like Rows object that contains tuple-like Row objects

Example:

```
>>> t = Table().with_columns({
...     'letter': ['a', 'b', 'c', 'z'],
...     'count':  [  9,   3,   3,   1],
...     'points': [  1,   2,   2,  10],
... })
>>> t.rows
Rows(letter | count | points
```

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```
a       | 9       | 1
b       | 3       | 2
c       | 3       | 2
z       | 1       | 10)
```

3.1.17 datascience.tables.Table.row

Table.**row**(*index*)

Return a row.

Please see extended docstring at https://github.com/data-8/datascience/blob/614db00e7d22e52683860d2beaa4037bec26cf87/datascience/tables.py#L5673-L5765 for how to interact with Rows.

3.1.18 datascience.tables.Table.labels

property Table.**labels**

Return a tuple of column labels.

Returns:
tuple of labels

Example:

```
>>> t = Table().with_columns({
...     'letter': ['a', 'b', 'c', 'z'],
...     'count':  [  9,   3,   3,   1],
...     'points': [  1,   2,   2,  10],
... })
>>> t.labels
('letter', 'count', 'points')
```

3.1.19 datascience.tables.Table.first

Table.**first**(*label*)

Return the zeroth item in a column.

Args:
`label` (str) – value of column label

Returns:
zeroth item of column

Example:

```
>>> t = Table().with_columns({
...     'letter': ['a', 'b', 'c', 'z'],
...     'count':  [  9,   3,   3,   1],
...     'points': [  1,   2,   2,  10],
... })
```

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```
>>> t.first('letter')
'a'
```

3.1.20 datascience.tables.Table.last

`Table.last(label)`

Return the last item in a column.

Args:
`label` (str) – value of column label

Returns:
last item of column

Example:

```
>>> t = Table().with_columns({
...     'letter': ['a', 'b', 'c', 'z'],
...     'count':  [  9,   3,   3,   1],
...     'points': [  1,   2,   2,  10],
... })
>>> t.last('letter')
'z'
```

3.1.21 datascience.tables.Table.values

property `Table.values`

Return data in *self* as a numpy array.

If all columns are the same dtype, the resulting array will have this dtype. If there are >1 dtypes in columns, then the resulting array will have dtype *object*.

Example:

```
>>> tiles = Table().with_columns(
...     'letter', make_array('c', 'd'),
...     'count',  make_array(2, 4),
... )
>>> tiles.values
array([['c', 2],
   ['d', 4]], dtype=object)
>>> t = Table().with_columns(
...     'col1', make_array(1, 2),
...     'col2', make_array(3, 4),
... )
>>> t.values
array([[1, 3],
   [2, 4]])
```

3.1.22 datascience.tables.Table.column_index

`Table.column_index(label)`

Return the index of a column by looking up its label.

Args:
`label` (str) – label value of a column

Returns:
integer value specifying the index of the column label

Example:

```
>>> t = Table().with_columns({
...     'letter': ['a', 'b', 'c', 'z'],
...     'count':  [  9,   3,   3,   1],
...     'points': [  1,   2,   2,  10],
... })
>>> t.column_index('letter')
0
```

3.1.23 datascience.tables.Table.apply

`Table.apply(fn, *column_or_columns)`

Apply `fn` to each element or elements of `column_or_columns`. If no `column_or_columns` provided, *fn*` is applied to each row.

Args:

`fn` (function) – The function to apply to each element
of `column_or_columns`.

`column_or_columns` – Columns containing the arguments to `fn`
as either column labels (`str`) or column indices (`int`). The number of columns must match the number of arguments that `fn` expects.

Raises:

`ValueError` – if `column_label` is not an existing
column in the table.

`TypeError` – if insufficient number of `column_label` passed
to `fn`.

Returns:
An array consisting of results of applying `fn` to elements specified by `column_label` in each row.

```
>>> t = Table().with_columns(
...     'letter', make_array('a', 'b', 'c', 'z'),
...     'count',  make_array(9, 3, 3, 1),
...     'points', make_array(1, 2, 2, 10))
>>> t
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
```

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```
z      | 1      | 10
>>> t.apply(lambda x: x - 1, 'points')
array([0, 1, 1, 9])
>>> t.apply(lambda x, y: x * y, 'count', 'points')
array([ 9,  6,  6, 10])
>>> t.apply(lambda x: x - 1, 'count', 'points')
Traceback (most recent call last):
    ...
TypeError: <lambda>() takes 1 positional argument but 2 were given
>>> t.apply(lambda x: x - 1, 'counts')
Traceback (most recent call last):
    ...
ValueError: The column "counts" is not in the table. The table contains these␣
↪columns: letter, count, points
```

Whole rows are passed to the function if no columns are specified.

```
>>> t.apply(lambda row: row[1] * 2)
array([18,  6,  6,  2])
```

Mutation (modifies table in place)

Table.set_format(column_or_columns, formatter)	Set the pretty print format of a column(s) and/or convert its values.
Table.move_to_start(column_label)	Move a column to be the first column.
Table.move_to_end(column_label)	Move a column to be the last column.
Table.append(row_or_table)	Append a row or all rows of a table in place.
Table.append_column(label, values[, formatter])	Appends a column to the table or replaces a column.
Table.relabel(column_label, new_label)	Changes the label(s) of column(s) specified by `column_label` to labels in `new_label`.
Table.remove(row_or_row_indices)	Removes a row or multiple rows of a table in place (row number is 0 indexed).

3.1.24 datascience.tables.Table.set_format

`Table.`**`set_format`**(*column_or_columns*, *formatter*)

Set the pretty print format of a column(s) and/or convert its values.

Args:

`column_or_columns`: values to group (column label or index, or array)

`formatter`: a function applied to a single value within the
`column_or_columns` at a time or a formatter class, or formatter class instance.

Returns:

A Table with `formatter` applied to each `column_or_columns`.

The following example formats the column "balance" by passing in a formatter class instance. The formatter is run each time `__repr__` is called. So, while the table is formatted upon being printed to the console, the underlying values within the table remain untouched. It's worth noting that while `set_format` returns the table with the new formatters applied, this change is applied directly to the original table and then the original table is returned. This means `set_format` is what's known as an inplace operation.

```
>>> account_info = Table().with_columns(
...     "user", make_array("gfoo", "bbar", "tbaz", "hbat"),
...     "balance", make_array(200, 555, 125, 430))
>>> account_info
user | balance
gfoo | 200
bbar | 555
tbaz | 125
hbat | 430
>>> from datascience.formats import CurrencyFormatter
>>> account_info.set_format("balance", CurrencyFormatter("BZ$")) # Belize Dollar
user | balance
gfoo | BZ$200
bbar | BZ$555
tbaz | BZ$125
hbat | BZ$430
>>> account_info["balance"]
array([200, 555, 125, 430])
>>> account_info
user | balance
gfoo | BZ$200
bbar | BZ$555
tbaz | BZ$125
hbat | BZ$430
```

The following example formats the column "balance" by passing in a formatter function.

```
>>> account_info = Table().with_columns(
...     "user", make_array("gfoo", "bbar", "tbaz", "hbat"),
...     "balance", make_array(200, 555, 125, 430))
>>> account_info
user | balance
gfoo | 200
bbar | 555
tbaz | 125
hbat | 430
>>> def iceland_krona_formatter(value):
...     return f"{value} kr"
>>> account_info.set_format("balance", iceland_krona_formatter)
user | balance
gfoo | 200 kr
bbar | 555 kr
tbaz | 125 kr
hbat | 430 kr
```

The following, formats the column "balance" by passing in a formatter class. Note the formatter class must have a Boolean `converts_values` attribute set and a `format_column` method that returns a function that formats a single value at a time. The `format_column` method accepts the name of the column and the value of the column as arguments and returns a formatter function that accepts a value and Boolean indicating whether that value is the column name. In the following example, if the `if label: return value` was removed, the column name "balance" would be formatted and printed as "balance kr". The `converts_values` attribute should be set to False unless a `convert_values` method is also defined on the formatter class.

```
>>> account_info = Table().with_columns(
...     "user", make_array("gfoo", "bbar", "tbaz", "hbat"),
...     "balance", make_array(200, 555, 125, 430))
>>> account_info
user | balance
gfoo | 200
bbar | 555
tbaz | 125
hbat | 430
>>> class IcelandKronaFormatter():
...     def __init__(self):
...         self.converts_values = False
...
...     def format_column(self, label, column):
...         def format_krona(value, label):
...             if label:
...                 return value
...             return f"{value} kr"
...
...         return format_krona
>>> account_info.set_format("balance", IcelandKronaFormatter)
user | balance
gfoo | 200 kr
bbar | 555 kr
tbaz | 125 kr
hbat | 430 kr
>>> account_info["balance"]
array([200, 555, 125, 430])
```

set_format can also be used to convert values. If you set the converts_values attribute to True and define a convert_column method that accepts the column values and returns the converted column values on the formatter class, the column values will be permanently converted to the new column values in a one time operation.

```
>>> account_info = Table().with_columns(
...     "user", make_array("gfoo", "bbar", "tbaz", "hbat"),
...     "balance", make_array(200.01, 555.55, 125.65, 430.18))
>>> account_info
user | balance
gfoo | 200.01
bbar | 555.55
tbaz | 125.65
hbat | 430.18
>>> class IcelandKronaFormatter():
...     def __init__(self):
...         self.converts_values = True
...
...     def format_column(self, label, column):
...         def format_krona(value, label):
...             if label:
...                 return value
...             return f"{value} kr"
...
```

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```
...         return format_krona
...
...     def convert_column(self, values):
...         # Drop the fractional kr.
...         return values.astype(int)
>>> account_info.set_format("balance", IcelandKronaFormatter)
user | balance
gfoo | 200 kr
bbar | 555 kr
tbaz | 125 kr
hbat | 430 kr
>>> account_info
user | balance
gfoo | 200 kr
bbar | 555 kr
tbaz | 125 kr
hbat | 430 kr
>>> account_info["balance"]
array([200, 555, 125, 430])
```

In the following example, multiple columns are configured to use the same formatter. Note the following formatter takes into account the length of all values in the column and formats them to be the same character length. This is something that the default table formatter does for you but, if you write a custom formatter, you must do yourself.

```
>>> account_info = Table().with_columns(
...     "user", make_array("gfoo", "bbar", "tbaz", "hbat"),
...     "checking", make_array(200, 555, 125, 430),
...     "savings", make_array(1000, 500, 1175, 6700))
>>> account_info
user | checking | savings
gfoo | 200      | 1000
bbar | 555      | 500
tbaz | 125      | 1175
hbat | 430      | 6700
>>> class IcelandKronaFormatter():
...     def __init__(self):
...         self.converts_values = False
...
...     def format_column(self, label, column):
...         val_width = max([len(str(v)) + len(" kr") for v in column])
...         val_width = max(len(str(label)), val_width)
...
...         def format_krona(value, label):
...             if label:
...                 return value
...             return f"{value} kr".ljust(val_width)
...
...         return format_krona
>>> account_info.set_format(["checking", "savings"], IcelandKronaFormatter)
user | checking | savings
gfoo | 200 kr   | 1000 kr
bbar | 555 kr   | 500 kr
```

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```
tbaz | 125 kr   | 1175 kr
hbat | 430 kr   | 6700 kr
```

3.1.25 datascience.tables.Table.move_to_start

`Table.move_to_start(column_label)`

Move a column to be the first column.

The following example moves column C to be the first column. Note, move_to_start not only returns the original table with the column moved but, it also moves the column in the original. This is what's known as an inplace operation.

```
>>> table = Table().with_columns(
...     "A", make_array(1, 2, 3, 4),
...     "B", make_array("foo", "bar", "baz", "bat"),
...     "C", make_array('a', 'b', 'c', 'd'))
>>> table
A    | B    | C
1    | foo  | a
2    | bar  | b
3    | baz  | c
4    | bat  | d
>>> table.move_to_start("C")
C    | A    | B
a    | 1    | foo
b    | 2    | bar
c    | 3    | baz
d    | 4    | bat
>>> table
C    | A    | B
a    | 1    | foo
b    | 2    | bar
c    | 3    | baz
d    | 4    | bat
```

3.1.26 datascience.tables.Table.move_to_end

`Table.move_to_end(column_label)`

Move a column to be the last column.

The following example moves column A to be the last column. Note, move_to_end not only returns the original table with the column moved but, it also moves the column in the original. This is what's known as an inplace operation.

```
>>> table = Table().with_columns(
...     "A", make_array(1, 2, 3, 4),
...     "B", make_array("foo", "bar", "baz", "bat"),
...     "C", make_array('a', 'b', 'c', 'd'))
>>> table
A    | B    | C
```

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```
1    | foo  | a
2    | bar  | b
3    | baz  | c
4    | bat  | d
>>> table.move_to_end("A")
B    | C    | A
foo  | a    | 1
bar  | b    | 2
baz  | c    | 3
bat  | d    | 4
>>> table
B    | C    | A
foo  | a    | 1
bar  | b    | 2
baz  | c    | 3
bat  | d    | 4
```

3.1.27 datascience.tables.Table.append

Table.**append**(*row_or_table*)

Append a row or all rows of a table in place. An appended table must have all columns of self.

The following example appends a row record to the table, followed by appending a table having all columns of self.

```
>>> table = Table().with_columns(
...     "A", make_array(1),
...     "B", make_array("foo"),
...     "C", make_array('a'))
>>> table
A    | B    | C
1    | foo  | a
>>> table.append([2, "bar", 'b'])
A    | B    | C
1    | foo  | a
2    | bar  | b
>>> table
A    | B    | C
1    | foo  | a
2    | bar  | b
>>> table.append(Table().with_columns(
...     "A", make_array(3, 4),
...     "B", make_array("baz", "bat"),
...     "C", make_array('c', 'd')))
A    | B    | C
1    | foo  | a
2    | bar  | b
3    | baz  | c
4    | bat  | d
>>> table
A    | B    | C
```

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```
1     | foo   | a
2     | bar   | b
3     | baz   | c
4     | bat   | d
```

3.1.28 datascience.tables.Table.append_column

`Table.append_column`(*label*, *values*, *formatter=None*)

Appends a column to the table or replaces a column.

`__setitem__` is aliased to this method:
`table.append_column('new_col', make_array(1, 2, 3))` is equivalent to `table['new_col'] = make_array(1, 2, 3)`.

Args:
`label` (str): The label of the new column.

`values` (single value or list/array): If a single value, every
value in the new column is `values`.

If a list or array, the new column contains the values in `values`, which must be the same length as the table.

`formatter` (single formatter): Adds a formatter to the column being
appended. No formatter added by default.

Returns:
Original table with new or replaced column

Raises:

`ValueError`: If

- `label` is not a string.
- `values` is a list/array and does not have the same length as the number of rows in the table.

```
>>> table = Table().with_columns(
...     'letter', make_array('a', 'b', 'c', 'z'),
...     'count',  make_array(9, 3, 3, 1),
...     'points', make_array(1, 2, 2, 10))
>>> table
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10
>>> table.append_column('new_col1', make_array(10, 20, 30, 40))
letter | count | points | new_col1
a      | 9     | 1      | 10
b      | 3     | 2      | 20
c      | 3     | 2      | 30
z      | 1     | 10     | 40
>>> table.append_column('new_col2', 'hello')
letter | count | points | new_col1 | new_col2
```

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```
a      | 9     | 1       | 10         | hello
b      | 3     | 2       | 20         | hello
c      | 3     | 2       | 30         | hello
z      | 1     | 10      | 40         | hello
>>> table.append_column(123, make_array(1, 2, 3, 4))
Traceback (most recent call last):
    ...
ValueError: The column label must be a string, but a int was given
>>> table.append_column('bad_col', [1, 2])
Traceback (most recent call last):
    ...
ValueError: Column length mismatch. New column does not have the same number of␣
↪rows as table.
```

3.1.29 datascience.tables.Table.relabel

Table.**relabel**(*column_label*, *new_label*)

Changes the label(s) of column(s) specified by `column_label` to labels in `new_label`.

Args:

`column_label` – (single str or array of str) The label(s) of columns to be changed to `new_label`.

`new_label` – (single str or array of str): The label name(s) of columns to replace `column_label`.

Raises:

`ValueError` – if `column_label` is not in table, or if `column_label` and `new_label` are not of equal length.

`TypeError` – if `column_label` and/or `new_label` is not `str`.

Returns:

Original table with `new_label` in place of `column_label`.

```
>>> table = Table().with_columns(
...     'points', make_array(1, 2, 3),
...     'id',     make_array(12345, 123, 5123))
>>> table.relabel('id', 'yolo')
points | yolo
1      | 12345
2      | 123
3      | 5123
>>> table.relabel(make_array('points', 'yolo'),
...   make_array('red', 'blue'))
red  | blue
1    | 12345
2    | 123
3    | 5123
>>> table.relabel(make_array('red', 'green', 'blue'),
...   make_array('cyan', 'magenta', 'yellow', 'key'))
```

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```
Traceback (most recent call last):
    ...
ValueError: Invalid arguments. column_label and new_label must be of equal length.
```

3.1.30 datascience.tables.Table.remove

Table.**remove**(*row_or_row_indices*)

Removes a row or multiple rows of a table in place (row number is 0 indexed). If row_or_row_indices is not int or list, no changes will be made to the table.

The following example removes 2nd row (row_or_row_indices = 1), followed by removing 2nd and 3rd rows (row_or_row_indices = [1, 2]).

```
>>> table = Table().with_columns(
...     "A", make_array(1, 2, 3, 4),
...     "B", make_array("foo", "bar", "baz", "bat"),
...     "C", make_array('a', 'b', 'c', 'd'))
>>> table
A    | B    | C
1    | foo  | a
2    | bar  | b
3    | baz  | c
4    | bat  | d
>>> table.remove(1)
A    | B    | C
1    | foo  | a
3    | baz  | c
4    | bat  | d
>>> table
A    | B    | C
1    | foo  | a
3    | baz  | c
4    | bat  | d
>>> table.remove([1, 2])
A    | B    | C
1    | foo  | a
>>> table
A    | B    | C
1    | foo  | a
```

Transformation (creates a new table)

Table.copy(*[, shallow])	Return a copy of a table.
Table.select(*column_or_columns)	Return a table with only the columns in `column_or_columns`.
Table.drop(*column_or_columns)	Return a Table with only columns other than selected label or labels.
Table.take()	Return a new Table with selected rows taken by index.
Table.exclude()	Return a new Table without a sequence of rows excluded by number.
Table.move_column(label, index)	Returns a new table with specified column moved to the specified column index.
Table.where(column_or_label[, ...])	Return a new `Table` containing rows where `value_or_predicate` returns True for values in `column_or_label`.
Table.sort(column_or_label[, descending, ...])	Return a Table of rows sorted according to the values in a column.
Table.group(column_or_label[, collect])	Group rows by unique values in a column; count or aggregate others.
Table.groups(labels[, collect])	Group rows by multiple columns, count or aggregate others.
Table.pivot(columns, rows[, values, ...])	Generate a table with a column for each unique value in `columns`, with rows for each unique value in `rows`.
Table.stack(key[, labels])	Takes k original columns and returns two columns, with col.
Table.join(column_label, other[, other_label])	Creates a new table with the columns of self and other, containing rows for all values of a column that appear in both tables.
Table.stats([ops])	Compute statistics for each column and place them in a table.
Table.percentile(p)	Return a new table with one row containing the pth percentile for each column.
Table.sample([k, with_replacement, weights])	Return a new table where k rows are randomly sampled from the original table.
Table.shuffle()	Return a new table where all the rows are randomly shuffled from the original table.
Table.sample_from_distribution(distribution, k)	Return a new table with the same number of rows and a new column.
Table.split(k)	Return a tuple of two tables where the first table contains `k` rows randomly sampled and the second contains the remaining rows.
Table.bin(*columns, **vargs)	Group values by bin and compute counts per bin by column.
Table.pivot_bin(pivot_columns, value_column)	Form a table with columns formed by the unique tuples in pivot_columns containing counts per bin of the values associated with each tuple in the value_column.
Table.relabeled(label, new_label)	Return a new table with `label` specifying column label(s) replaced by corresponding `new_label`.
Table.with_row(row)	Return a table with an additional row.
Table.with_rows(rows)	Return a table with additional rows.
Table.with_column(label, values[, formatter])	Return a new table with an additional or replaced column.
Table.with_columns(*labels_and_values, ...)	Return a table with additional or replaced columns.

3.1.31 datascience.tables.Table.copy

Table.**copy**(*, *shallow=False*)

Return a copy of a table.

Args:
shallow: perform a shallow copy

Returns:
A copy of the table.

By default, copy performs a deep copy of the original table. This means that it constructs a new object and recursively inserts copies into it of the objects found in the original. Note in the following example, table_copy is a deep copy of original_table so when original_table is updated it does not change table_copy as it does not contain reference's to orignal_tables objects due to the deep copy.

```
>>> value = ["foo"]
>>> original_table = Table().with_columns(
...     "A", make_array(1, 2, 3),
...     "B", make_array(value, ["foo", "bar"], ["foo"]),
... )
>>> original_table
A    | B
1    | ['foo']
2    | ['foo', 'bar']
3    | ['foo']
>>> table_copy = original_table.copy()
>>> table_copy
A    | B
1    | ['foo']
2    | ['foo', 'bar']
3    | ['foo']
>>> value.append("bar")
>>> original_table
A    | B
1    | ['foo', 'bar']
2    | ['foo', 'bar']
3    | ['foo']
>>> table_copy
A    | B
1    | ['foo']
2    | ['foo', 'bar']
3    | ['foo']
```

By contrast, when a shallow copy is performed, a new object is constructed and references are inserted into it to the objects found in the original. Note in the following example how the update to original_table occurs in both table_shallow_copy and original_table because table_shallow_copy contains references to the original_table.

```
>>> value = ["foo"]
>>> original_table = Table().with_columns(
...     "A", make_array(1, 2, 3),
...     "B", make_array(value, ["foo", "bar"], ["foo"]),
... )
>>> original_table
A    | B
```

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```
1    | ['foo']
2    | ['foo', 'bar']
3    | ['foo']
>>> table_shallow_copy = original_table.copy(shallow=True)
>>> table_shallow_copy
A    | B
1    | ['foo']
2    | ['foo', 'bar']
3    | ['foo']
>>> value.append("bar")
>>> original_table
A    | B
1    | ['foo', 'bar']
2    | ['foo', 'bar']
3    | ['foo']
>>> table_shallow_copy
A    | B
1    | ['foo', 'bar']
2    | ['foo', 'bar']
3    | ['foo']
```

3.1.32 datascience.tables.Table.select

Table.**select**(**column_or_columns*)

Return a table with only the columns in column_or_columns.

Args:

column_or_columns: Columns to select from the Table as either column labels (str) or column indices (int).

Returns:

A new instance of Table containing only selected columns. The columns of the new Table are in the order given in column_or_columns.

Raises:

KeyError if any of column_or_columns are not in the table.

```
>>> flowers = Table().with_columns(
...     'Number of petals', make_array(8, 34, 5),
...     'Name', make_array('lotus', 'sunflower', 'rose'),
...     'Weight', make_array(10, 5, 6)
... )
```

```
>>> flowers
Number of petals | Name      | Weight
8                | lotus     | 10
34               | sunflower | 5
5                | rose      | 6
```

```
>>> flowers.select('Number of petals', 'Weight')
Number of petals | Weight
```

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```
8                | 10
34               | 5
5                | 6
```

```
>>> flowers  # original table unchanged
Number of petals | Name      | Weight
8                | lotus     | 10
34               | sunflower | 5
5                | rose      | 6
```

```
>>> flowers.select(0, 2)
Number of petals | Weight
8                | 10
34               | 5
5                | 6
```

3.1.33 datascience.tables.Table.drop

`Table.drop(*column_or_columns)`

Return a Table with only columns other than selected label or labels.

Args:

`column_or_columns` (string or list of strings): The header names or indices of the columns to be dropped.

`column_or_columns` must be an existing header name, or a valid column index.

Returns:

An instance of `Table` with given columns removed.

```
>>> t = Table().with_columns(
...     'burgers',  make_array('cheeseburger', 'hamburger', 'veggie burger'),
...     'prices',   make_array(6, 5, 5),
...     'calories', make_array(743, 651, 582))
>>> t
burgers       | prices | calories
cheeseburger  | 6      | 743
hamburger     | 5      | 651
veggie burger | 5      | 582
>>> t.drop('prices')
burgers       | calories
cheeseburger  | 743
hamburger     | 651
veggie burger | 582
>>> t.drop(['burgers', 'calories'])
prices
6
5
5
>>> t.drop('burgers', 'calories')
prices
6
```

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```
5
5
>>> t.drop([0, 2])
prices
6
5
5
>>> t.drop(0, 2)
prices
6
5
5
>>> t.drop(1)
burgers       | calories
cheeseburger  | 743
hamburger     | 651
veggie burger | 582
```

3.1.34 datascience.tables.Table.take

`Table.take()`

Return a new Table with selected rows taken by index.

Args:
`row_indices_or_slice` (integer or array of integers): The row index, list of row indices or a slice of row indices to be selected.

Returns:
A new instance of `Table` with selected rows in order corresponding to `row_indices_or_slice`.

Raises:
`IndexError`, if any `row_indices_or_slice` is out of bounds with respect to column length.

```
>>> grades = Table().with_columns('letter grade',
...     make_array('A+', 'A', 'A-', 'B+', 'B', 'B-'),
...     'gpa', make_array(4, 4, 3.7, 3.3, 3, 2.7))
>>> grades
letter grade | gpa
A+           | 4
A            | 4
A-           | 3.7
B+           | 3.3
B            | 3
B-           | 2.7
>>> grades.take(0)
letter grade | gpa
A+           | 4
>>> grades.take(-1)
letter grade | gpa
B-           | 2.7
>>> grades.take(make_array(2, 1, 0))
letter grade | gpa
```

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```
A-           | 3.7
A            | 4
A+           | 4
>>> grades.take[:3]
letter grade | gpa
A+           | 4
A            | 4
A-           | 3.7
>>> grades.take(np.arange(0,3))
letter grade | gpa
A+           | 4
A            | 4
A-           | 3.7
>>> grades.take(0, 2)
letter grade | gpa
A+           | 4
A-           | 3.7
>>> grades.take(10)
Traceback (most recent call last):
    ...
IndexError: index 10 is out of bounds for axis 0 with size 6
```

3.1.35 datascience.tables.Table.exclude

`Table.exclude()`

Return a new Table without a sequence of rows excluded by number.

Args:

`row_indices_or_slice` (integer or list of integers or slice):
The row index, list of row indices or a slice of row indices to be excluded.

Returns:
A new instance of `Table`.

```
>>> t = Table().with_columns(
...     'letter grade', make_array('A+', 'A', 'A-', 'B+', 'B', 'B-'),
...     'gpa', make_array(4, 4, 3.7, 3.3, 3, 2.7))
>>> t
letter grade | gpa
A+           | 4
A            | 4
A-           | 3.7
B+           | 3.3
B            | 3
B-           | 2.7
>>> t.exclude(4)
letter grade | gpa
A+           | 4
A            | 4
A-           | 3.7
B+           | 3.3
```

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```
B-           | 2.7
>>> t.exclude(-1)
letter grade | gpa
A+           | 4
A            | 4
A-           | 3.7
B+           | 3.3
B            | 3
>>> t.exclude(make_array(1, 3, 4))
letter grade | gpa
A+           | 4
A-           | 3.7
B-           | 2.7
>>> t.exclude(range(3))
letter grade | gpa
B+           | 3.3
B            | 3
B-           | 2.7
>>> t.exclude(0, 2)
letter grade | gpa
A            | 4
B+           | 3.3
B            | 3
B-           | 2.7
```

Note that `exclude` also supports NumPy-like indexing and slicing:

```
>>> t.exclude[:3]
letter grade | gpa
B+           | 3.3
B            | 3
B-           | 2.7
```

```
>>> t.exclude[1, 3, 4]
letter grade | gpa
A+           | 4
A-           | 3.7
B-           | 2.7
```

3.1.36 datascience.tables.Table.move_column

`Table.move_column`(*label*, *index*)

Returns a new table with specified column moved to the specified column index.

Args:

`label` (str) A single label of column to be moved.

`index` (int) A single index of column to move to.

```
>>> titanic = Table().with_columns('age', make_array(21, 44, 56, 89, 95
...     , 40, 80, 45), 'survival', make_array(0,0,0,1, 1, 1, 0, 1),
```

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```
...     'gender',  make_array('M', 'M', 'M', 'M', 'F', 'F', 'F', 'F'),
...     'prediction', make_array(0, 0, 1, 1, 0, 1, 0, 1))
>>> titanic
age  | survival | gender | prediction
21   | 0        | M      | 0
44   | 0        | M      | 0
56   | 0        | M      | 1
89   | 1        | M      | 1
95   | 1        | F      | 0
40   | 1        | F      | 1
80   | 0        | F      | 0
45   | 1        | F      | 1
>>> titanic.move_column('survival', 3)
age  | gender | prediction | survival
21   | M      | 0          | 0
44   | M      | 0          | 0
56   | M      | 1          | 0
89   | M      | 1          | 1
95   | F      | 0          | 1
40   | F      | 1          | 1
80   | F      | 0          | 0
45   | F      | 1          | 1
```

3.1.37 datascience.tables.Table.where

`Table.where`(*column_or_label*, *value_or_predicate=None*, *other=None*)

Return a new `Table` containing rows where `value_or_predicate` returns True for values in `column_or_label`.

Args:

`column_or_label`: A column of the `Table` either as a label (`str`) or an index (`int`). Can also be an array of booleans; only the rows where the array value is `True` are kept.

`value_or_predicate`: If a function, it is applied to every value in `column_or_label`. Only the rows where `value_or_predicate` returns True are kept. If a single value, only the rows where the values in `column_or_label` are equal to `value_or_predicate` are kept.

`other`: Optional additional column label for `value_or_predicate` to make pairwise comparisons. See the examples below for usage. When `other` is supplied, `value_or_predicate` must be a callable function.

Returns:

If `value_or_predicate` is a function, returns a new `Table` containing only the rows where `value_or_predicate(val)` is True for the `val``s in ``column_or_label`.

If `value_or_predicate` is a value, returns a new `Table` containing only the rows where the values in `column_or_label` are equal to `value_or_predicate`.

If `column_or_label` is an array of booleans, returns a new `Table` containing only the rows where `column_or_label` is `True`.

```
>>> marbles = Table().with_columns(
...     "Color", make_array("Red", "Green", "Blue",
```

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```
...                         "Red", "Green", "Green"),
...     "Shape", make_array("Round", "Rectangular", "Rectangular",
...                         "Round", "Rectangular", "Round"),
...     "Amount", make_array(4, 6, 12, 7, 9, 2),
...     "Price", make_array(1.30, 1.20, 2.00, 1.75, 0, 3.00))
```

```
>>> marbles
Color | Shape       | Amount | Price
Red   | Round       | 4      | 1.3
Green | Rectangular | 6      | 1.2
Blue  | Rectangular | 12     | 2
Red   | Round       | 7      | 1.75
Green | Rectangular | 9      | 0
Green | Round       | 2      | 3
```

Use a value to select matching rows

```
>>> marbles.where("Price", 1.3)
Color | Shape | Amount | Price
Red   | Round | 4      | 1.3
```

In general, a higher order predicate function such as the functions in `datascience.predicates.are` can be used.

```
>>> from datascience.predicates import are
>>> # equivalent to previous example
>>> marbles.where("Price", are.equal_to(1.3))
Color | Shape | Amount | Price
Red   | Round | 4      | 1.3
```

```
>>> marbles.where("Price", are.above(1.5))
Color | Shape       | Amount | Price
Blue  | Rectangular | 12     | 2
Red   | Round       | 7      | 1.75
Green | Round       | 2      | 3
```

Use the optional argument `other` to apply predicates to compare columns.

```
>>> marbles.where("Price", are.above, "Amount")
Color | Shape | Amount | Price
Green | Round | 2      | 3
```

```
>>> marbles.where("Price", are.equal_to, "Amount") # empty table
Color | Shape | Amount | Price
```

3.1.38 datascience.tables.Table.sort

`Table.sort(column_or_label, descending=False, distinct=False)`

Return a Table of rows sorted according to the values in a column.

Args:

`column_or_label`: the column whose values are used for sorting.

descending: if True, sorting will be in descending, rather than
ascending order.

distinct: if True, repeated values in `column_or_label` will
be omitted.

Returns:

An instance of `Table` containing rows sorted based on the values in `column_or_label`.

```
>>> marbles = Table().with_columns(
...     "Color", make_array("Red", "Green", "Blue", "Red", "Green", "Green"),
...     "Shape", make_array("Round", "Rectangular", "Rectangular", "Round",
↪"Rectangular", "Round"),
...     "Amount", make_array(4, 6, 12, 7, 9, 2),
...     "Price", make_array(1.30, 1.30, 2.00, 1.75, 1.40, 1.00))
>>> marbles
Color | Shape       | Amount | Price
Red   | Round       | 4      | 1.3
Green | Rectangular | 6      | 1.3
Blue  | Rectangular | 12     | 2
Red   | Round       | 7      | 1.75
Green | Rectangular | 9      | 1.4
Green | Round       | 2      | 1
>>> marbles.sort("Amount")
Color | Shape       | Amount | Price
Green | Round       | 2      | 1
Red   | Round       | 4      | 1.3
Green | Rectangular | 6      | 1.3
Red   | Round       | 7      | 1.75
Green | Rectangular | 9      | 1.4
Blue  | Rectangular | 12     | 2
>>> marbles.sort("Amount", descending = True)
Color | Shape       | Amount | Price
Blue  | Rectangular | 12     | 2
Green | Rectangular | 9      | 1.4
Red   | Round       | 7      | 1.75
Green | Rectangular | 6      | 1.3
Red   | Round       | 4      | 1.3
Green | Round       | 2      | 1
>>> marbles.sort(3) # the Price column
Color | Shape       | Amount | Price
Green | Round       | 2      | 1
Red   | Round       | 4      | 1.3
Green | Rectangular | 6      | 1.3
Green | Rectangular | 9      | 1.4
Red   | Round       | 7      | 1.75
Blue  | Rectangular | 12     | 2
```

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```
>>> marbles.sort(3, distinct = True)
Color | Shape       | Amount | Price
Green | Round       | 2      | 1
Red   | Round       | 4      | 1.3
Green | Rectangular | 9      | 1.4
Red   | Round       | 7      | 1.75
Blue  | Rectangular | 12     | 2
```

3.1.39 datascience.tables.Table.group

`Table.group(column_or_label, collect=None)`

Group rows by unique values in a column; count or aggregate others.

Args:

`column_or_label`: values to group (column label or index, or array)

`collect`: a function applied to values in other columns for each group

Returns:

A Table with each row corresponding to a unique value in `column_or_label`, where the first column contains the unique values from `column_or_label`, and the second contains counts for each of the unique values. If `collect` is provided, a Table is returned with all original columns, each containing values calculated by first grouping rows according to `column_or_label`, then applying `collect` to each set of grouped values in the other columns.

Note:

The grouped column will appear first in the result table. If `collect` does not accept arguments with one of the column types, that column will be empty in the resulting table.

```
>>> marbles = Table().with_columns(
...     "Color", make_array("Red", "Green", "Blue", "Red", "Green", "Green"),
...     "Shape", make_array("Round", "Rectangular", "Rectangular", "Round",
↪"Rectangular", "Round"),
...     "Amount", make_array(4, 6, 12, 7, 9, 2),
...     "Price", make_array(1.30, 1.30, 2.00, 1.75, 1.40, 1.00))
>>> marbles
Color | Shape       | Amount | Price
Red   | Round       | 4      | 1.3
Green | Rectangular | 6      | 1.3
Blue  | Rectangular | 12     | 2
Red   | Round       | 7      | 1.75
Green | Rectangular | 9      | 1.4
Green | Round       | 2      | 1
>>> marbles.group("Color") # just gives counts
Color | count
Blue  | 1
Green | 3
Red   | 2
>>> marbles.group("Color", max) # takes the max of each grouping, in each column
Color | Shape max   | Amount max | Price max
Blue  | Rectangular | 12         | 2
Green | Round       | 9          | 1.4
```

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```
Red   | Round       | 7           | 1.75
>>> marbles.group("Shape", sum) # sum doesn't make sense for strings
Shape       | Color sum | Amount sum | Price sum
Rectangular |           | 27         | 4.7
Round       |           | 13         | 4.05
```

3.1.40 datascience.tables.Table.groups

`Table.groups`(*labels*, *collect=None*)

Group rows by multiple columns, count or aggregate others.

Args:

`labels`: list of column names (or indices) to group on

`collect`: a function applied to values in other columns for each group

Returns: A Table with each row corresponding to a unique combination of values in the columns specified in `labels`, where the first columns are those specified in `labels`, followed by a column of counts for each of the unique values. If `collect` is provided, a Table is returned with all original columns, each containing values calculated by first grouping rows according to to values in the `labels` column, then applying `collect` to each set of grouped values in the other columns.

Note:

The grouped columns will appear first in the result table. If `collect` does not accept arguments with one of the column types, that column will be empty in the resulting table.

```
>>> marbles = Table().with_columns(
...     "Color", make_array("Red", "Green", "Blue", "Red", "Green", "Green"),
...     "Shape", make_array("Round", "Rectangular", "Rectangular", "Round",
↪"Rectangular", "Round"),
...     "Amount", make_array(4, 6, 12, 7, 9, 2),
...     "Price", make_array(1.30, 1.30, 2.00, 1.75, 1.40, 1.00))
>>> marbles
Color | Shape       | Amount | Price
Red   | Round       | 4      | 1.3
Green | Rectangular | 6      | 1.3
Blue  | Rectangular | 12     | 2
Red   | Round       | 7      | 1.75
Green | Rectangular | 9      | 1.4
Green | Round       | 2      | 1
>>> marbles.groups(["Color", "Shape"])
Color | Shape       | count
Blue  | Rectangular | 1
Green | Rectangular | 2
Green | Round       | 1
Red   | Round       | 2
>>> marbles.groups(["Color", "Shape"], sum)
Color | Shape       | Amount sum | Price sum
Blue  | Rectangular | 12         | 2
Green | Rectangular | 15         | 2.7
Green | Round       | 2          | 1
Red   | Round       | 11         | 3.05
```

3.1.41 datascience.tables.Table.pivot

`Table.pivot`(*columns*, *rows*, *values=None*, *collect=None*, *zero=None*)

Generate a table with a column for each unique value in `columns`, with rows for each unique value in `rows`. Each row counts/aggregates the values that match both row and column based on `collect`.

Args:

`columns` – a single column label or index, (`str` or `int`),
used to create new columns, based on its unique values.

`rows` – row labels or indices, (`str` or `int` or list),
used to create new rows based on it's unique values.

`values` – column label in table for use in aggregation.
Default None.

`collect` – aggregation function, used to group `values`
over row-column combinations. Default None.

`zero` – zero value to use for non-existent row-column
combinations.

Raises:

TypeError – if `collect` is passed in and `values` is not,
vice versa.

Returns:
New pivot table, with row-column combinations, as specified, with aggregated `values` by `collect` across the intersection of `columns` and `rows`. Simple counts provided if values and collect are None, as default.

```
>>> titanic = Table().with_columns('age', make_array(21, 44, 56, 89, 95
...    , 40, 80, 45), 'survival', make_array(0,0,0,1, 1, 1, 0, 1),
...    'gender',  make_array('M', 'M', 'M', 'M', 'F', 'F', 'F', 'F'),
...    'prediction', make_array(0, 0, 1, 1, 0, 1, 0, 1))
>>> titanic
age  | survival | gender | prediction
21   | 0        | M      | 0
44   | 0        | M      | 0
56   | 0        | M      | 1
89   | 1        | M      | 1
95   | 1        | F      | 0
40   | 1        | F      | 1
80   | 0        | F      | 0
45   | 1        | F      | 1
>>> titanic.pivot('survival', 'gender')
gender | 0    | 1
F      | 1    | 3
M      | 3    | 1
>>> titanic.pivot('prediction', 'gender')
gender | 0    | 1
F      | 2    | 2
M      | 2    | 2
>>> titanic.pivot('survival', 'gender', values='age', collect = np.mean)
gender | 0       | 1
F      | 80      | 60
```

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```
M      | 40.3333 | 89
>>> titanic.pivot('survival', make_array('prediction', 'gender'))
prediction | gender | 0    | 1
0          | F      | 1    | 1
0          | M      | 2    | 0
1          | F      | 0    | 2
1          | M      | 1    | 1
>>> titanic.pivot('survival', 'gender', values = 'age')
Traceback (most recent call last):
   ...
TypeError: values requires collect to be specified
>>> titanic.pivot('survival', 'gender', collect = np.mean)
Traceback (most recent call last):
   ...
TypeError: collect requires values to be specified
```

3.1.42 datascience.tables.Table.stack

`Table.stack`(*key*, *labels=None*)

Takes k original columns and returns two columns, with col. 1 of all column names and col. 2 of all associated data.

Args:

key: Name of a column from table which is the basis for stacking values from the table.

labels: List of column names which must be included in the stacked representation of the table. If no value is supplied for this argument, then the function considers all columns from the original table.

Returns:

A table whose first column consists of stacked values from column passed in `key`. The second column of this returned table consists of the column names passed in `labels`, whereas the final column consists of the data values corresponding to the respective values in the first and second columns of the new table.

Examples:

```
>>> t = Table.from_records([
...   {
...    'column1':'data1',
...    'column2':86,
...    'column3':'b',
...    'column4':5,
...   },
...   {
...    'column1':'data2',
...    'column2':51,
...    'column3':'c',
...    'column4':3,
...   },
...   {
...    'column1':'data3',
```

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```
...     'column2':32,
...     'column3':'a',
...     'column4':6,
...   }
... ])
```

```
>>> t
column1 | column2 | column3 | column4
data1   | 86      | b       | 5
data2   | 51      | c       | 3
data3   | 32      | a       | 6
```

```
>>> t.stack('column2')
column2 | column  | value
86      | column1 | data1
86      | column3 | b
86      | column4 | 5
51      | column1 | data2
51      | column3 | c
51      | column4 | 3
32      | column1 | data3
32      | column3 | a
32      | column4 | 6
```

```
>>> t.stack('column2',labels=['column4','column1'])
column2 | column  | value
86      | column1 | data1
86      | column4 | 5
51      | column1 | data2
51      | column4 | 3
32      | column1 | data3
32      | column4 | 6
```

3.1.43 datascience.tables.Table.join

`Table.`**`join`**(*column_label*, *other*, *other_label=None*)

Creates a new table with the columns of self and other, containing rows for all values of a column that appear in both tables.

Args:

`column_label`: label of column or array of labels in self that is used to
join rows of `other`.

`other`: Table object to join with self on matching values of
`column_label`.

Kwargs:

`other_label`: default None, assumes `column_label`.
Otherwise in `other` used to join rows.

Returns:
New table self joined with `other` by matching values in `column_label` and `other_label`. If the resulting join is empty, returns None.

```
>>> table = Table().with_columns('a', make_array(9, 3, 3, 1),
...     'b', make_array(1, 2, 2, 10),
...     'c', make_array(3, 4, 5, 6))
>>> table
a    | b    | c
9    | 1    | 3
3    | 2    | 4
3    | 2    | 5
1    | 10   | 6
>>> table2 = Table().with_columns( 'a', make_array(9, 1, 1, 1),
... 'd', make_array(1, 2, 2, 10),
... 'e', make_array(3, 4, 5, 6))
>>> table2
a    | d    | e
9    | 1    | 3
1    | 2    | 4
1    | 2    | 5
1    | 10   | 6
>>> table.join('a', table2)
a    | b    | c    | d    | e
1    | 10   | 6    | 2    | 4
1    | 10   | 6    | 2    | 5
1    | 10   | 6    | 10   | 6
9    | 1    | 3    | 1    | 3
>>> table.join('a', table2, 'a') # Equivalent to previous join
a    | b    | c    | d    | e
1    | 10   | 6    | 2    | 4
1    | 10   | 6    | 2    | 5
1    | 10   | 6    | 10   | 6
9    | 1    | 3    | 1    | 3
>>> table.join('a', table2, 'd') # Repeat column labels relabeled
a    | b    | c    | a_2  | e
1    | 10   | 6    | 9    | 3
>>> table2 #table2 has three rows with a = 1
a    | d    | e
9    | 1    | 3
1    | 2    | 4
1    | 2    | 5
1    | 10   | 6
>>> table #table has only one row with a = 1
a    | b    | c
9    | 1    | 3
3    | 2    | 4
3    | 2    | 5
1    | 10   | 6
>>> table.join(['a', 'b'], table2, ['a', 'd']) # joining on multiple columns
a    | b    | c    | e
1    | 10   | 6    | 6
9    | 1    | 3    | 3
```

3.1.44 datascience.tables.Table.stats

`Table.stats`(*ops=(<built-in function min>, <built-in function max>, <function median>, <built-in function sum>)*)

Compute statistics for each column and place them in a table.

Args:

`ops` – A tuple of stat functions to use to compute stats.

Returns:

A `Table` with a prepended statistic column with the name of the fucntion's as the values and the calculated stats values per column.

By default stats calculates the minimum, maximum, np.median, and sum of each column.

```
>>> table = Table().with_columns(
...     'A', make_array(4, 0, 6, 5),
...     'B', make_array(10, 20, 17, 17),
...     'C', make_array(18, 13, 2, 9))
>>> table.stats()
statistic | A    | B    | C
min       | 0    | 10   | 2
max       | 6    | 20   | 18
median    | 4.5  | 17   | 11
sum       | 15   | 64   | 42
```

Note, stats are calculated even on non-numeric columns which may lead to unexpected behavior or in more severe cases errors. This is why it may be best to eliminate non-numeric columns from the table before running stats.

```
>>> table = Table().with_columns(
...     'B', make_array(10, 20, 17, 17),
...     'C', make_array("foo", "bar", "baz", "baz"))
>>> table.stats()
statistic | B    | C
min       | 10   | bar
max       | 20   | foo
median    | 17   |
sum       | 64   |
>>> table.select('B').stats()
statistic | B
min       | 10
max       | 20
median    | 17
sum       | 64
```

`ops` can also be overridden to calculate custom stats.

```
>>> table = Table().with_columns(
...     'A', make_array(4, 0, 6, 5),
...     'B', make_array(10, 20, 17, 17),
...     'C', make_array(18, 13, 2, 9))
>>> def weighted_average(x):
...     return np.average(x, weights=[1, 0, 1.5, 1.25])
>>> table.stats(ops=(weighted_average, np.mean, np.median, np.std))
statistic        | A       | B       | C
```

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```
weighted_average | 5.13333 | 15.1333 | 8.6
mean             | 3.75    | 16      | 10.5
median           | 4.5     | 17      | 11
std              | 2.27761 | 3.67423 | 5.85235
```

3.1.45 datascience.tables.Table.percentile

Table.**percentile**(*p*)

Return a new table with one row containing the pth percentile for each column.

Assumes that each column only contains one type of value.

Returns a new table with one row and the same column labels. The row contains the pth percentile of the original column, where the pth percentile of a column is the smallest value that at at least as large as the p% of numbers in the column.

```
>>> table = Table().with_columns(
...     'count',  make_array(9, 3, 3, 1),
...     'points', make_array(1, 2, 2, 10))
>>> table
count | points
9     | 1
3     | 2
3     | 2
1     | 10
>>> table.percentile(80)
count | points
9     | 10
```

3.1.46 datascience.tables.Table.sample

Table.**sample**(*k=None*, *with_replacement=True*, *weights=None*)

Return a new table where k rows are randomly sampled from the original table.

Args:

k – specifies the number of rows (`int`) to be sampled from
the table. Default is k equal to number of rows in the table.

`with_replacement` – (`bool`) By default True;
Samples `k` rows with replacement from table, else samples `k` rows without replacement.

`weights` – Array specifying probability the ith row of the
table is sampled. Defaults to None, which samples each row with equal probability. `weights` must be a valid probability distribution – i.e. an array the length of the number of rows, summing to 1.

Raises:

ValueError – if `weights` is not length equal to number of rows
in the table; or, if `weights` does not sum to 1.

Returns:

A new instance of `Table` with `k` rows resampled.

```
>>> jobs = Table().with_columns(
...     'job',  make_array('a', 'b', 'c', 'd'),
...     'wage', make_array(10, 20, 15, 8))
>>> jobs
job  | wage
a    | 10
b    | 20
c    | 15
d    | 8
>>> jobs.sample()
job  | wage
b    | 20
b    | 20
a    | 10
d    | 8
>>> jobs.sample(with_replacement=True)
job  | wage
d    | 8
b    | 20
c    | 15
a    | 10
>>> jobs.sample(k = 2)
job  | wage
b    | 20
c    | 15
>>> ws =  make_array(0.5, 0.5, 0, 0)
>>> jobs.sample(k=2, with_replacement=True, weights=ws)
job  | wage
a    | 10
a    | 10
>>> jobs.sample(k=2, weights=make_array(1, 0, 1, 0))
Traceback (most recent call last):
    ...
ValueError: probabilities do not sum to 1
>>> jobs.sample(k=2, weights=make_array(1, 0, 0)) # Weights must be length of table.
Traceback (most recent call last):
    ...
ValueError: 'a' and 'p' must have same size
```

3.1.47 datascience.tables.Table.shuffle

`Table.shuffle()`

Return a new table where all the rows are randomly shuffled from the original table.

Returns:

A new instance of `Table` with all `k` rows shuffled.

3.1.48 datascience.tables.Table.sample_from_distribution

Table.**sample_from_distribution**(*distribution*, *k*, *proportions=False*)

Return a new table with the same number of rows and a new column. The values in the distribution column are define a multinomial. They are replaced by sample counts/proportions in the output.

```
>>> sizes = Table(['size', 'count']).with_rows([
...     ['small', 50],
...     ['medium', 100],
...     ['big', 50],
... ])
>>> np.random.seed(99)
>>> sizes.sample_from_distribution('count', 1000)
size   | count | count sample
small  | 50    | 228
medium | 100   | 508
big    | 50    | 264
>>> sizes.sample_from_distribution('count', 1000, True)
size   | count | count sample
small  | 50    | 0.261
medium | 100   | 0.491
big    | 50    | 0.248
```

3.1.49 datascience.tables.Table.split

Table.**split**(*k*)

Return a tuple of two tables where the first table contains k rows randomly sampled and the second contains the remaining rows.

Args:

k (int): The number of rows randomly sampled into the first
table. k must be between 1 and num_rows - 1.

Raises:
ValueError: k is not between 1 and num_rows - 1.

Returns:
A tuple containing two instances of Table.

```
>>> jobs = Table().with_columns(
...     'job',  make_array('a', 'b', 'c', 'd'),
...     'wage', make_array(10, 20, 15, 8))
>>> jobs
job  | wage
a    | 10
b    | 20
c    | 15
d    | 8
>>> sample, rest = jobs.split(3)
>>> sample
job  | wage
c    | 15
```

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```
a    | 10
b    | 20
>>> rest
job  | wage
d    | 8
```

3.1.50 datascience.tables.Table.bin

Table.**bin**(**columns*, ***vargs*)

Group values by bin and compute counts per bin by column.

By default, bins are chosen to contain all values in all columns. The following named arguments from numpy.histogram can be applied to specialize bin widths:

If the original table has n columns, the resulting binned table has n+1 columns, where column 0 contains the lower bound of each bin.

Args:

columns (str or int): Labels or indices of columns to be
binned. If empty, all columns are binned.

bins (int or sequence of scalars): If bins is an int,
it defines the number of equal-width bins in the given range (10, by default). If bins is a sequence, it defines the bin edges, including the rightmost edge, allowing for non-uniform bin widths.

range ((float, float)): The lower and upper range of
the bins. If not provided, range contains all values in the table. Values outside the range are ignored.

density (bool): If False, the result will contain the number of
samples in each bin. If True, the result is the value of the probability density function at the bin, normalized such that the integral over the range is 1. Note that the sum of the histogram values will not be equal to 1 unless bins of unity width are chosen; it is not a probability mass function.

3.1.51 datascience.tables.Table.pivot_bin

Table.**pivot_bin**(*pivot_columns*, *value_column*, *bins=None*, ***vargs*)

Form a table with columns formed by the unique tuples in pivot_columns containing counts per bin of the values associated with each tuple in the value_column.

By default, bins are chosen to contain all values in the value_column. The following named arguments from numpy.histogram can be applied to specialize bin widths:

Args:

bins (int or sequence of scalars): If bins is an int,
it defines the number of equal-width bins in the given range (10, by default). If bins is a sequence, it defines the bin edges, including the rightmost edge, allowing for non-uniform bin widths.

range ((float, float)): The lower and upper range of
the bins. If not provided, range contains all values in the table. Values outside the range are ignored.

normed (bool): If False, the result will contain the number of
samples in each bin. If True, the result is normalized such that the integral over the range is 1.

Returns:
New pivot table with unique rows of specified `pivot_columns`, populated with 0s and 1s with respect to values from `value_column` distributed into specified `bins` and `range`.

Examples:

```
>>> t = Table.from_records([
...   {
...    'column1':'data1',
...    'column2':86,
...    'column3':'b',
...    'column4':5,
...   },
...   {
...    'column1':'data2',
...    'column2':51,
...    'column3':'c',
...    'column4':3,
...   },
...   {
...    'column1':'data3',
...    'column2':32,
...    'column3':'a',
...    'column4':6,
...   }
... ])
```

```
>>> t
column1 | column2 | column3 | column4
data1   | 86      | b       | 5
data2   | 51      | c       | 3
data3   | 32      | a       | 6
```

```
>>> t.pivot_bin(pivot_columns='column1',value_column='column2')
bin  | data1 | data2 | data3
32   | 0     | 0     | 1
37.4 | 0     | 0     | 0
42.8 | 0     | 0     | 0
48.2 | 0     | 1     | 0
53.6 | 0     | 0     | 0
59   | 0     | 0     | 0
64.4 | 0     | 0     | 0
69.8 | 0     | 0     | 0
75.2 | 0     | 0     | 0
80.6 | 1     | 0     | 0
... (1 rows omitted)
```

```
>>> t.pivot_bin(pivot_columns=['column1','column2'],value_column='column4')
bin  | data1-86 | data2-51 | data3-32
3    | 0        | 1        | 0
3.3  | 0        | 0        | 0
3.6  | 0        | 0        | 0
3.9  | 0        | 0        | 0
```

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```
4.2  | 0          | 0          | 0
4.5  | 0          | 0          | 0
4.8  | 1          | 0          | 0
5.1  | 0          | 0          | 0
5.4  | 0          | 0          | 0
5.7  | 0          | 0          | 1
... (1 rows omitted)
```

```
>>> t.pivot_bin(pivot_columns='column1',value_column='column2',bins=[20,45,100])
bin  | data1 | data2 | data3
20   | 0     | 0     | 1
45   | 1     | 1     | 0
100  | 0     | 0     | 0
```

```
>>> t.pivot_bin(pivot_columns='column1',value_column='column2',bins=5,range=[30,60])
bin  | data1 | data2 | data3
30   | 0     | 0     | 1
36   | 0     | 0     | 0
42   | 0     | 0     | 0
48   | 0     | 1     | 0
54   | 0     | 0     | 0
60   | 0     | 0     | 0
```

Exporting / Displaying

Table.show([max_rows])	Display the table.
Table.as_text([max_rows, sep])	Format table as text
Table.as_html([max_rows])	Format table as HTML
Table.index_by(column_or_label)	Return a dict keyed by values in a column that contains lists of
Table.to_array()	Convert the table to a structured NumPy array.
Table.to_df()	Convert the table to a Pandas DataFrame.
Table.to_csv(filename)	Creates a CSV file with the provided filename.

3.1.52 datascience.tables.Table.show

`Table.show`(*max_rows=0*)

Display the table.

Args:

`max_rows`: Maximum number of rows to be output by the function

Returns:

A subset of the Table with number of rows specified in `max_rows`. First `max_rows` number of rows are displayed. If no value is passed for `max_rows`, then the entire Table is returned.

Examples:

```
>>> t = Table().with_columns(
...     "column1", make_array("data1", "data2", "data3"),
...     "column2", make_array(86, 51, 32),
```

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```
...     "column3", make_array("b", "c", "a"),
...     "column4", make_array(5, 3, 6)
... )
```

```
>>> t
column1 | column2 | column3 | column4
data1   | 86      | b       | 5
data2   | 51      | c       | 3
data3   | 32      | a       | 6
```

```
>>> t.show()
<IPython.core.display.HTML object>
```

```
>>> t.show(max_rows=2)
<IPython.core.display.HTML object>
```

3.1.53 datascience.tables.Table.as_text

`Table.as_text(max_rows=0, sep=' | ')`

Format table as text

Args:

max_rows(int) The maximum number of rows to be present in the converted string of table. (Optional Argument) sep(str) The seperator which will appear in converted string between the columns. (Optional Argument)

Returns:

String form of the table

The table is just converted to a string with columns seperated by the seperator(argument- default(' | ')) and rows seperated by 'n'

Few examples of the as_text() method are as follows:

1.

```
>>> table = Table().with_columns({'name': ['abc', 'xyz', 'uvw'], 'age': [12,14,
↪20],'height': [5.5,6.0,5.9],})
>>> table
name | age  | height
abc  | 12   | 5.5
xyz  | 14   | 6
uvw  | 20   | 5.9
```

```
>>> table_astext = table.as_text()
>>> table_astext
'name | age  | height\nabc  | 12   | 5.5\nxyz  | 14   | 6\nuvw  | 20   | 5.9'
```

```
>>> type(table)
<class 'datascience.tables.Table'>
```

```
>>> type(table_astext)
<class 'str'>
```

2.

```
>>> sizes = Table(['size', 'count']).with_rows([     ['small', 50],      ['medium
↪', 100],      ['big', 50], ])
>>> sizes
size   | count
small  | 50
medium | 100
big    | 50
```

```
>>> sizes_astext = sizes.as_text()
>>> sizes_astext
'size   | count\nsmall  | 50\nmedium | 100\nbig    | 50'
```

3.

```
>>> sizes_astext = sizes.as_text(1)
>>> sizes_astext
'size  | count\nsmall | 50\n... (2 rows omitted)'
```

4.

```
>>> sizes_astext = sizes.as_text(2, ' - ')
>>> sizes_astext
'size   - count\nsmall  - 50\nmedium - 100\n... (1 rows omitted)'
```

3.1.54 datascience.tables.Table.as_html

`Table.as_html(max_rows=0)`

Format table as HTML

Args:

max_rows(int) The maximum number of rows to be present in the converted string of table. (Optional Argument)

Returns:

String representing the HTML form of the table

The table is converted to the html format of the table which can be used on a website to represent the table.

Few examples of the as_html() method are as follows. - These examples seem difficult for us to observe and understand since they are in html format, they are useful when you want to display the table on webpages

1. Simple table being converted to HTML

```
>>> table = Table().with_columns({'name': ['abc', 'xyz', 'uvw'], 'age': [12,14,
↪20],'height': [5.5,6.0,5.9],})
```

```
>>> table
name | age  | height
abc  | 12   | 5.5
xyz  | 14   | 6
uvw  | 20   | 5.9
```

```
>>> table_as_html = table.as_html()
>>> table_as_html
'<table border="1" class="dataframe">\n    <thead>\n        <tr>\n
<th>name</th> <th>age</th> <th>height</th>\n
</tr>\n    </thead>\n    <tbody>\n
<tr>\n            <td>abc </td> <td>12  </td> <td>5.5   </td>\n        </tr>\n ␣
↪
<tr>\n            <td>xyz </td> <td>14  </td> <td>6     </td>\n        </tr>\n ␣
↪
<tr>\n            <td>uvw </td> <td>20  </td> <td>5.9   </td>\n        </tr>\n ␣
↪
</tbody>\n</table>'
```

2. Simple table being converted to HTML with max_rows passed in

```
>>> table
name | age  | height
abc  | 12   | 5.5
xyz  | 14   | 6
uvw  | 20   | 5.9
```

```
>>> table_as_html_2 = table.as_html(max_rows = 2)
>>> table_as_html_2
'<table border="1" class="dataframe">\n    <thead>\n        <tr>\n
<th>name</th> <th>age</th> <th>height</th>\n
</tr>\n    </thead>\n    <tbody>\n
<tr>\n            <td>abc </td> <td>12  </td> <td>5.5   </td>\n        </tr>\n ␣
↪
<tr>\n            <td>xyz </td> <td>14  </td> <td>6     </td>\n        </tr>\n ␣
↪
</tbody>\n</table>\n<p>... (1 rows omitted)</p>'
```

3.1.55 datascience.tables.Table.index_by

`Table.`**`index_by`**(*column_or_label*)

Return a dict keyed by values in a column that contains lists of
rows corresponding to each value.

Args:
`columns_or_labels`: Name or label of a column of the Table, values of which are keys in the returned dict.

Returns:
A dictionary with values from the column specified in the argument `columns_or_labels` as keys. The corresponding data is a list of Row of values from the rest of the columns of the Table.

Examples:

```
>>> t = Table().with_columns(
...     "column1", make_array("data1", "data2", "data3", "data4"),
...     "column2", make_array(86, 51, 32, 91),
...     "column3", make_array("b", "c", "a", "a"),
...     "column4", make_array(5, 3, 6, 9)
... )
```

```
>>> t
column1 | column2 | column3 | column4
data1   | 86      | b       | 5
data2   | 51      | c       | 3
data3   | 32      | a       | 6
data4   | 91      | a       | 9
```

```
>>> t.index_by('column2')
{86: [Row(column1='data1', column2=86, column3='b', column4=5)], 51: [Row(column1=
↪'data2', column2=51, column3='c', column4=3)], 32: [Row(column1='data3',␣
↪column2=32, column3='a', column4=6)], 91: [Row(column1='data4', column2=91,␣
↪column3='a', column4=9)]}
```

```
>>> t.index_by('column3')
{'b': [Row(column1='data1', column2=86, column3='b', column4=5)], 'c': [Row(column1=
↪'data2', column2=51, column3='c', column4=3)], 'a': [Row(column1='data3',␣
↪column2=32, column3='a', column4=6), Row(column1='data4', column2=91, column3='a',
↪ column4=9)]}
```

3.1.56 datascience.tables.Table.to_array

`Table.to_array()`

Convert the table to a structured NumPy array.

The resulting array contains a sequence of rows from the table.

Args:
None

Returns:
arr: a NumPy array

The following is an example of calling to_array() >>> t = Table().with_columns([… 'letter', ['a','b','c','z'], … 'count', [9,3,3,1], … 'points', [1,2,2,10], …])

```
>>> t
letter | count | points
a      | 9     | 1
b      | 3     | 2
c      | 3     | 2
z      | 1     | 10
```

```
>>> example = t.to_array()
```

```
>>> example
array([('a', 9,  1), ('b', 3,  2), ('c', 3,  2), ('z', 1, 10)],
dtype=[('letter', '<U1'), ('count', '<i8'), ('points', '<i8')])
```

```
>>> example['letter']
array(['a', 'b', 'c', 'z'],
dtype='<U1')
```

3.1.57 datascience.tables.Table.to_df

`Table.to_df()`

Convert the table to a Pandas DataFrame.

Args:
None

Returns:

The Pandas DataFrame of the table

It just converts the table to Pandas DataFrame so that we can use DataFrame instead of the table at some required places.

Here's an example of using the to_df() method:

```
>>> table = Table().with_columns({'name': ['abc', 'xyz', 'uvw'],
... 'age': [12,14,20],
... 'height': [5.5,6.0,5.9],
... })
```

```
>>> table
name | age  | height
abc  | 12   | 5.5
xyz  | 14   | 6
uvw  | 20   | 5.9
```

```
>>> table_df = table.to_df()
```

```
>>> table_df
  name  age  height
0  abc   12     5.5
1  xyz   14     6.0
2  uvw   20     5.9
```

```
>>> type(table)
<class 'datascience.tables.Table'>
```

```
>>> type(table_df)
<class 'pandas.core.frame.DataFrame'>
```

3.1.58 datascience.tables.Table.to_csv

`Table.to_csv`(*filename*)

Creates a CSV file with the provided filename.

The CSV is created in such a way that if we run `table.to_csv('my_table.csv')` we can recreate the same table with `Table.read_table('my_table.csv')`.

Args:
`filename` (str): The filename of the output CSV file.

Returns:
None, outputs a file with name `filename`.

```
>>> jobs = Table().with_columns(
...     'job',  make_array('a', 'b', 'c', 'd'),
...     'wage', make_array(10, 20, 15, 8))
>>> jobs
job  | wage
a    | 10
b    | 20
c    | 15
d    | 8
>>> jobs.to_csv('my_table.csv')
<outputs a file called my_table.csv in the current directory>
```

Visualizations

Table.plot([column_for_xticks, select, ...])	Plot line charts for the table.
Table.bar([column_for_categories, select, ...])	Plot bar charts for the table.
Table.group_bar(column_label, **vargs)	Plot a bar chart for the table.
Table.barh([column_for_categories, select, ...])	Plot horizontal bar charts for the table.
Table.group_barh(column_label, **vargs)	Plot a horizontal bar chart for the table.
Table.pivot_hist(pivot_column_label, ...[, ...])	Draw histograms of each category in a column.
Table.hist(*columns[, overlay, bins, ...])	Plots one histogram for each column in columns.
Table.hist_of_counts(*columns[, overlay, ...])	Plots one count-based histogram for each column in columns.
Table.scatter(column_for_x[, select, ...])	Creates scatterplots, optionally adding a line of best fit.
Table.scatter3d(column_for_x, column_for_y)	Convenience wrapper for `Table#iscatter3d`
Table.boxplot(**vargs)	Plots a boxplot for the table.
Table.interactive_plots()	Redirects `plot`, `barh`, `hist`, and `scatter` to their plotly equivalents
Table.static_plots()	Turns off redirection of `plot`, `barh`, `hist`, and `scatter` to their plotly equivalents

3.1.59 datascience.tables.Table.plot

`Table.plot`(*column_for_xticks=None*, *select=None*, *overlay=True*, *width=None*, *height=None*, ***vargs*)

Plot line charts for the table. Redirects to `Table#iplot` for plotly charts if interactive plots are enabled with `Table#interactive_plots`

Args:

column_for_xticks (`str/array`): A column containing x-axis labels

Kwargs:

overlay (bool): create a chart with one color per data column;
if False, each plot will be displayed separately.

show (bool): whether to show the figure if using interactive plots; if false, the figure
is returned instead

vargs: Additional arguments that get passed into *plt.plot*.
See http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.plot for additional arguments that can be passed into vargs.

Raises:

ValueError – Every selected column must be numerical.

Returns:

Returns a line plot (connected scatter). Each plot is labeled using the values in *column_for_xticks* and one plot is produced for all other columns in self (or for the columns designated by *select*).

```
>>> table = Table().with_columns(
...     'days',  make_array(0, 1, 2, 3, 4, 5),
...     'price', make_array(90.5, 90.00, 83.00, 95.50, 82.00, 82.00),
...     'projection', make_array(90.75, 82.00, 82.50, 82.50, 83.00, 82.50))
>>> table
days | price | projection
0    | 90.5  | 90.75
1    | 90    | 82
2    | 83    | 82.5
3    | 95.5  | 82.5
4    | 82    | 83
5    | 82    | 82.5
>>> table.plot('days')
<line graph with days as x-axis and lines for price and projection>
>>> table.plot('days', overlay=False)
<line graph with days as x-axis and line for price>
<line graph with days as x-axis and line for projection>
>>> table.plot('days', 'price')
<line graph with days as x-axis and line for price>
```

3.1.60 datascience.tables.Table.bar

`Table.bar`(*column_for_categories=None*, *select=None*, *overlay=True*, *width=None*, *height=None*, ***vargs*)

Plot bar charts for the table.

Each plot is labeled using the values in *column_for_categories* and one plot is produced for every other column (or for the columns designated by *select*).

Every selected column except *column_for_categories* must be numerical.

Args:
column_for_categories (str): A column containing x-axis categories

Kwargs:

overlay (bool): create a chart with one color per data column;
if False, each will be displayed separately.

vargs: Additional arguments that get passed into *plt.bar*.
See http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.bar for additional arguments that can be passed into vargs.

3.1.61 datascience.tables.Table.group_bar

`Table.group_bar`(*column_label*, ***vargs*)

Plot a bar chart for the table.

The values of the specified column are grouped and counted, and one bar is produced for each group.

Note: This differs from `bar` in that there is no need to specify bar heights; the height of a category's bar is the number of copies of that category in the given column. This method behaves more like `hist` in that regard, while `bar` behaves more like `plot` or `scatter` (which require the height of each point to be specified).

Args:
`column_label` (str or int): The name or index of a column

Kwargs:

overlay (bool): create a chart with one color per data column;
if False, each will be displayed separately.

width (float): The width of the plot, in inches height (float): The height of the plot, in inches

vargs: Additional arguments that get passed into *plt.bar*.
See http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.bar for additional arguments that can be passed into vargs.

3.1.62 datascience.tables.Table.barh

`Table.barh`(*column_for_categories=None*, *select=None*, *overlay=True*, *width=None*, ***vargs*)

Plot horizontal bar charts for the table. Redirects to `Table#ibarh` if interactive plots are enabled with `Table#interactive_plots`

Args:

`column_for_categories` (`str`): A column containing y-axis categories
used to create buckets for bar chart.

Kwargs:

overlay (bool): create a chart with one color per data column;
if False, each will be displayed separately.

show (bool): whether to show the figure if using interactive plots; if false, the
figure is returned instead

vargs: Additional arguments that get passed into *plt.barh*.
See http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.barh for additional arguments that can be passed into vargs.

Raises:

ValueError – Every selected except column for `column_for_categories`
must be numerical.

Returns:
Horizontal bar graph with buckets specified by `column_for_categories`. Each plot is labeled using the values in `column_for_categories` and one plot is produced for every other column (or for the columns designated by `select`).

```
>>> t = Table().with_columns(
...     'Furniture', make_array('chairs', 'tables', 'desks'),
...     'Count', make_array(6, 1, 2),
...     'Price', make_array(10, 20, 30)
...     )
>>> t
Furniture | Count | Price
chairs    | 6     | 10
tables    | 1     | 20
desks     | 2     | 30
>>> t.barh('Furniture')
<bar graph with furniture as categories and bars for count and price>
>>> t.barh('Furniture', 'Price')
<bar graph with furniture as categories and bars for price>
>>> t.barh('Furniture', make_array(1, 2))
<bar graph with furniture as categories and bars for count and price>
```

3.1.63 datascience.tables.Table.group_barh

`Table.`**`group_barh`**(*column_label*, ***vargs*)

Plot a horizontal bar chart for the table.

The values of the specified column are grouped and counted, and one bar is produced for each group.

Note: This differs from `barh` in that there is no need to specify bar heights; the size of a category's bar is the number of copies of that category in the given column. This method behaves more like `hist` in that regard, while `barh` behaves more like `plot` or `scatter` (which require the second coordinate of each point to be specified in another column).

Args:
`column_label` (str or int): The name or index of a column

Kwargs:

overlay (bool): create a chart with one color per data column;
if False, each will be displayed separately.

width (float): The width of the plot, in inches height (float): The height of the plot, in inches

vargs: Additional arguments that get passed into *plt.bar*.
See http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.bar for additional arguments that can be passed into vargs.

3.1.64 datascience.tables.Table.pivot_hist

Table.**pivot_hist**(*pivot_column_label*, *value_column_label*, *overlay=True*, *width=6*, *height=4*, ***vargs*)

Draw histograms of each category in a column. (Deprecated)

Recommended: Use hist(value_column_label, group=pivot_column_label), or with side_by_side=True if you really want side-by-side bars.

3.1.65 datascience.tables.Table.hist

Table.**hist**(**columns*, *overlay=True*, *bins=None*, *bin_column=None*, *unit=None*, *counts=None*, *group=None*, *rug=False*, *side_by_side=False*, *left_end=None*, *right_end=None*, *width=None*, *height=None*, ***vargs*)

Plots one histogram for each column in columns. If no column is specified, plot all columns. If interactive plots are enabled via `Table#interactive_plots`, redirects plotting to plotly with `Table#ihist`.

Kwargs:

overlay (bool): If True, plots 1 chart with all the histograms
overlaid on top of each other (instead of the default behavior of one histogram for each column in the table). Also adds a legend that matches each bar color to its column. Note that if the histograms are not overlaid, they are not forced to the same scale.

bins (list or int): Lower bound for each bin in the
histogram or number of bins. If None, bins will be chosen automatically.

bin_column (column name or index): A column of bin lower bounds.
All other columns are treated as counts of these bins. If None, each value in each row is assigned a count of 1.

counts (column name or index): Deprecated name for bin_column.

unit (string): A name for the units of the plotted column (e.g.
'kg'), to be used in the plot.

group (column name or index): A column of categories. The rows are
grouped by the values in this column, and a separate histogram is generated for each group. The histograms are overlaid or plotted separately depending on the overlay argument. If None, no such grouping is done.

side_by_side (bool): Whether histogram bins should be plotted side by
side (instead of directly overlaid). Makes sense only when plotting multiple histograms, either by passing several columns or by using the group option.

left_end (int or float) and right_end (int or float): (Not supported
for overlayed histograms) The left and right edges of the shading of the histogram. If only one of these is None, then that property will be treated as the extreme edge of the histogram. If both are left None, then no shading will occur.

density (boolean): If True, will plot a density distribution of the data.
Otherwise plots the counts.

shade_split (string, {"whole", "new", "split"}): If left_end or right_end are specified, shade_split determines how a bin is split that the end falls between two bin endpoints. If shade_split = "whole", the entire bin will be shaded. If shade_split = "new", then a new bin will be created and data split appropriately. If shade_split = "split", the data will first be placed into the original bins, and then separated into two bins with equal height.

show (bool): whether to show the figure for interactive plots; if false, the figure is returned instead

vargs: Additional arguments that get passed into :func:plt.hist. See http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.hist for additional arguments that can be passed into vargs. These include: *range*, *normed/density*, *cumulative*, and *orientation*, to name a few.

```
>>> t = Table().with_columns(
...     'count',  make_array(9, 3, 3, 1),
...     'points', make_array(1, 2, 2, 10))
>>> t
count | points
9     | 1
3     | 2
3     | 2
1     | 10
>>> t.hist()
<histogram of values in count>
<histogram of values in points>
```

```
>>> t = Table().with_columns(
...     'value',      make_array(101, 102, 103),
...     'proportion', make_array(0.25, 0.5, 0.25))
>>> t.hist(bin_column='value')
<histogram of values weighted by corresponding proportions>
```

```
>>> t = Table().with_columns(
...     'value',    make_array(1,   2,   3,   2,   5  ),
...     'category', make_array('a', 'a', 'a', 'b', 'b'))
>>> t.hist('value', group='category')
<two overlaid histograms of the data [1, 2, 3] and [2, 5]>
```

3.1.66 datascience.tables.Table.hist_of_counts

`Table.hist_of_counts(`**columns*, *overlay=True*, *bins=None*, *bin_column=None*, *group=None*, *side_by_side=False*, *width=None*, *height=None*, ***vargs*`)`

Plots one count-based histogram for each column in columns. The heights of each bar will represent the counts, and all the bins must be of equal size.

If no column is specified, plot all columns.

Kwargs:

overlay (bool): If True, plots 1 chart with all the histograms overlaid on top of each other (instead of the default behavior of one histogram for each column in the table). Also adds a legend that matches each bar color to its column. Note that if the histograms are not overlaid, they are not forced to the same scale.

bins (array or int): Lower bound for each bin in the
histogram or number of bins. If None, bins will be chosen automatically.

bin_column (column name or index): A column of bin lower bounds.
All other columns are treated as counts of these bins. If None, each value in each row is assigned a count of 1.

group (column name or index): A column of categories. The rows are
grouped by the values in this column, and a separate histogram is generated for each group. The histograms are overlaid or plotted separately depending on the overlay argument. If None, no such grouping is done.

side_by_side (bool): Whether histogram bins should be plotted side by
side (instead of directly overlaid). Makes sense only when plotting multiple histograms, either by passing several columns or by using the group option.

vargs: Additional arguments that get passed into :func:plt.hist.
See http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.hist for additional arguments that can be passed into vargs. These include: *range*, *cumulative*, and *orientation*, to name a few.

```
>>> t = Table().with_columns(
...     'count',  make_array(9, 3, 3, 1),
...     'points', make_array(1, 2, 2, 10))
>>> t
count | points
9     | 1
3     | 2
3     | 2
1     | 10
>>> t.hist_of_counts()
<histogram of values in count with counts on y-axis>
<histogram of values in points with counts on y-axis>
```

```
>>> t = Table().with_columns(
...     'value', make_array(101, 102, 103),
...     'count', make_array(5, 10, 5))
>>> t.hist_of_counts(bin_column='value')
<histogram of values weighted by corresponding counts>
```

```
>>> t = Table().with_columns(
...     'value',    make_array(1,   2,   3,   2,   5  ),
...     'category', make_array('a', 'a', 'a', 'b', 'b'))
>>> t.hist('value', group='category')
<two overlaid histograms of the data [1, 2, 3] and [2, 5]>
```

3.1.67 datascience.tables.Table.scatter

`Table.scatter`(*column_for_x*, *select=None*, *overlay=True*, *fit_line=False*, *group=None*, *labels=None*, *sizes=None*, *width=None*, *height=None*, *s=20*, ***vargs*)

Creates scatterplots, optionally adding a line of best fit. Redirects to `Table#iscatter` if interactive plots are enabled with `Table#interactive_plots`

args:

`column_for_x` (`str`): the column to use for the x-axis values
and label of the scatter plots.

kwargs:

`overlay` (`bool`): if true, creates a chart with one color
per data column; if false, each plot will be displayed separately.

`fit_line` (`bool`): draw a line of best fit for each set of points.

`vargs`: additional arguments that get passed into *plt.scatter*.
see http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.scatter for additional arguments that can be passed into vargs. these include: *marker* and *norm*, to name a couple.

`group`: a column of categories to be used for coloring dots per
each category grouping.

`labels`: a column of text labels to annotate dots.

`sizes`: a column of values to set the relative areas of dots.

`s`: size of dots. if sizes is also provided, then dots will be
in the range 0 to 2 * s.

`colors`: (deprecated) A synonym for `group`. Retained
temporarily for backwards compatibility. This argument will be removed in future releases.

`show` (`bool`): whether to show the figure if using interactive plots; if false,
the figure is returned instead

Raises:
ValueError – Every column, `column_for_x` or `select`, must be numerical

Returns:
Scatter plot of values of `column_for_x` plotted against values for all other columns in self. Each plot uses the values in *column_for_x* for horizontal positions. One plot is produced for all other columns in self as y (or for the columns designated by *select*).

```
>>> table = Table().with_columns(
...     'x', make_array(9, 3, 3, 1),
...     'y', make_array(1, 2, 2, 10),
...     'z', make_array(3, 4, 5, 6))
>>> table
x    | y    | z
9    | 1    | 3
3    | 2    | 4
3    | 2    | 5
1    | 10   | 6
>>> table.scatter('x')
<scatterplot of values in y and z on x>
```

```
>>> table.scatter('x', overlay=False)
<scatterplot of values in y on x>
<scatterplot of values in z on x>
```

```
>>> table.scatter('x', fit_line=True)
<scatterplot of values in y and z on x with lines of best fit>
```

3.1.68 datascience.tables.Table.scatter3d

`Table.scatter3d`(*column_for_x*, *column_for_y*, *select=None*, *overlay=True*, *fit_line=False*, *group=None*, *labels=None*, *sizes=None*, *width=None*, *height=None*, *s=5*, *colors=None*, ***vargs*)

Convenience wrapper for `Table#iscatter3d`

Creates 3D scatterplots by calling `Table#iscatter3d` with the same arguments. Cannot be used if interactive plots are not enabled (by calling `Table#interactive_plots`).

Args:

`column_for_x` (`str`): The column to use for the x-axis values
and label of the scatter plots.

`column_for_y` (`str`): The column to use for the y-axis values
and label of the scatter plots.

Kwargs:

`overlay` (`bool`): If true, creates a chart with one color
per data column; if False, each plot will be displayed separately.

`group`: A column of categories to be used for coloring dots per
each category grouping.

`labels`: A column of text labels to annotate dots.

`sizes`: A column of values to set the relative areas of dots.

`width` (`int`): the width (in pixels) of the plot area

`height` (`int`): the height (in pixels) of the plot area

`s`: Size of dots. If sizes is also provided, then dots will be
in the range 0 to 2 * s.

`colors`: (deprecated) A synonym for `group`. Retained
temporarily for backwards compatibility. This argument will be removed in future releases.

`show` (`bool`): whether to show the figure; if false, the figure is returned instead

`vargs` (`dict`): additional kwargs passed to
`plotly.graph_objects.Figure.update_layout`

Raises:

AssertionError – Interactive plots must be enabled by calling `Table#interactive_plots`
first

ValueError – Every column, `column_for_x`, `column_for_x`, or `select`, must be
numerical

Returns:

Scatter plot of values of `column_for_x` and `column_for_y` plotted against
values for all other columns in self.

```
>>> table = Table().with_columns(
...     'x', make_array(9, 3, 3, 1),
...     'y', make_array(1, 2, 2, 10),
...     'z1', make_array(3, 4, 5, 6),
...     'z2', make_array(0, 2, 1, 0))
>>> table
x    | y    | z1   | z2
9    | 1    | 3    | 0
3    | 2    | 4    | 2
3    | 2    | 5    | 1
1    | 10   | 6    | 0
>>> table.iscatter3d('x', 'y')
<plotly 3D scatterplot of values in z1 and z2 on x and y>
>>> table.iscatter3d('x', 'y', overlay=False)
<plotly 3D scatterplot of values in z1 on x and y>
<plotly 3D scatterplot of values in z2 on x and y
```

3.1.69 datascience.tables.Table.boxplot

`Table.boxplot(**vargs)`

Plots a boxplot for the table.

Every column must be numerical.

Kwargs:

vargs: Additional arguments that get passed into *plt.boxplot*.
See http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.boxplot for additional arguments that can be passed into vargs. These include *vert* and *showmeans*.

Returns:
None

Raises:
ValueError: The Table contains columns with non-numerical values.

```
>>> table = Table().with_columns(
...     'test1', make_array(92.5, 88, 72, 71, 99, 100, 95, 83, 94, 93),
...     'test2', make_array(89, 84, 74, 66, 92, 99, 88, 81, 95, 94))
>>> table
test1 | test2
92.5  | 89
88    | 84
72    | 74
71    | 66
99    | 92
100   | 99
95    | 88
83    | 81
94    | 95
93    | 94
```

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```
>>> table.boxplot()
<boxplot of test1 and boxplot of test2 side-by-side on the same figure>
>>> table2 = Table().with_columns(
...     'numeric_col', make_array(1, 2, 3, 4),
...     'alpha_col', make_array('a', 'b', 'c', 'd'))
>>> table2.boxplot()
Traceback (most recent call last):
    ...
ValueError: The column 'alpha_col' contains non-numerical values. A boxplot cannot␣
↪be drawn for this table.
```

3.1.70 datascience.tables.Table.interactive_plots

classmethod Table.**interactive_plots**()

Redirects `plot`, `barh`, `hist`, and `scatter` to their plotly equivalents

Sets a global variable that redirects `Table.plot` to `Table.iplot`, `Table.barh` to `Table.ibarh`, etc. This can be turned off by calling `Table.static_plots`.

```
>>> table = Table().with_columns(
...     'days',  make_array(0, 1, 2, 3, 4, 5),
...     'price', make_array(90.5, 90.00, 83.00, 95.50, 82.00, 82.00),
...     'projection', make_array(90.75, 82.00, 82.50, 82.50, 83.00, 82.50))
>>> table
days | price | projection
0    | 90.5  | 90.75
1    | 90    | 82
2    | 83    | 82.5
3    | 95.5  | 82.5
4    | 82    | 83
5    | 82    | 82.5
>>> table.plot('days')
<matplotlib line graph with days as x-axis and lines for price and projection>
>>> Table.interactive_plots()
>>> table.plot('days')
<plotly interactive line graph with days as x-axis and lines for price and␣
↪projection>
```

3.1.71 datascience.tables.Table.static_plots

classmethod Table.**static_plots**()

Turns off redirection of `plot`, `barh`, `hist`, and `scatter` to their plotly equivalents

Unsets a global variable that redirects `Table.plot` to `Table.iplot`, `Table.barh` to `Table.ibarh`, etc. This can be turned on by calling `Table.interactive_plots`.

```
>>> table = Table().with_columns(
...     'days',  make_array(0, 1, 2, 3, 4, 5),
...     'price', make_array(90.5, 90.00, 83.00, 95.50, 82.00, 82.00),
...     'projection', make_array(90.75, 82.00, 82.50, 82.50, 83.00, 82.50))
```

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```
>>> table
days | price | projection
0    | 90.5  | 90.75
1    | 90    | 82
2    | 83    | 82.5
3    | 95.5  | 82.5
4    | 82    | 83
5    | 82    | 82.5
>>> table.plot('days')
<matplotlib line graph with days as x-axis and lines for price and projection>
>>> Table.interactive_plots()
>>> table.plot('days')
<plotly interactive line graph with days as x-axis and lines for price and␣
↪projection>
>>> Table.static_plots()
>>> table.plot('days')
<matplotlib line graph with days as x-axis and lines for price and projection>
```

3.2 Maps (`datascience.maps`)

Draw maps using folium.

class `datascience.maps.Circle`(*lat*, *lon*, *popup=''*, *color='blue'*, *area=314.1592653589793*, ***kwargs*)

A marker displayed with either Folium's circle_marker or circle methods.

The `circle_marker` method draws circles that stay the same size regardless of map zoom, whereas the circle method draws circles that have a fixed radius in meters. To toggle between them, use the `radius_in_meters` flag in the draw_on function.

popup – text that pops up when marker is clicked color – fill color area – pixel-squared area of the circle

Defaults from Folium:

fill_opacity: float, default 0.6
Circle fill opacity

More options can be passed into kwargs by following the attributes listed in *https://leafletjs.com/reference-1.4.0.html#circlemarker* or *https://leafletjs.com/reference-1.4.0.html#circle*.

For example, to draw three circles with circle_marker:

```
t = Table().with_columns([
        'lat', [37.8, 38, 37.9],
        'lon', [-122, -122.1, -121.9],
        'label', ['one', 'two', 'three'],
        'color', ['red', 'green', 'blue'],
        'area', [3000, 4000, 5000],
    ])
Circle.map_table(t)
```

To draw three circles with the circle methods, replace the last line with:

```
Circle.map_table(t, radius_in_meters=True)
```

draw_on(*folium_map*, *radius_in_meters=False*)

Add feature to Folium map object.

class datascience.maps.**Map**(*features=()*, *ids=()*, *width=960*, *height=500*, ***kwargs*)

A map from IDs to features. Keyword args are forwarded to folium.

color(*values*, *ids=()*, *key_on='feature.id'*, *palette='YlOrBr'*, ***kwargs*)

Color map features by binning values.

values – a sequence of values or a table of keys and values ids – an ID for each value; if none are provided, indices are used key_on – attribute of each feature to match to ids palette – one of the following color brewer palettes:

> 'BuGn', 'BuPu', 'GnBu', 'OrRd', 'PuBu', 'PuBuGn', 'PuRd', 'RdPu', 'YlGn', 'YlGnBu', 'YlOrBr', and 'YlOrRd'.

Defaults from Folium:

threshold_scale: list, default None
Data range for D3 threshold scale. Defaults to the following range of quantiles: [0, 0.5, 0.75, 0.85, 0.9], rounded to the nearest order-of-magnitude integer. Ex: 270 rounds to 200, 5600 to 6000.

fill_opacity: float, default 0.6
Area fill opacity, range 0-1.

line_color: string, default 'black'
GeoJSON geopath line color.

line_weight: int, default 1
GeoJSON geopath line weight.

line_opacity: float, default 1
GeoJSON geopath line opacity, range 0-1.

legend_name: string, default None
Title for data legend. If not passed, defaults to columns[1].

copy()

Copies the current Map into a new one and returns it. Note: This only copies rendering attributes. The underlying map is NOT deep-copied. This is as a result of no functionality in Folium. Ref: https://github.com/python-visualization/folium/issues/1207

property features

format(***kwargs*)

Apply formatting.

geojson()

Render features as a FeatureCollection.

overlay(*feature*, *color='Blue'*, *opacity=0.6*)

Overlays `feature` on the map. Returns a new Map.

Args:

feature: a `Table` of map features, a list of map features,
a Map, a Region, or a circle marker map table. The features will be overlayed on the Map with specified `color`.

`color` (`str`): Color of feature. Defaults to 'Blue'

opacity (float): Opacity of overlain feature. Defaults to
0.6.

Returns:
A new Map with the overlain feature.

classmethod read_geojson(*path_or_json_or_string_or_url*)

Read a geoJSON string, object, file, or URL. Return a dict of features keyed by ID.

class datascience.maps.Marker(*lat*, *lon*, *popup=''*, *color='blue'*, ***kwargs*)

A marker displayed with Folium's simple_marker method.

popup – text that pops up when marker is clicked color – The color of the marker. You can use: ['red', 'blue', 'green', 'purple', 'orange', 'darkred', 'lightred', 'beige', 'darkblue', 'darkgreen', 'cadetblue', 'darkpurple', 'white', 'pink', 'lightblue', 'lightgreen', 'gray', 'black', 'lightgray'] to use standard folium icons. If a hex color code is provided, (color must start with '#'), a folium.plugin.BeautifyIcon will be used instead.

Defaults from Folium:

marker_icon: string, default 'info-sign'
icon from (http://getbootstrap.com/components/) you want on the marker

clustered_marker: boolean, default False
boolean of whether or not you want the marker clustered with other markers

icon_angle: int, default 0
angle of icon

popup_width: int, default 300
width of popup

The icon can be further customized by by passing in attributes into kwargs by using the attributes listed in *https://python-visualization.github.io/folium/modules.html#folium.map.Icon*.

copy()

Return a deep copy

draw_on(*folium_map*)

Add feature to Folium map object.

format(***kwargs*)

Apply formatting.

geojson(*feature_id*)

GeoJSON representation of the marker as a point.

property lat_lons

Sequence of lat_lons that describe a map feature (for zooming).

classmethod map(*latitudes*, *longitudes*, *labels=None*, *colors=None*, *areas=None*, *other_attrs=None*, *clustered_marker=False*, ***kwargs*)

Return markers from columns of coordinates, labels, & colors.

The areas column is not applicable to markers, but sets circle areas.

Arguments: (TODO) document all options

index_map: list of integers, default None (when not applicable)
list of indices that maps each marker to a corresponding label at the index in cluster_labels (only applicable when multiple marker clusters are being used)

cluster_labels: list of strings, default None (when not applicable)
list of labels used for each cluster of markers (only applicable when multiple marker clusters are being used)

colorbar_scale: list of floats, default None (when not applicable)
list of cutoffs used to indicate where the bins are for each color (only applicable when colorscale gradient is being used)

include_color_scale_outliers: boolean, default None (when not applicable)
boolean of whether or not outliers are included in the colorscale gradient for markers (only applicable when colorscale gradient is being used)

radius_in_meters: boolean, default False
boolean of whether or not Circles should have their radii specified in meters, scales with map zoom

clustered_marker: boolean, default False
boolean of whether or not you want the marker clustered with other markers

other_attrs: dictionary of (key) property names to (value) property values, default None
A dictionary that list any other attributes that the class Marker/Circle should have

`classmethod map_table`(*table*, *clustered_marker=False*, *include_color_scale_outliers=True*, *radius_in_meters=False*, ***kwargs*)

Return markers from the columns of a table.

The first two columns of the table must be the latitudes and longitudes (in that order), followed by 'labels', 'colors', 'color_scale', 'radius_scale', 'cluster_by', 'area_scale', and/or 'areas' (if applicable) in any order with columns explicitly stating what property they are representing.

Args:

`cls`: Type of marker being drawn on the map {Marker, Circle}.

`table`: Table of data to be made into markers. The first two columns of the table must be the latitudes and longitudes (in that order), followed by 'labels', 'colors', 'cluster_by', 'color_scale', 'radius_scale', 'area_scale', and/or 'areas' (if applicable) in any order with columns explicitly stating what property they are representing. Additional columns for marker-specific attributes such as 'marker_icon' for the Marker class can be included as well.

`clustered_marker`: Boolean indicating if markers should be clustered with folium.plugins.MarkerCluster.

`include_color_scale_outliers`: Boolean indicating if outliers should be included in the color scale gradient or not.

`radius_in_meters`: Boolean indicating if circle markers should be drawn to map scale or zoom scale.

`class datascience.maps.Region`(*geojson*, ***kwargs*)

A GeoJSON feature displayed with Folium's geo_json method.

`copy`()

Return a deep copy

`draw_on`(*folium_map*)

Add feature to Folium map object.

`format`(***kwargs*)

Apply formatting.

`geojson`(*feature_id*)

Return GeoJSON with ID substituted.

property lat_lons
A flat list of (lat, lon) pairs.

property polygons
Return a list of polygons describing the region.

- Each polygon is a list of linear rings, where the first describes the exterior and the rest describe interior holes.
- Each linear ring is a list of positions where the last is a repeat of the first.
- Each position is a (lat, lon) pair.

property properties

property type
The GEOJSON type of the regions: Polygon or MultiPolygon.

datascience.maps.**get_coordinates**(*table*, *replace_columns=False*, *remove_nans=False*)
Adds latitude and longitude coordinates to table based on other location identifiers. Must be in the United States.

Takes table with columns "zip code" or "city" and/or "county" and "state" in column names and adds the columns "lat" and "lon". If a county is not found inside the dataset, that row's latitude and longitude coordinates are replaced with np.nans. The 'replace_columns' flag indicates if the "city", "county", "state", and "zip code" columns should be removed afterwards. The 'remove_nans' flag indicates if rows with nan latitudes and longitudes should be removed. Robust to capitalization in city and county names. If a row's location with multiple zip codes is specified, the latitude and longitude pair assigned to the row will correspond to the smallest zip code.

Dataset was acquired on July 2, 2020 from https://docs.gaslamp.media/download-zip-code-latitude-longitude-city-state-county-csv. Found in geocode_datasets/geocode_states.csv. Modified column names and made city/county columns all in lowercase.

Args:
table: A table with counties that need to mapped to coordinates replace_columns: A boolean that indicates if "county", "city", "state", and "zip code" columns should be removed remove_nans: A boolean that indicates if columns with invalid longitudes and latitudes should be removed

Returns:
Table with latitude and longitude coordinates

3.3 Predicates (datascience.predicates)

Predicate functions.

class datascience.predicates.**are**
Predicate functions. The class is named "are" for calls to where.

For example, given a table, predicates can be used to pick rows as follows.

```
>>> from datascience import Table
>>> t = Table().with_columns([
...     'Sizes', ['S', 'M', 'L', 'XL'],
...     'Waists', [30, 34, 38, 42],
... ])
>>> t.where('Sizes',  are.equal_to('L'))
Sizes | Waists
L     | 38
```

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```
>>> t.where('Waists', are.above(38))
Sizes | Waists
XL    | 42
>>> t.where('Waists', are.above_or_equal_to(38))
Sizes | Waists
L     | 38
XL    | 42
>>> t.where('Waists', are.below(38))
Sizes | Waists
S     | 30
M     | 34
>>> t.where('Waists', are.below_or_equal_to(38))
Sizes | Waists
S     | 30
M     | 34
L     | 38
>>> t.where('Waists', are.strictly_between(30, 38))
Sizes | Waists
M     | 34
>>> t.where('Waists', are.between(30, 38))
Sizes | Waists
S     | 30
M     | 34
>>> t.where('Waists', are.between_or_equal_to(30, 38))
Sizes | Waists
S     | 30
M     | 34
L     | 38
>>> t.where('Sizes',  are.equal_to('L'))
Sizes | Waists
L     | 38
>>> t.where('Waists', are.not_above(38))
Sizes | Waists
S     | 30
M     | 34
L     | 38
>>> t.where('Waists', are.not_above_or_equal_to(38))
Sizes | Waists
S     | 30
M     | 34
>>> t.where('Waists', are.not_below(38))
Sizes | Waists
L     | 38
XL    | 42
>>> t.where('Waists', are.not_below_or_equal_to(38))
Sizes | Waists
XL    | 42
>>> t.where('Waists', are.not_strictly_between(30, 38))
Sizes | Waists
S     | 30
L     | 38
XL    | 42
```

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```
>>> t.where('Waists', are.not_between(30, 38))
Sizes | Waists
L     | 38
XL    | 42
>>> t.where('Waists', are.not_between_or_equal_to(30, 38))
Sizes | Waists
XL    | 42
>>> t.where('Sizes', are.containing('L'))
Sizes | Waists
L     | 38
XL    | 42
>>> t.where('Sizes', are.not_containing('L'))
Sizes | Waists
S     | 30
M     | 34
>>> t.where('Sizes', are.contained_in('MXL'))
Sizes | Waists
M     | 34
L     | 38
XL    | 42
>>> t.where('Sizes', are.contained_in('L'))
Sizes | Waists
L     | 38
>>> t.where('Sizes', are.not_contained_in('MXL'))
Sizes | Waists
S     | 30
```

static above(*y*)

Greater than y.

static above_or_equal_to(*y*)

Greater than or equal to y.

static below(*y*)

Less than y.

static below_or_equal_to(*y*)

Less than or equal to y.

static between(*y*, *z*)

Greater than or equal to y and less than z.

static between_or_equal_to(*y*, *z*)

Greater than or equal to y and less than or equal to z.

static contained_in(*superstring*)

A string that is part of the given superstring.

static containing(*substring*)

A string that contains within it the given substring.

static equal_to(*y*)

Equal to y.

static not_above(*y*)
Is not above y

static not_above_or_equal_to(*y*)
Is neither above y nor equal to y

static not_below(*y*)
Is not below y

static not_below_or_equal_to(*y*)
Is neither below y nor equal to y

static not_between(*y*, *z*)
Is equal to y or less than y or greater than z

static not_between_or_equal_to(*y*, *z*)
Is less than y or greater than z

static not_contained_in(*superstring*)
A string that is not contained within the superstring

static not_containing(*substring*)
A string that does not contain substring

static not_equal_to(*y*)
Is not equal to y

static not_strictly_between(*y*, *z*)
Is equal to y or equal to z or less than y or greater than z

static strictly_between(*y*, *z*)
Greater than y and less than z.

3.4 Formats (datascience.formats)

String formatting for table entries.

class datascience.formats.**CurrencyFormatter**(*symbol='$'*, **args*, ***vargs*)
Format currency and convert to float.

convert_value(*value*)
Convert value to float. If value is a string, ensure that the first character is the same as symbol ie. the value is in the currency this formatter is representing.

format_value(*value*)
Format currency.

class datascience.formats.**DateFormatter**(*format='%Y-%m-%d %H:%M:%S.%f'*, **args*, ***vargs*)
Format date & time and convert to UNIX timestamp.

convert_value(*value*)
Convert 2015-08-03 to a Unix timestamp int.

format_value(*value*)
Format timestamp as a string.

class datascience.formats.**DistributionFormatter**(*decimals=2*, **args*, ***vargs*)

Normalize a column and format as percentages.

convert_column(*values*)

Normalize values.

class datascience.formats.**Formatter**(*min_width=None*, *max_width=None*, *etc=None*)

String formatter that truncates long values.

convert_column(*values*)

Convert each value using the convert_value method.

static convert_value(*value*)

Identity conversion (override to convert values).

property converts_values

Whether this Formatter also converts values.

etc = ' ...'

format_column(*label*, *column*)

Return a formatting function that pads & truncates values.

static format_value(*value*)

Pretty-print an arbitrary value.

max_width = 60

min_width = 4

class datascience.formats.**NumberFormatter**(*decimals=2*, *decimal_point='.'*, *separator=','*, *int_to_float=False*, **args*, ***vargs*)

Format numbers that may have delimiters.

convert_value(*value*)

Convert string 93,000.00 to float 93000.0.

format_value(*value*)

Pretty-print an arbitrary value.

class datascience.formats.**PercentFormatter**(*decimals=2*, **args*, ***vargs*)

Format a number as a percentage.

format_value(*value*)

Format number as percentage.

3.5 Utility Functions (datascience.util)

Utility functions

datascience.util.**is_non_string_iterable**(*value*)

Returns a boolean value representing whether a value is iterable.

`datascience.util.make_array(*elements)`

Returns an array containing all the arguments passed to this function. A simple way to make an array with a few elements.

As with any array, all arguments should have the same type.

Args:
`elements` (variadic): elements

Returns:
A NumPy array of same length as the provided varadic argument `elements`

```
>>> make_array(0)
array([0])
>>> make_array(2, 3, 4)
array([2, 3, 4])
>>> make_array("foo", "bar")
array(['foo', 'bar'],
      dtype='<U3')
>>> make_array()
array([], dtype=float64)
```

`datascience.util.minimize(f, start=None, smooth=False, log=None, array=False, **vargs)`

Minimize a function f of one or more arguments.

Args:
f: A function that takes numbers and returns a number

start: A starting value or list of starting values

smooth: Whether to assume that f is smooth and use first-order info

log: Logging function called on the result of optimization (e.g. print)

vargs: Other named arguments passed to scipy.optimize.minimize

Returns either:

(a) the minimizing argument of a one-argument function

(b) an array of minimizing arguments of a multi-argument function

`datascience.util.percentile(p, arr=None)`

Returns the pth percentile of the input array (the value that is at least as great as p% of the values in the array).

If arr is not provided, percentile returns itself curried with p

```
>>> percentile(74.9, [1, 3, 5, 9])
5
>>> percentile(75, [1, 3, 5, 9])
5
>>> percentile(75.1, [1, 3, 5, 9])
9
>>> f = percentile(75)
>>> f([1, 3, 5, 9])
5
```

`datascience.util.plot_cdf_area(rbound=None, lbound=None, mean=0, sd=1)`

Plots a normal curve with specified parameters and area below curve shaded between `lbound` and `rbound`.

Args:

rbound (numeric): right boundary of shaded region

lbound (numeric): left boundary of shaded region; by default is negative infinity

mean (numeric): mean/expectation of normal distribution

sd (numeric): standard deviation of normal distribution

datascience.util.**plot_normal_cdf**(*rbound=None*, *lbound=None*, *mean=0*, *sd=1*)

Plots a normal curve with specified parameters and area below curve shaded between lbound and rbound.

Args:

rbound (numeric): right boundary of shaded region

lbound (numeric): left boundary of shaded region; by default is negative infinity

mean (numeric): mean/expectation of normal distribution

sd (numeric): standard deviation of normal distribution

datascience.util.**proportions_from_distribution**(*table*, *label*, *sample_size*, *column_name='Random Sample'*)

Adds a column named column_name containing the proportions of a random draw using the distribution in label.

This method uses np.random.Generator.multinomial to draw sample_size samples from the distribution in table.column(label), then divides by sample_size to create the resulting column of proportions.

Args:

table: An instance of Table.

label: Label of column in table. This column must contain a
distribution (the values must sum to 1).

sample_size: The size of the sample to draw from the distribution.

column_name: The name of the new column that contains the sampled
proportions. Defaults to 'Random Sample'.

Returns:

A copy of table with a column column_name containing the sampled proportions. The proportions will sum to 1.

Throws:

ValueError: If the label is not in the table, or if
table.column(label) does not sum to 1.

datascience.util.**sample_proportions**(*sample_size: int*, *probabilities*)

Return the proportion of random draws for each outcome in a distribution.

This function is similar to np.random.Generator.multinomial, but returns proportions instead of counts.

Args:

sample_size: The size of the sample to draw from the distribution.

probabilities: An array of probabilities that forms a distribution.

Returns:

An array with the same length as probability that sums to 1.

`datascience.util.table_apply(table, func, subset=None)`

Applies a function to each column and returns a Table.

Args:

`table`: The table to apply your function to.

`func`: The function to apply to each column.

`subset`: A list of columns to apply the function to; if None,
the function will be applied to all columns in table.

Returns:

A table with the given function applied. It will either be the shape == shape(table), or shape (1, table.shape[1])

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