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# **data\_tools Documentation**

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# CONTENTS

<b>1</b>	<b>Disclaimer</b>	<b>3</b>
<b>2</b>	<b>Dependencies</b>	<b>5</b>
<b>3</b>	<b>Installation</b>	<b>7</b>
<b>4</b>	<b>Modules</b>	<b>9</b>
4.1	data_tools.databases . . . . .	9
4.2	data_tools.diffusion . . . . .	11
4.3	data_tools.models . . . . .	11
4.4	data_tools.plots . . . . .	12
4.5	data_tools.sets . . . . .	16
4.6	data_tools.strings . . . . .	17
	<b>Python Module Index</b>	<b>19</b>
	<b>Index</b>	<b>21</b>



Data tools: a collection of Python functions and classes designed to make data scientists' life easier.

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## DISCLAIMER

This package is still under development and will be periodically updated with new features. Contributions are very welcome (fork + pull request). If you find any bug or suggestion for upgrades, please use the [issue system](#).

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## DEPENDENCIES

- NumPy
- Matplotlib
- Pandas
- SciPy
- Scikit-learn



## INSTALLATION

First download/clone `data_tools` from the [GitHub repository](https://github.com/Nic-Nic/data_tools). From the terminal:

```
git clone https://github.com/Nic-Nic/data_tools.git
cd data_tools
```

Then you can install it by running `setup.py` as follows:

```
python setup.py sdist
```

Or using `pip`:

```
pip install .
```

Along with `data_tools`, all dependencies will be installed as well as the testing suite. In order to run the tests, type on the terminal:

```
python -m test_data_tools
```

**NOTE:** `data_tools.plots` module does not have any tests implemented.



## MODULES

### 4.1 data\_tools.databases

Databases functions module.

`data_tools.databases.kegg_link(query, target='pathway')`

Queries a request to the KEGG database to find related entries using cross-references. A list of available database(s) and query examples can be found in <https://www.kegg.jp/kegg/rest/keggapi.html#link>.

- **Arguments:**

- *query* [list]: Or any iterable type containing the identifier(s) to be queried as [str]. These can be either valid database identifiers or databases *per se* (see the link above).
- *target* [str]: Optional, 'pathway' by default. Targeted database to which the query should be linked to. You can check other options available in the URL above.

- **Returns:**

- [pandas.DataFrame]: Two-column table containing both the input query identifiers and their linked ones.

- **Example:**

```
>>> my_query = ['hsa:10458', 'ece:Z5100']
>>> kegg_link(my_query)
  query      pathway
0  hsa:10458  path:hsa04520
1  hsa:10458  path:hsa04810
2  ece:Z5100  path:ece05130
```

`data_tools.databases.kegg_pathway_mapping(df, mapid, filename=None)`

Makes a request to KEGG pathway mapping tool according to a given pathway ID (see [https://www.kegg.jp/kegg/tool/map\\_pathway2.html](https://www.kegg.jp/kegg/tool/map_pathway2.html) for more information). The user must provide a query of IDs to be mapped with their corresponding background colors (and optionally also foreground colors). The result is downloaded in the current directory or a user-specified path.

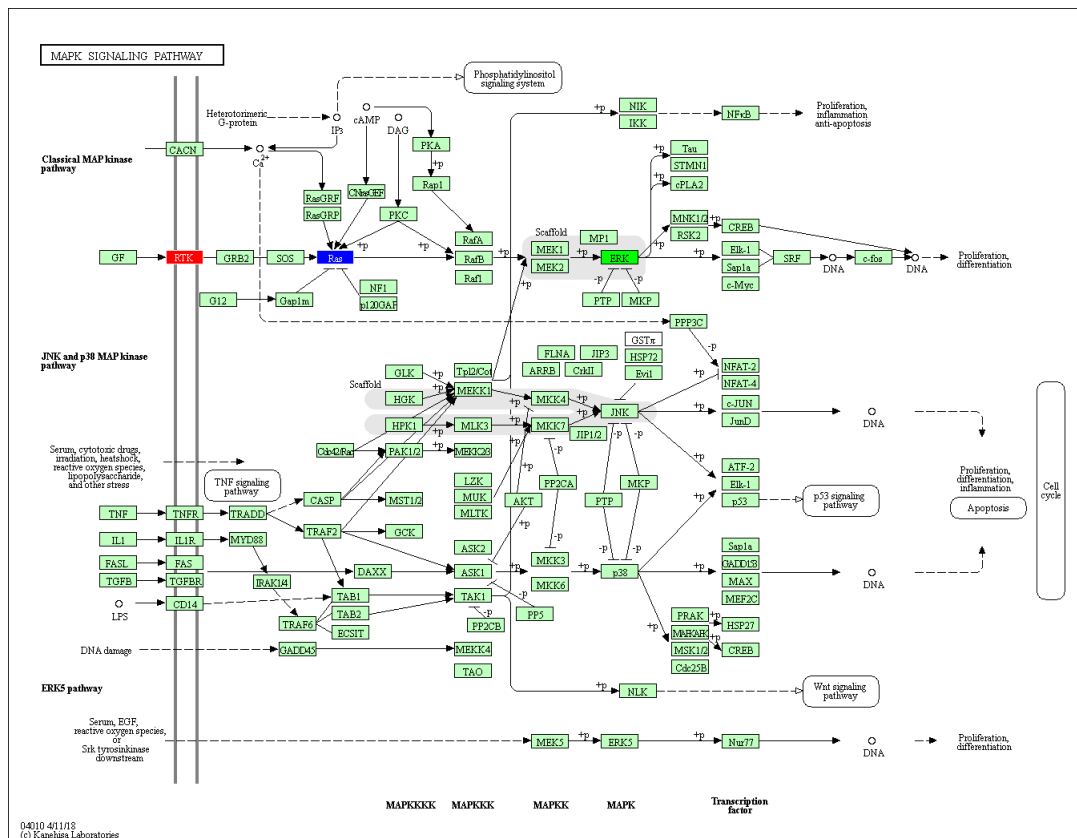
- **Arguments:**

- *df* [pandas.DataFrame]: Dataframe containing KEGG valid IDs in the first column and corresponding background colors (e.g.: red, blue, ...). Optionally, a third column with the foreground (font) colors can also be provided (black by default). **NOTE:** hexadecimal codes for colors is also supported. Index and column names of dataframe are ignored.
- *mapid* [str]: A valid KEGG pathway ID. It can be a general (e.g.: “mapXXXXX”) or organism-specific ID (e.g.: “hsaXXXXX”).

- `filename [str]`: Optional, `None` by default. This is, the image will be stored in the current directory with the `mapid` provided as file name. If provided, the image will be stored within the specified path/file name.

- **Example:**

```
>>> my_query = pandas.DataFrame([[ '1956', 'red', '#f1f1f1'],
...                               [ '3845', 'blue', '#f1f1f1'],
...                               [ '5594', 'green', 'black']])
>>> kegg_pathway_mapping(my_query, 'hsa04010')
```



`data_tools.databases.up_map(query, source='ACC', target='GENENAME')`

Queries a request to UniProt.org in order to map a given list of identifiers. You can check the options available of input/output identifiers at [https://www.uniprot.org/help/api\\_idmapping](https://www.uniprot.org/help/api_idmapping).

- **Arguments:**

- `query [list]`: Or any iterable type containing the identifiers to be queried as `[str]`.
- `source [str]`: Optional, `'ACC'` by default. This is, UniProt accession number. You can check other options available in the URL above.
- `target [str]`: Optional, `'GENENAME'` by default. You can check other options available in the URL above.

- **Returns:**

- `[pandas.DataFrame]`: Two-column table containing both the inputted identifiers and the mapping result of these.

- **Example:**

```
>>> my_query = ['P00533', 'P31749', 'P16220']
>>> up_map(my_query)
      ACC GENENAME
0  P00533      EGFR
1  P31749      AKT1
2  P16220      CREB1
```

## 4.2 data\_tools.diffusion

Diffusion solvers module.

`data_tools.diffusion.euler_explicit1D(x0, dt, dx2, d=1, bcs='periodic')`

Computes diffusion on a 1D space over a time-step using Euler explicit method.

- **Arguments:**

- `x0` [numpy.ndarray]: Initial state of a 1D array from which the diffusion is to be computed.
- `dt` [float]: Discretization time-step.
- `dx2` [float]: Discretization spatial-step (squared).
- `d` [float]: Diffusion coefficient.
- `bcs` [str]: Optional, 'periodic' by default. Determines the boundary conditions. Available options are 'periodic', 'dirichlet' or 'neumann'.

- **Returns:**

- [numpy.ndarray]: Computed state array (1D) after one time-step according to the parameters and conditions selected.

## 4.3 data\_tools.models

Model classes module.

**class** `data_tools.models.Lasso(Cs=500, cv=10, sampler='skf', solver='liblinear', **kwargs)`

Wrapper class inheriting from `sklearn.linear_model.LogisticRegressionCV` with L1 regularization.

- **Arguments:**

- `Cs` [int]: Optional, 500 by default. Integer or list of float values of regularization parameters to test. If an integer is passed, it will determine the number of values taken from a logarithmic scale between  $1e-4$  and  $1e4$ . Note that the value of the parameter is defined as the inverse of the regularization strength.
- `cv` [int]: Optional, 10 by default. Denotes the number of cross validation (CV) folds.
- `sampler` [str]: Optional, 'skf' by default. Determines which sampling method is used to generate the test and training sets for CV. Methods available are K-Fold ('kf'), Shuffle Split ('ss') and their stratified variants ('skf' and 'sss' respectively).
- `solver` [str]: Optional, 'liblinear' by default. Determines which solver algorithm to use. Note that L1 regularization can only be handled by 'liblinear' and 'saga'. Additionally if the classification is multinomial, only the latter option is available.

- ***\*\*kwargs***: Optional. Any other keyword argument accepted by the `sklearn.linear_model.LogisticRegressionCV` class.

Other keyword arguments and functions available from the parent class `LogisticRegressionCV` can be found in [Scikit-Learn's reference](#).

**fit\_data** (*x*, *y*, *silent=False*)

Fits the data to the logistic model.

- **Arguments:**

- *x* [`pandas.DataFrame`]: Contains the values/measurements [`float`] of the features (columns) for each sample/replicate (rows).
- *y* [`pandas.Series`]: List or any iterable containing the observed class of each sample (must have the same order as in *x*).
- *silent* [`bool`]: Optional, `False` by default. Determines whether messages are printed or not.

**plot\_coef** (*filename=None*, *figsize=None*)

Plots the non-zero coefficients for the fitted predictor features.

- **Arguments:**

- *filename* [`str`]: Optional, `None` by default. If passed, indicates the file name or path where to store the figure. Format must be specified (e.g.: `.png`, `.pdf`, etc)
- *figsize* [`tuple`]: Optional, `None` by default (default matplotlib size). Any iterable containing two values denoting the figure size (in inches) as [`width`, `height`].

- **Returns:**

- [`matplotlib.figure.Figure`]: Figure object containing the bar plot of the non-zero coefficients.

**plot\_score** (*filename=None*, *figsize=None*)

Plots the mean score across all folds obtained during CV. The optimum C parameter chosen and its score are highlighted.

- **Arguments:**

- *filename* [`str`]: Optional, `None` by default. If passed, indicates the file name or path where to store the figure. Format must be specified (e.g.: `.png`, `.pdf`, etc)
- *figsize* [`tuple`]: Optional, `None` by default (default matplotlib size). Any iterable containing two values denoting the figure size (in inches) as [`width`, `height`].

- **Returns:**

- [`matplotlib.figure.Figure`]: Figure object containing the score plot.

## 4.4 data\_tools.plots

Plotting functions module.

`data_tools.plots.density` (*df*, *cvf=0.25*, *title=None*, *filename=None*, *figsize=None*)

Generates a density plot of the values on a data frame (row-wise).

- **Arguments:**

- *df* [`pandas.DataFrame`]: Contains the values to generate the plot. Each row is considered as an individual sample while each column contains a measured value.



- *cvf* [float]: Optional, 0.25 by default. Co-variance factor used in the gaussian kernel estimation. A higher value increases the smoothness.
- *title* [str]: Optional, None by default. Defines the plot title.
- *filename* [str]: Optional, None by default. If passed, indicates the file name or path where to store the figure. Format must be specified (e.g.: .png, .pdf, etc)
- *figsize* [tuple]: Optional, None by default (default matplotlib size). Any iterable containing two values denoting the figure size (in inches) as [width, height].

- **Returns:**

- [matplotlib.figure.Figure]: the figure object containing the density plot.

`data_tools.plots.piano_consensus` (*df*, *nchar*=40, *boxes*=True, *title*=None, *filename*=None, *figsize*=None)

Generates a GSEA consensus score plot like R package `piano`'s `consensusScores` function, but prettier. The main input is assumed to be a `pandas.DataFrame` whose data is the same as the `rankMat` from the result of `consensusScores`.

- **Arguments:**

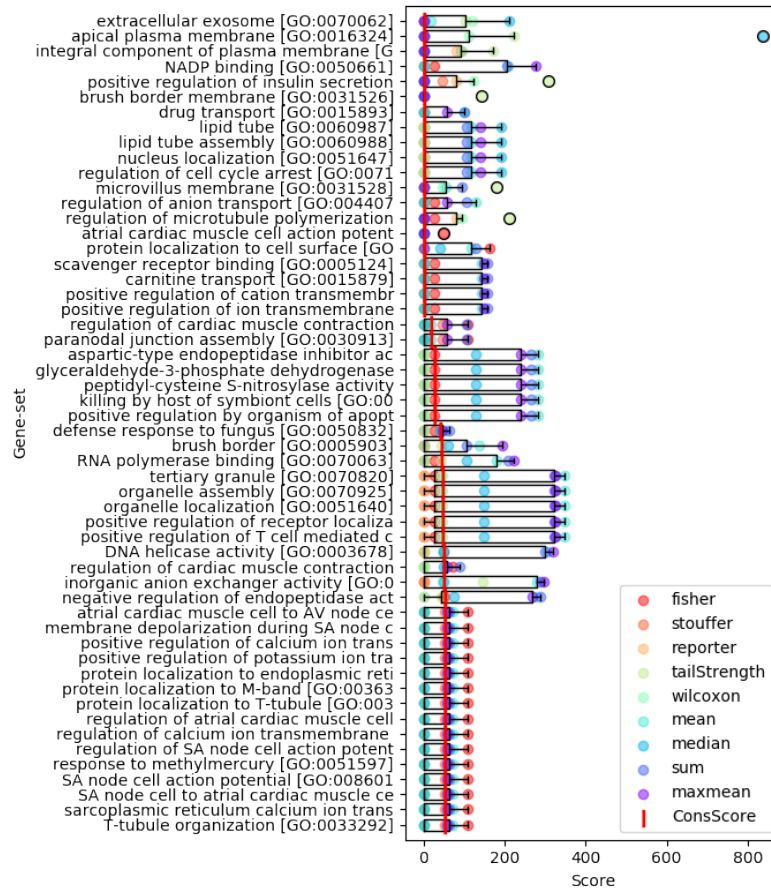
- *df* [pandas.DataFrame]: Values contained correspond to the scores of the gene-sets (consensus and each individual methods). Index must contain the gene-set labels. Columns are assumed to be `ConsRank` (ignored), `ConsScore` followed by the individual methods (e.g.: `mean`, `median`, `sum`, etc).
- *nchar* [int]: Optional, 40 by default. Number of string characters of the gene-set labels of the plot.
- *boxes* [bool]: Optional, True by default. Determines whether to show the boxplots of the gene-sets or not.
- *title* [str]: Optional, None by default. Defines the plot title.
- *filename* [str]: Optional, None by default. If passed, indicates the file name or path where to store the figure. Format must be specified (e.g.: .png, .pdf, etc)
- *figsize* [tuple]: Optional, None by default (default matplotlib size). Any iterable containing two values denoting the figure size (in inches) as [width, height].

- **Returns:**

- [matplotlib.figure.Figure]: the figure object containing a combination of box and scatter plots of the gene-set scores.

- **Example:**

```
>>> piano_consensus(df, figsize=[7, 8])
```



`data_tools.plots.venn` (*N*, labels=['A', 'B', 'C', 'D'], c=['C0', 'C1', 'C2', 'C3'], title=None, filename=None, figsize=None)

Plots a Venn diagram from a list of sets *N*. Number of sets must be between 2 and 4 (inclusive).

- **Arguments:**

- *N* [list]: Or any iterable type containing [set] objects.
- *labels* [list]: Optional, ['A', 'B', 'C', 'D'] by default. Labels for the sets following the same order as provided in *N*.
- *c* [list]: Optional, ['C0', 'C1', 'C2', 'C3'] by default (matplotlib default colors). Any iterable containing color arguments tolerated by matplotlib (e.g.: ['r', 'b'] for red and blue). Must contain at least the same number of elements as *N* (if more are provided, they will be ignored).
- *title* [str]: Optional, None by default. Defines the plot title.
- *filename* [str]: Optional, None by default. If passed, indicates the file name or path where to store the figure. Format must be specified (e.g.: .png, .pdf, etc)
- *figsize* [tuple]: Optional, None by default (default matplotlib size). Any iterable containing two values denoting the figure size (in inches) as [width, height].

- **Returns:**

- `[matplotlib.figure.Figure]`: the figure object containing a combination of box and scatter plots of the gene-set scores.

- **Example:**

```
>>> N = [{0, 1}, {2, 3}, {1, 3, 4}] # Sets A, B, C
>>> venn(N)
```



`data_tools.plots.volcano` (*logfc*, *logpval*, *thr\_pval*=0.05, *thr\_fc*=2.0, *c*=('C0', 'C1'), *legend*=True, *title*=None, *filename*=None, *figsize*=None)

Generates a volcano plot from the differential expression data provided.

- **Arguments:**

- *logfc* [list]: Or any iterable type. Contains the log (usually base 2) fold-change values. Must have the same length as *logpval*.
- *logpval* [list]: Or any iterable type. Contains the -log p-values (usually base 10). Must have the same length as *logfc*.
- *thr\_pval* [float]: Optional, 0.05 by default. Specifies the p-value (non log-transformed) threshold to consider a measurement as significantly differentially expressed.
- *thr\_fc* [float]: Optional, 2. by default. Specifies the FC (non log-transformed) threshold to consider a measurement as significantly differentially expressed.
- *c* [tuple]: Optional, ('C0', 'C1') by default (matplotlib default colors). Any iterable containing two color arguments tolerated by matplotlib (e.g.: ['r', 'b'] for red and blue). First one is used for non-significant points, second for the significant ones.
- *legend* [bool]: Optional, True by default. Indicates whether to show the plot legend or not.
- *title* [str]: Optional, None by default. Defines the plot title.
- *filename* [str]: Optional, None by default. If passed, indicates the file name or path where to store the figure. Format must be specified (e.g.: .png, .pdf, etc)

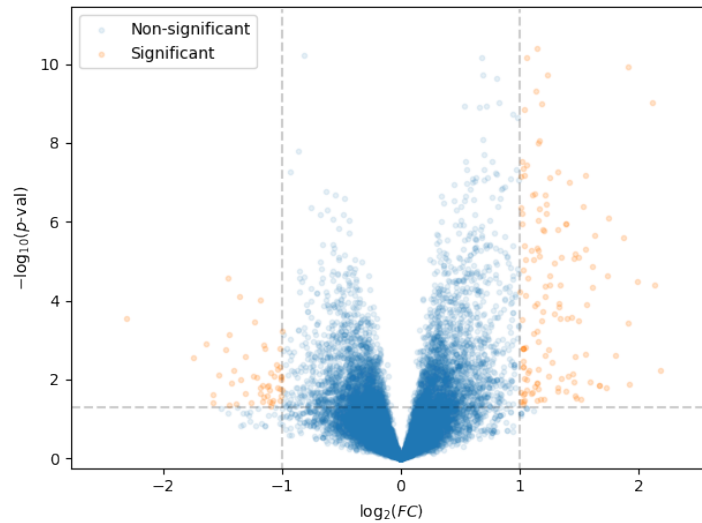
- *figsize* [tuple]: Optional, `None` by default (default matplotlib size). Any iterable containing two values denoting the figure size (in inches) as [width, height].

- **Returns:**

- [matplotlib.figure.Figure]: Figure object containing the volcano plot.

- **Example:**

```
>>> volcano(my_log_fc, my_log_pval)
```



## 4.5 data\_tools.sets

Set operations module.

`data_tools.sets.bit_or(a, b)`

Returns the bit operation OR between two bit-strings *a* and *b*. NOTE: *a* and *b* must have the same size.

- **Arguments:**

- *a* [tuple]: Or any iterable type.
- *b* [tuple]: Or any iterable type.

- **Returns:**

- [tuple]: OR operation between *a* and *b* element-wise.

- **Examples:**

```
>>> a, b = (0, 0, 1), (1, 0, 1)
>>> bit_or(a, b)
(1, 0, 1)
```

`data_tools.sets.find_min(A)`

Finds and returns the subset of vectors whose sum is minimum from a given set *A*.

- **Arguments:**

- *A* [set]: Set of vectors ([tuple] or any iterable).

- **Returns:**
  - [set]: Subset of vectors in  $A$  whose sum is minimum.
- **Examples:**

```
>>> A = {(0, 1, 1), (0, 1, 0), (1, 0, 0), (1, 1, 1)}
>>> find_min(A)
set([(0, 1, 0), (1, 0, 0)])
```

`data_tools.sets.in_all(x, N)`

Checks if a vector  $x$  is present in all sets contained in a list  $N$ .

- **Arguments:**
  - $x$  [tuple]: Or any hashable type as long as is the same contained in the sets of  $N$ .
  - $N$  [list]: Or any iterable type containing [set] objects.
- **Returns:**
  - [bool]: True if  $x$  is found in all sets of  $N$ , False otherwise.
- **Examples:**

```
>>> N = [{(0, 0), (0, 1)}, # <- set A
...      {(0, 0), (1, 1), (1, 0)}] # <- set B
>>> x = (0, 0)
>>> in_all(x, N)
True
>>> y = (0, 1)
>>> in_all(y, N)
False
```

`data_tools.sets.subsets(N)`

Function that computes all possible logical relations between all sets on a list  $N$  and returns all subsets. This is, the subsets that would represent each intersecting area on a Venn diagram.

- **Arguments:**
  - $N$  [list]: Or any iterable type containing [set] objects.
- **Returns:**
  - [dict]: Collection of subsets according to the logical relations between the sets in  $N$ . The keys are binary codes that denote the logical relation (see examples below).
- **Examples:**

```
>>> N = [{0, 1, 2}, {2, 3, 4}]
>>> subsets(N)
{'11': set([2]), '10': set([0, 1]), '01': set([3, 4])}
>>> N = [{0, 1}, {2, 3}, {1, 3, 4}]
>>> subsets(N)
{'010': set([2]), '011': set([3]), '001': set([4]), '111': set([
]), '110': set([]), '100': set([0]), '101': set([1])}
```

## 4.6 data\_tools.strings

String operations module.

`data_tools.strings.is_numeric(s)`

Determines if a string can be considered a numeric value. NaN is also considered, since it is float type.

- **Arguments:**

- `s [str]`: String to be evaluated.

- **Returns:**

- `[bool]`: True/False depending if the condition is satisfied.

- **Examples:**

```
>>> is_numeric('4')
True
>>> is_numeric('-3.2')
True
>>> is_numeric('number')
False
>>> is_numeric('NaN')
True
```

`data_tools.strings.join_str_lists(a, b, sep="")`

Joins element-wise two lists (or any 1D iterable) of strings with a given separator (if provided). Length of the input lists must be equal.

- **Arguments:**

- `a [list]`: Contains the first elements [str] of the joint strings.
- `b [list]`: Contains the second elements [str] of the joint strings.
- `sep [str]`: Optional ' ' (non separated) by default. Determines the separator between the joint strings.

- **Returns:**

- `[list]`: List of the joint strings.

- **Example:**

```
>>> a = ['a', 'b']
>>> b = ['1', '2']
>>> join_str_lists(a, b, sep='_')
['a_1', 'b_2']
```

## PYTHON MODULE INDEX

### d

`data_tools.databases`, [9](#)  
`data_tools.diffusion`, [11](#)  
`data_tools.models`, [11](#)  
`data_tools.plots`, [12](#)  
`data_tools.sets`, [16](#)  
`data_tools.strings`, [17](#)





## INDEX

### B

bit\_or() (in module data\_tools.sets), 16

### D

data\_tools.databases (module), 9

data\_tools.diffusion (module), 11

data\_tools.models (module), 11

data\_tools.plots (module), 12

data\_tools.sets (module), 16

data\_tools.strings (module), 17

density() (in module data\_tools.plots), 12

### E

euler\_explicit1D() (in module data\_tools.diffusion), 11

### F

find\_min() (in module data\_tools.sets), 16

fit\_data() (data\_tools.models.Lasso method), 12

### I

in\_all() (in module data\_tools.sets), 17

is\_numeric() (in module data\_tools.strings), 17

### J

join\_str\_lists() (in module data\_tools.strings), 18

### K

kegg\_link() (in module data\_tools.databases), 9

kegg\_pathway\_mapping() (in module data\_tools.databases), 9

### L

Lasso (class in data\_tools.models), 11

### P

piano\_consensus() (in module data\_tools.plots), 13

plot\_coef() (data\_tools.models.Lasso method), 12

plot\_score() (data\_tools.models.Lasso method), 12

### S

subsets() (in module data\_tools.sets), 17

### U

up\_map() (in module data\_tools.databases), 10

### V

venn() (in module data\_tools.plots), 14

volcano() (in module data\_tools.plots), 15