

# Package ‘destiny’

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**Type** Package

**Title** Creates diffusion maps

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**Description** Create and plot diffusion maps.

**License** GPL-3

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<https://github.com/theislab/destiny/>,  
<https://www.helmholtz-muenchen.de/icb/destiny>,  
<https://bioconductor.org/packages/destiny>,  
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gridExtra, cowplot, conflicted, viridis, rgl, scRNAseq,  
org.Mm.eg.db, scran, repr

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**Collate** 'RcppExports.R' 'aaa.r' 'accessor-generics.r' 'censoring.r' 'colorlegend.r' 'cube\_helix.r' 'dataset-helpers.r' 'destiny-package.r' 's4-unions.r' 'dist-matrix-coerce.r' 'sigmas.r' 'diffusionmap.r' 'diffusionmap-methods-accession.r' 'diffusionmap-methods.r' 'plotheelpers.r' 'diffusionmap-plotting.r' 'dpt-branching.r' 'dpt-helpers.r' 'dpt.r' 'dpt-methods-matrix.r' 'dpt-methods.r' 'utils.r' 'dpt-plotting.r' 'eig\_decomp.r' 'expressionset-helpers.r' 'find\_dm\_k.r' 'gene-relevance.r' 'gene-relevance-methods.r' 'gene-relevance-plotting-differential-map.r' 'gene-relevance-plotting-gr-map.r' 'gene-relevance-plotting-rank.r' 'gene-relevance-plotting.r' 'guo-data.r' 'knn.r' 'l\_which.r' 'methods-coercion.r' 'methods-extraction.r' 'methods-update.r' 'predict.r' 'projection-dist.r' 'rankcor.r' 'sigmas-plotting.r'

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## Contents

|                                          |    |
|------------------------------------------|----|
| Coercion methods . . . . .               | 3  |
| colorlegend . . . . .                    | 4  |
| cube_helix . . . . .                     | 6  |
| destiny . . . . .                        | 8  |
| destiny generics . . . . .               | 9  |
| DiffusionMap accession methods . . . . . | 10 |
| DiffusionMap methods . . . . .           | 11 |
| DiffusionMap-class . . . . .             | 12 |
| dm_predict . . . . .                     | 15 |
| DPT matrix methods . . . . .             | 15 |

|                                        |           |
|----------------------------------------|-----------|
| DPT methods . . . . .                  | 17        |
| DPT-class . . . . .                    | 18        |
| eig_decomp . . . . .                   | 19        |
| ExpressionSet helper methods . . . . . | 19        |
| Extraction methods . . . . .           | 20        |
| find_dm_k . . . . .                    | 22        |
| find_knn . . . . .                     | 22        |
| find_sigmas . . . . .                  | 23        |
| find_tips . . . . .                    | 25        |
| Gene Relevance methods . . . . .       | 25        |
| GeneRelevance-class . . . . .          | 27        |
| guo . . . . .                          | 29        |
| l_which . . . . .                      | 30        |
| plot.DiffusionMap . . . . .            | 30        |
| plot.DPT . . . . .                     | 33        |
| plot.Sigmas . . . . .                  | 34        |
| plot_differential_map . . . . .        | 35        |
| projection_dist . . . . .              | 40        |
| random_root . . . . .                  | 41        |
| Sigmas-class . . . . .                 | 41        |
| updateObject methods . . . . .         | 43        |
| <b>Index</b>                           | <b>44</b> |

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|                  |                         |
|------------------|-------------------------|
| Coercion methods | <i>Coercion methods</i> |
|------------------|-------------------------|

---

## Description

Convert a [DiffusionMap](#) or [DPT](#) object to other classes

## Usage

```
## S4 method for signature 'DiffusionMap'
as.data.frame(x, row.names = NULL, optional = FALSE, ...)
```

```
fortify.DiffusionMap(model, data, ...)
```

```
## S4 method for signature 'DPT'
as.data.frame(x, row.names = NULL, optional = FALSE, ...)
```

```
fortify.DPT(model, data, ...)
```

```
## S4 method for signature 'DPT'
as.matrix(x, ...)
```

**Arguments**

|                        |                                                                                                                                    |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <code>x, model</code>  | A <a href="#">DiffusionMap</a> or <a href="#">DPT</a> object                                                                       |
| <code>row.names</code> | NULL or a character vector giving the row names for the data frame. Missing values are not allowed.                                |
| <code>optional</code>  | logical. If TRUE, setting row names and converting column names (to syntactic names: see <a href="#">make.names</a> ) is optional. |
| <code>...</code>       | Passed to <a href="#">as.data.frame</a>                                                                                            |
| <code>data</code>      | ignored                                                                                                                            |

**Details**

[fortify](#) is a ggplot2 generic allowing a diffusion map to be used as data parameter in [ggplot](#) or [qplot](#).

**Value**

An object of the desired class

**See Also**

[DiffusionMap accession methods](#), [Extraction methods](#), [DiffusionMap methods](#) for more

**Examples**

```
library(Biobase)
data(guo)
dm <- DiffusionMap(guo)
classes <- vapply(as.data.frame(dm), class, character(1L))
stopifnot(all(classes[paste0('DC', 1:20)] == 'numeric'))
stopifnot(all(classes[featureNames(guo)] == 'numeric'))
stopifnot(all(classes[varLabels(guo)] == c('factor', 'integer')))
```

---

colorlegend

---

*Color legend*


---

**Description**

Creates a color legend for a vector used to color a plot. It will use the current [palette\(\)](#) or the specified `pal` as reference.

**Usage**

```

colorlegend(
  col,
  pal = palette(),
  log = FALSE,
  posx = c(0.9, 0.93),
  posy = c(0.05, 0.9),
  main = NULL,
  cex_main = par("cex.sub"),
  cex_axis = par("cex.axis"),
  col_main = par("col.sub"),
  col_lab = par("col.lab"),
  steps = 5,
  steps_color = 100,
  digit = 2,
  left = FALSE,
  ...,
  cex.main = NULL,
  cex.axis = NULL,
  col.main = NULL,
  col.lab = NULL
)

```

**Arguments**

|                                                                                              |                                                                                                          |
|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| <code>col</code>                                                                             | Vector of factor, integer, or double used to determine the ticks.                                        |
| <code>pal</code>                                                                             | If <code>col</code> is double, <code>pal</code> is used as a continuous palette, else as categorical one |
| <code>log</code>                                                                             | Use logarithmic scale?                                                                                   |
| <code>posx</code>                                                                            | Left and right borders of the color bar relative to plot area (Vector of length 2; 0-1)                  |
| <code>posy</code>                                                                            | Bottom and top borders of color bar relative to plot area (Vector of length 2; 0-1)                      |
| <code>main</code>                                                                            | Legend title                                                                                             |
| <code>cex_main</code>                                                                        | Size of legend title font (default: subtitle font size <code>par('cex.sub')</code> )                     |
| <code>cex_axis</code>                                                                        | Size of ticks/category labels (default: axis font size <code>par('cex.axis')</code> )                    |
| <code>col_main</code>                                                                        | Color of legend title (default: subtitle color <code>par('col.sub')</code> )                             |
| <code>col_lab</code>                                                                         | Color of tick or category labels (default: axis color <code>par('col.lab')</code> )                      |
| <code>steps</code>                                                                           | Number of labels in case of a continuous axis. If 0 or FALSE, draw no ticks                              |
| <code>steps_color</code>                                                                     | Number of gradient samples in case of continuous axis                                                    |
| <code>digit</code>                                                                           | Number of digits for continuous axis labels                                                              |
| <code>left</code>                                                                            | logical. If TRUE, invert <code>posx</code>                                                               |
| <code>...</code>                                                                             | Additional parameters for the <code>text</code> call used for labels                                     |
| <code>cex.main</code> , <code>cex.axis</code> , <code>col.main</code> , <code>col.lab</code> | For compatibility with <code>par</code>                                                                  |

## Details

When passed a factor or integer vector, it will create a discrete legend, whereas a double vector will result in a continuous bar.

## Value

This function is called for the side effect of adding a colorbar to a plot and returns nothing/NULL.

## Examples

```
color_data <- 1:6
par(mar = par('mar') + c(0, 0, 0, 3))
plot(sample(6), col = color_data)
colorlegend(color_data)
```

---

cube\_helix

*Sequential color palette using the cube helix system*

---

## Description

Creates a perceptually monotonously decreasing (or increasing) lightness color palette with different tones. This was necessary in pre-*viridis* times, by now you can probably just use [hcl.colors](#)

## Usage

```
cube_helix(
  n = 6,
  start = 0,
  r = 0.4,
  hue = 0.8,
  gamma = 1,
  light = 0.85,
  dark = 0.15,
  reverse = FALSE
)

scale_colour_cube_helix(
  ...,
  start = 0,
  r = 0.4,
  hue = 0.8,
  gamma = 1,
  light = 0.85,
  dark = 0.15,
  reverse = FALSE,
  discrete = TRUE,
```

```

    guide = if (discrete) "legend" else "colourbar"
  )

scale_color_cube_helix(
  ...,
  start = 0,
  r = 0.4,
  hue = 0.8,
  gamma = 1,
  light = 0.85,
  dark = 0.15,
  reverse = FALSE,
  discrete = TRUE,
  guide = if (discrete) "legend" else "colourbar"
)

scale_fill_cube_helix(
  ...,
  start = 0,
  r = 0.4,
  hue = 0.8,
  gamma = 1,
  light = 0.85,
  dark = 0.15,
  reverse = FALSE,
  discrete = TRUE,
  guide = if (discrete) "legend" else "colourbar"
)

```

### Arguments

|                       |                                                                                               |
|-----------------------|-----------------------------------------------------------------------------------------------|
| <code>n</code>        | Number of colors to return (default: 6)                                                       |
| <code>start</code>    | Hue to start helix at ( $\text{start} \in [0, 3]$ , default: 0)                               |
| <code>r</code>        | Number of rotations of the helix. Can be negative. (default: 0.4)                             |
| <code>hue</code>      | Saturation. 0 means greyscale, 1 fully saturated colors (default: 0.8)                        |
| <code>gamma</code>    | Emphasize darker ( $\text{gamma} < 1$ ) or lighter ( $\text{gamma} > 1$ ) colors (default: 1) |
| <code>light</code>    | Lightest lightness (default: 0.85)                                                            |
| <code>dark</code>     | Darkest lightness (default: 0.15)                                                             |
| <code>reverse</code>  | logical. If TRUE, reverse lightness (default: FALSE)                                          |
| <code>...</code>      | parameters passed to <a href="#">discrete_scale</a> or <a href="#">continuous_scale</a>       |
| <code>discrete</code> | If TRUE, return a discrete scale, if FALSE a continuous one (default: TRUE)                   |
| <code>guide</code>    | Type of scale guide to use. See <a href="#">guides</a>                                        |

### Value

A character vector of hex colors with length `n`

## Examples

```
palette(cube_helix())
image(matrix(1:6), col = 1:6, pch = 19, axes = FALSE)

cr <- scales::colour_ramp(cube_helix(12, r = 3))
r <- runif(100)
plot(1:100, r, col = cr(r), type = 'b', pch = 20)
```

---

destiny

---

Create and plot diffusion maps

---

## Description

The main function is `DiffusionMap`, which returns an object you can `plot` (`plot.DiffusionMap` is then called).

## Author(s)

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## See Also

Useful links:

- <https://theislab.github.io/destiny/>
- <https://github.com/theislab/destiny/>
- <https://www.helmholtz-muenchen.de/icb/destiny>
- <https://bioconductor.org/packages/destiny>
- [doi:10.1093/bioinformatics/btv715](https://doi.org/10.1093/bioinformatics/btv715)
- Report bugs at <https://github.com/theislab/destiny/issues>

## Examples

```
demo(destiny, ask = FALSE)
```



---

|                  |                         |
|------------------|-------------------------|
| destiny generics | <i>destiny generics</i> |
|------------------|-------------------------|

---

## Description

destiny provides several generic methods and implements them for the [DiffusionMap](#) and [Sigmas](#) classes.

## Usage

```
eigenvalues(object)

eigenvalues(object) <- value

eigenvectors(object)

eigenvectors(object) <- value

sigmas(object)

sigmas(object) <- value

dataset(object)

dataset(object) <- value

distance(object)

distance(object) <- value

optimal_sigma(object)
```

## Arguments

|        |                                                            |
|--------|------------------------------------------------------------|
| object | Object from which to extract or to which to assign a value |
| value  | Value to assign within an object                           |

## Value

`eigenvalues` retrieves the numeric eigenvalues  
`eigenvectors` retrieves the eigenvectors matrix  
`sigmas` retrieves the [Sigmas](#) from an object utilizing it as kernel width  
`dataset` retrieves the data the object was created from  
`distance` retrieves the distance metric used to create the object, e.g. euclidean  
`optimal_sigma` retrieves the numeric value of the optimal sigma or local sigmas

**See Also**

[DiffusionMap methods](#) and [Sigmas](#) class for implementations

**Examples**

```
data(guo_norm)
dm <- DiffusionMap(guo_norm)
eigenvalues(dm)
eigenvectors(dm)
sigmas(dm)
optimal_sigma(dm)
dataset(dm)
distance(dm)
```

---

DiffusionMap accession methods

*DiffusionMap accession methods*

---

**Description**

Get and set eigenvalues, eigenvectors, and sigma(s) of a [DiffusionMap](#) object.

**Usage**

```
## S4 method for signature 'DiffusionMap'
eigenvalues(object)

## S4 replacement method for signature 'DiffusionMap'
eigenvalues(object) <- value

## S4 method for signature 'DiffusionMap'
eigenvectors(object)

## S4 replacement method for signature 'DiffusionMap'
eigenvectors(object) <- value

## S4 method for signature 'DiffusionMap'
sigmas(object)

## S4 replacement method for signature 'DiffusionMap'
sigmas(object) <- value

## S4 method for signature 'DiffusionMap'
dataset(object)

## S4 replacement method for signature 'DiffusionMap'
```

```
dataset(object) <- value

## S4 method for signature 'DiffusionMap'
distance(object)

## S4 replacement method for signature 'DiffusionMap'
distance(object) <- value

## S4 method for signature 'DiffusionMap'
optimal_sigma(object)
```

**Arguments**

|        |                                                            |
|--------|------------------------------------------------------------|
| object | A DiffusionMap                                             |
| value  | Vector of eigenvalues or matrix of eigenvectors to get/set |

**Value**

The assigned or retrieved value

**See Also**

[Extraction methods](#), [DiffusionMap methods](#), [Coercion methods](#) for more

**Examples**

```
data(guo)
dm <- DiffusionMap(guo)
eigenvalues(dm)
eigenvectors(dm)
sigmas(dm)
dataset(dm)
optimal_sigma(dm)
```

---

DiffusionMap methods    *DiffusionMap methods*

---

**Description**

Methods for external operations on diffusion maps

**Usage**

```
## S4 method for signature 'DiffusionMap'
print(x)

## S4 method for signature 'DiffusionMap'
show(object)
```

**Arguments**

x, object      A [DiffusionMap](#)

**Value**

The DiffusionMap object (print), or NULL (show), invisibly

**See Also**

[DiffusionMap accession methods](#), [Extraction methods](#), [Coercion methods](#) for more

**Examples**

```
data(guo)
dm <- DiffusionMap(guo)
print(dm)
show(dm)
```

---

DiffusionMap-class      *Create a diffusion map of cells*

---

**Description**

The provided data can be a double [matrix](#) of expression data or a [data.frame](#) with all non-integer (double) columns being treated as expression data features (and the others ignored), an [Expression-Set](#), or a [SingleCellExperiment](#).

**Usage**

```
DiffusionMap(
  data = stopifnot_distmatrix(distance),
  sigma = "local",
  k = find_dm_k(dataset_n_observations(data, distance) - 1L),
  n_eigs = min(20L, dataset_n_observations(data, distance) - 2L),
  density_norm = TRUE,
  ...,
  distance = c("euclidean", "cosine", "rankcor", "l2"),
  n_pcs = NULL,
  n_local = seq(to = min(k, 7L), length.out = min(k, 3L)),
  rotate = FALSE,
  censor_val = NULL,
  censor_range = NULL,
  missing_range = NULL,
  vars = NULL,
  knn_params = list(),
  verbose = !is.null(censor_range),
  suppress_dpt = FALSE
)
```

**Arguments**

|               |                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data          | Expression data to be analyzed and covariates. Provide vars to select specific columns other than the default: all double value columns. If distance is a distance matrix, data has to be a <a href="#">data.frame</a> with covariates only.                                                                                                                                                       |
| sigma         | Diffusion scale parameter of the Gaussian kernel. One of 'local', 'global', a ( <a href="#">numeric</a> ) global sigma or a <a href="#">Sigmas</a> object. When choosing 'global', a global sigma will be calculated using <a href="#">find_sigmas</a> . (Optional. default: 'local') A larger sigma might be necessary if the eigenvalues can not be found because of a singularity in the matrix |
| k             | Number of nearest neighbors to consider (default: a guess between 100 and $n - 1$ . See <a href="#">find_dm_k</a> ).                                                                                                                                                                                                                                                                               |
| n_eigs        | Number of eigenvectors/values to return (default: 20)                                                                                                                                                                                                                                                                                                                                              |
| density_norm  | logical. If TRUE, use density normalisation                                                                                                                                                                                                                                                                                                                                                        |
| ...           | Unused. All parameters to the right of the ... have to be specified by name (e.g. <code>DiffusionMap(data, distance = 'cosine')</code> )                                                                                                                                                                                                                                                           |
| distance      | Distance measurement method applied to data or a distance matrix/ <a href="#">dist</a> . For the allowed values, see <a href="#">find_knn</a> . If this is a <a href="#">sparseMatrix</a> , zeros are interpreted as "not a close neighbors", which allows the use of kNN-sparsified matrices (see the return value of <a href="#">find_knn</a> ).                                                 |
| n_pcs         | Number of principal components to compute to base calculations on. Using e.g. 50 PCs results in more regular looking diffusion maps. The default NULL will not compute principal components, but use <code>reducedDims(data, 'pca')</code> if present. Set to NA to suppress using PCs.                                                                                                            |
| n_local       | If <code>sigma == 'local'</code> , the <code>n_local</code> th nearest neighbor(s) determine(s) the local sigma                                                                                                                                                                                                                                                                                    |
| rotate        | logical. If TRUE, rotate the eigenvalues to get a slimmer diffusion map                                                                                                                                                                                                                                                                                                                            |
| censor_val    | Value regarded as uncertain. Either a single value or one for every dimension (Optional, default: <code>censor_val</code> )                                                                                                                                                                                                                                                                        |
| censor_range  | Uncertainty range for censoring (Optional, default: none). A length-2-vector of certainty range start and end. TODO: also allow $2 \times G$ matrix                                                                                                                                                                                                                                                |
| missing_range | Whole data range for missing value model. Has to be specified if NAs are in the data                                                                                                                                                                                                                                                                                                               |
| vars          | Variables (columns) of the data to use. Specifying NULL will select all columns (default: All floating point value columns)                                                                                                                                                                                                                                                                        |
| knn_params    | Parameters passed to <a href="#">find_knn</a>                                                                                                                                                                                                                                                                                                                                                      |
| verbose       | Show a progressbar and other progress information (default: do it if censoring is enabled)                                                                                                                                                                                                                                                                                                         |
| suppress_dpt  | Specify TRUE to skip calculation of necessary (but spacious) information for <a href="#">DPT</a> in the returned object (default: FALSE)                                                                                                                                                                                                                                                           |

**Value**

A DiffusionMap object:

**Slots**

eigenvalues Eigenvalues ranking the eigenvectors  
 eigenvectors Eigenvectors mapping the datapoints to n\_eigs dimensions  
 sigmas [Sigmas](#) object with either information about the [find\\_sigmas](#) heuristic run or just local or [optimal\\_sigma](#).  
 data\_env Environment referencing the data used to create the diffusion map  
 eigenvect0 First (constant) eigenvector not included as diffusion component.  
 transitions Transition probabilities. Can be NULL  
 d Density vector of transition probability matrix  
 d\_norm Density vector of normalized transition probability matrix  
 k The k parameter for kNN  
 n\_pcs Number of principal components used in kNN computation (NA if raw data was used)  
 n\_local The n\_localth nearest neighbor(s) is/are used to determine local kernel density  
 density\_norm Was density normalization used?  
 rotate Were the eigenvectors rotated?  
 distance Distance measurement method used  
 censor\_val Censoring value  
 censor\_range Censoring range  
 missing\_range Whole data range for missing value model  
 vars Vars parameter used to extract the part of the data used for diffusion map creation  
 knn\_params Parameters passed to [find\\_knn](#)

**See Also**

[DiffusionMap methods](#) to get and set the slots. [find\\_sigmas](#) to pre-calculate a fitting global sigma parameter

**Examples**

```

data(guo)
DiffusionMap(guo)
DiffusionMap(guo, 13, censor_val = 15, censor_range = c(15, 40), verbose = TRUE)

covars <- data.frame(covar1 = letters[1:100])
dists <- dist(matrix(rnorm(100*10), 100))
DiffusionMap(covars, distance = dists)

```

---

|            |                                                                                                                                                         |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| dm_predict | <i>Predict new data points using an existing DiffusionMap. The resulting matrix can be used in <a href="#">the plot method for the DiffusionMap</a></i> |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|

---

## Description

Predict new data points using an existing DiffusionMap. The resulting matrix can be used in [the plot method for the DiffusionMap](#)

## Usage

```
dm_predict(dm, new_data, ..., verbose = FALSE)
```

## Arguments

|          |                                                                                                                                                                                             |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| dm       | A <a href="#">DiffusionMap</a> object.                                                                                                                                                      |
| new_data | New data points to project into the diffusion map. Can be a <a href="#">matrix</a> , <a href="#">data.frame</a> , <a href="#">ExpressionSet</a> , or <a href="#">SingleCellExperiment</a> . |
| ...      | Passed to <a href="#">proxy::dist</a> (new_data, data, dm@distance, ...).                                                                                                                   |
| verbose  | Show progress messages?                                                                                                                                                                     |

## Value

A  $nrow(new\_data) \times ncol(eigenvectors(dif))$  matrix of projected diffusion components for the new data.

## Examples

```
data(guo)
g1 <- guo[, guo$num_cells != 32L]
g2 <- guo[, guo$num_cells == 32L]
dm <- DiffusionMap(g1)
dc2 <- dm_predict(dm, g2)
plot(dm, new_dcs = dc2)
```

---

|                    |                           |
|--------------------|---------------------------|
| DPT matrix methods | <i>DPT Matrix methods</i> |
|--------------------|---------------------------|

---

## Description

Treat DPT object as a matrix of cell-by-cell DPT distances.

**Usage**

```
## S4 method for signature 'DPT,index,index,logicalOrMissing'
x[i, j, ..., drop = TRUE]

## S4 method for signature 'DPT,index,missing,logicalOrMissing'
x[i, j, ..., drop = TRUE]

## S4 method for signature 'DPT,missing,index,logicalOrMissing'
x[i, j, ..., drop = TRUE]

## S4 method for signature 'DPT,missing,missing,logicalOrMissing'
x[i, j, ..., drop = TRUE]

## S4 method for signature 'DPT,index,index'
x[[i, j, ...]]

## S4 method for signature 'DPT'
nrow(x)

## S4 method for signature 'DPT'
ncol(x)

## S4 method for signature 'DPT'
dim(x)
```

**Arguments**

|      |                                                                                   |
|------|-----------------------------------------------------------------------------------|
| x    | DPT object.                                                                       |
| i, j | Numeric or logical index.                                                         |
| ...  | ignored                                                                           |
| drop | If TRUE, coerce result to a vector if it would otherwise have 1 %in% dim(result). |

**Value**

[ returns a dense matrix or (if applicable and isTRUE(drop)) a vector.  
 [[ returns single distance value  
 nrow and ncol return the number of cells  
 dim returns c(n\_cells, n\_cells)

**See Also**

[as.matrix.DPT](#)

**Examples**

```
data(guo_norm)
dm <- DiffusionMap(guo_norm)
```



```
dpt <- DPT(dm)
set.seed(1)
plot(dpt[random_root(dpt), ], Biobase::exprs(guo_norm)['DppaI', ])
```

---

DPT methods

*DPT methods*


---

## Description

Methods for the [DPT](#) class. `branch_divide` subdivides branches for plotting (see the examples).

## Usage

```
branch_divide(dpt, divide = integer(0L))

tips(dpt)

## S4 method for signature 'DPT'
dataset(object)

## S4 replacement method for signature 'DPT'
dataset(object) <- value
```

## Arguments

|                          |                                              |
|--------------------------|----------------------------------------------|
| <code>dpt, object</code> | DPT object                                   |
| <code>divide</code>      | Vector of branch numbers to use for division |
| <code>value</code>       | Value of slot to set                         |

## Value

`branch_divide` and `dataset<-` return the changed object, `dataset` the extracted data, and `tips` the tip indices.

## See Also

[plot.DPT](#) uses `branch_divide` for its `divide` argument.

## Examples

```
data(guo_norm)
dpt <- DPT(DiffusionMap(guo_norm))
dpt_9_branches <- branch_divide(dpt, 1:3)
plot(dpt_9_branches, col_by = 'branch')
```

DPT-class

*Diffusion Pseudo Time***Description**

Create pseudotime ordering and assigns cell to one of three branches

**Usage**

```
DPT(dm, tips = random_root(dm), ..., w_width = 0.1)
```

**Arguments**

|         |                                                                                                                         |
|---------|-------------------------------------------------------------------------------------------------------------------------|
| dm      | A <a href="#">DiffusionMap</a> object. Its transition probabilities will be used to calculate the DPT                   |
| tips    | The cell index/indices from which to calculate the DPT(s) (integer of length 1-3)                                       |
| ...     | Unused. All parameters to the right of the ... have to be specified by name (e.g. <code>DPT(dm, w_width = 0.2)</code> ) |
| w_width | Window width to use for deciding the branch cutoff                                                                      |

**Details**

Treat it as a matrix of pseudotime by subsetting (`[ dim nrow ncol as.matrix)`, and as a list of pseudotime, and expression vectors (`$ [[ names as.data.frame)`).

**Value**

A DPT object:

**Slots**

branch [matrix](#) (of [integer](#)) recursive branch labels for each cell (row); NA for undecided. Use [branch\\_divide](#) to modify this.

tips [matrix](#) (of [logical](#)) indicating if a cell (row) is a tip of the corresponding branch level (col)

dm [DiffusionMap](#) used to create this DPT object

**Examples**

```
data(guo_norm)
dm <- DiffusionMap(guo_norm)
dpt <- DPT(dm)
str(dpt)
```

eig\_decomp

*Fast eigen decomposition using [eigs](#)***Description**

By default uses a random initialization vector that you can make deterministic using [set.seed](#) or override by specifying `opts = list(initvec = ...)`.

**Usage**

```
eig_decomp(m, n_eigs, sym, ..., opts = list())
```

**Arguments**

|                     |                                                                                    |
|---------------------|------------------------------------------------------------------------------------|
| <code>m</code>      | A matrix (e.g. from the Matrix package) or a function (see <a href="#">eigs</a> ). |
| <code>n_eigs</code> | Number of eigenvectors to return.                                                  |
| <code>sym</code>    | defunct and ignored.                                                               |
| <code>...</code>    | Passed to <a href="#">eigs</a> .                                                   |
| <code>opts</code>   | Passed to <a href="#">eigs</a> .                                                   |

**Value**

see [eigs](#).

**Examples**

```
eig_decomp(cbind(c(1,0,-1), c(0,1,0), c(-1,0,1)), 2)
```

---

 ExpressionSet helper methods

*Convert object to [ExpressionSet](#) or read it from a file*

---

**Description**

These functions present quick way to create [ExpressionSet](#) objects.

**Usage**

```
as.ExpressionSet(x, ...)
```

```
## S4 method for signature 'data.frame'
```

```
as.ExpressionSet(x, annotation_cols = !sapply(x, is.double))
```

```
read.ExpressionSet(file, header = TRUE, ...)
```

**Arguments**

|                              |                                                                                                                               |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>               | <a href="#">data.frame</a> to convert to an <a href="#">ExpressionSet</a> .                                                   |
| <code>...</code>             | Additional parameters to <a href="#">read.table</a>                                                                           |
| <code>annotation_cols</code> | The data.frame columns used as annotations. All others are used as expressions. (Logical, character or numerical index array) |
| <code>file</code>            | File path to read ASCII data from                                                                                             |
| <code>header</code>          | Specifies if the file has a header row.                                                                                       |

**Details**

They work by using all continuous (double) columns as expression data, and all others as observation annotations.

**Value**

an [ExpressionSet](#) object

**See Also**

[read.table](#) on which `read.ExpressionSet` is based, and [ExpressionSet](#).

**Examples**

```
library(Biobase)
df <- data.frame(Time = seq_len(3), #integer column
                 Actb = c(0.05, 0.3, 0.8),
                 Gapdh = c(0.2, 0.03, 0.1))
set <- as.ExpressionSet(df)
rownames(exprs(set)) == c('Actb', 'Gapdh')
phenoData(set)$Time == 1:3
```

**Description**

Extract common information from objects. Apart from the input data's branches, you can extract diffusion components via `$DCx`. From [DPT](#) objects, you can also extract the branch label via `$Branch`, or the diffusion pseudo time for a numbered cell via `$DPTx`.

**Usage**

```
## S4 method for signature 'DiffusionMap'
names(x)

## S4 method for signature 'DPT'
names(x)

## S4 method for signature 'DiffusionMap,character,missing'
x[[i, j, ...]]

## S4 method for signature 'DPT,character,missing'
x[[i, j, ...]]

## S4 method for signature 'DiffusionMap'
x$name

## S4 method for signature 'DPT'
x$name
```

**Arguments**

|         |                                                                               |
|---------|-------------------------------------------------------------------------------|
| x       | <a href="#">DiffusionMap</a> or <a href="#">DPT</a> object                    |
| i, name | Name of a diffusion component 'DCx', 'DPTx', 'Branch' or column from the data |
| j       | N/A                                                                           |
| ...     | ignored                                                                       |

**Value**

The names or data row, see respective generics.

**See Also**

[Extract](#), [names](#) for the generics. [DiffusionMap accession methods](#), [DiffusionMap methods](#), [Coercion methods](#) for more

**Examples**

```
data(guo)
dm <- DiffusionMap(guo)
dm$DC1      # A diffusion component
dm$Actb     # A gene expression vector
dm$num_cells # Phenotype metadata

dpt <- DPT(dm)
dm$Branch
dm$DPT1
```

---

|           |                          |
|-----------|--------------------------|
| find_dm_k | <i>Find a suitable k</i> |
|-----------|--------------------------|

---

### Description

The k parameter for the k nearest neighbors used in [DiffusionMap](#) should be as big as possible while still being computationally feasible. This function approximates it depending on the size of the dataset n.

### Usage

```
find_dm_k(n, min_k = 100L, small = 1000L, big = 10000L)
```

### Arguments

|       |                                                                                            |
|-------|--------------------------------------------------------------------------------------------|
| n     | Number of possible neighbors (nrow(dataset) - 1)                                           |
| min_k | Minimum number of neighbors. Will be chosen for $n \geq big$                               |
| small | Number of neighbors considered small. If/where $n \leq small$ , n itself will be returned. |
| big   | Number of neighbors considered big. If/where $n \geq big$ , min_k will be returned.        |

### Value

A vector of the same length as n that contains suitable k values for the respective n

### Examples

```
curve(find_dm_k(n), 0, 13000, xname = 'n')
curve(find_dm_k(n) / n, 0, 13000, xname = 'n')
```

---

|          |                   |
|----------|-------------------|
| find_knn | <i>kNN search</i> |
|----------|-------------------|

---

### Description

Approximate k nearest neighbor search with flexible distance function.

**Usage**

```
find_knn(
  data,
  k,
  ...,
  query = NULL,
  distance = c("euclidean", "cosine", "rankcor", "l2"),
  method = c("covertree", "hnsu"),
  sym = TRUE,
  verbose = FALSE
)
```

**Arguments**

|          |                                                                                                                                                                                                                |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data     | Data matrix                                                                                                                                                                                                    |
| k        | Number of nearest neighbors                                                                                                                                                                                    |
| ...      | Parameters passed to <a href="#">hnsu_knn</a>                                                                                                                                                                  |
| query    | Query matrix. Leave it out to use data as query                                                                                                                                                                |
| distance | Distance metric to use. Allowed measures: Euclidean distance (default), cosine distance ( $1 - \text{corr}(c_1, c_2)$ ) or rank correlation distance ( $1 - \text{corr}(\text{rank}(c_1), \text{rank}(c_2))$ ) |
| method   | Method to use. 'hnsu' is tunable with ... but generally less exact than 'covertree' (default: 'covertree')                                                                                                     |
| sym      | Return a symmetric matrix (as long as query is NULL)?                                                                                                                                                          |
| verbose  | Show a progressbar? (default: FALSE)                                                                                                                                                                           |

**Value**

A [list](#) with the entries:

index A  $nrow(data) \times k$  [integer matrix](#) containing the indices of the k nearest neighbors for each cell.

dist A  $nrow(data) \times k$  [double matrix](#) containing the distances to the k nearest neighbors for each cell.

dist\_mat A [dgCMatrix](#) if sym == TRUE, else a [dsCMatrix](#) ( $nrow(query) \times nrow(data)$ ). Any zero in the matrix (except for the diagonal) indicates that the cells in the corresponding pair are close neighbors.

---

|             |                                                                                                           |
|-------------|-----------------------------------------------------------------------------------------------------------|
| find_sigmas | <i>Calculate the average dimensionality for m different gaussian kernel widths (<math>\sigma</math>).</i> |
|-------------|-----------------------------------------------------------------------------------------------------------|

---

**Description**

The sigma with the maximum value in average dimensionality is close to the ideal one. Increasing step number gets this nearer to the ideal one.

**Usage**

```
find_sigmas(
  data,
  step_size = 0.1,
  steps = 10L,
  start = NULL,
  sample_rows = 500L,
  early_exit = FALSE,
  ...,
  censor_val = NULL,
  censor_range = NULL,
  missing_range = NULL,
  vars = NULL,
  verbose = TRUE
)
```

**Arguments**

|               |                                                                                                                                                                                                      |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data          | Data set with $n$ observations. Can be a <a href="#">data.frame</a> , <a href="#">matrix</a> , <a href="#">ExpressionSet</a> or <a href="#">SingleCellExperiment</a> .                               |
| step_size     | Size of log-sigma steps                                                                                                                                                                              |
| steps         | Number of steps/calculations                                                                                                                                                                         |
| start         | Initial value to search from. (Optional. default: $\log_{10}(\min(\text{dist}(\text{data})))$ )                                                                                                      |
| sample_rows   | Number of random rows to use for sigma estimation or vector of row indices/names to use. In the first case, only used if actually smaller than the number of available rows (Optional. default: 500) |
| early_exit    | logical. If TRUE, return if the first local maximum is found, else keep running                                                                                                                      |
| ...           | Unused. All parameters to the right of the ... have to be specified by name (e.g. <code>find_sigmas(data, verbose = FALSE)</code> )                                                                  |
| censor_val    | Value regarded as uncertain. Either a single value or one for every dimension                                                                                                                        |
| censor_range  | Uncertainty range for censoring. A length-2-vector of certainty range start and end. TODO: also allow $2 \times G$ matrix                                                                            |
| missing_range | Whole data range for missing value model. Has to be specified if NAs are in the data                                                                                                                 |
| vars          | Variables (columns) of the data to use. Specifying TRUE will select all columns (default: All floating point value columns)                                                                          |
| verbose       | logical. If TRUE, show a progress bar and plot the output                                                                                                                                            |

**Value**

Object of class [Sigmas](#)

**See Also**

[Sigmas](#), the class returned by this; [DiffusionMap](#), the class this is used for



**Examples**

```
data(guo)
sigs <- find_sigmas(guo, verbose = TRUE)
DiffusionMap(guo, sigs)
```

find\_tips

*Find tips in a DiffusionMap object***Description**

Find tips in a DiffusionMap object

**Usage**

```
find_tips(dm_or_dpt, root = random_root(dm_or_dpt))
```

**Arguments**

|           |                                                              |
|-----------|--------------------------------------------------------------|
| dm_or_dpt | A <a href="#">DiffusionMap</a> or <a href="#">DPT</a> object |
| root      | Root cell index from which to find tips. (default: random)   |

**Value**

An integer vector of length 3

**Examples**

```
data(guo)
dm <- DiffusionMap(guo)
is_tip <- l_which(find_tips(dm), len = ncol(guo))
plot(dm, col = factor(is_tip))
```

Gene Relevance methods

*Gene Relevance methods***Description**

featureNames <- ... can be used to set the gene names used for plotting (e.g. if the data contains hardly readably gene or transcript IDs). dataset gets the expressions used for the gene relevance calculations, and distance the distance measure.

**Usage**

```
## S4 method for signature 'GeneRelevance'
print(x)

## S4 method for signature 'GeneRelevance'
show(object)

## S4 method for signature 'GeneRelevance'
featureNames(object)

## S4 replacement method for signature 'GeneRelevance,characterOrFactor'
featureNames(object) <- value

## S4 method for signature 'GeneRelevance'
dataset(object)

## S4 replacement method for signature 'GeneRelevance'
dataset(object) <- value

## S4 method for signature 'GeneRelevance'
distance(object)

## S4 replacement method for signature 'GeneRelevance'
distance(object) <- value
```

**Arguments**

|           |                                                                       |
|-----------|-----------------------------------------------------------------------|
| x, object | GeneRelevance object                                                  |
| value     | A text vector ( <a href="#">character</a> or <a href="#">factor</a> ) |

**Value**

dataset, distance, and featureNames return the stored properties. The other methods return a GeneRelevance object (print, ... <- ...), or NULL (show), invisibly

**See Also**

[gene\\_relevance](#), [Gene Relevance plotting](#)

**Examples**

```
data(guo_norm)
dm <- DiffusionMap(guo_norm)
gr <- gene_relevance(dm)
stopifnot(distance(gr) == distance(dm))
featureNames(gr)[[37]] <- 'Id2 (suppresses differentiation)'
# now plot it with the changed gene name(s)
```

---

|                     |                                            |
|---------------------|--------------------------------------------|
| GeneRelevance-class | <i>Gene relevances for entire data set</i> |
|---------------------|--------------------------------------------|

---

**Description**

The relevance map is cached insided of the [DiffusionMap](#).

**Usage**

```
gene_relevance(  
  coords,  
  exprs,  
  ...,  
  k = 20L,  
  dims = 1:2,  
  distance = NULL,  
  smooth = TRUE,  
  remove_outliers = FALSE,  
  verbose = FALSE  
)  
  
## S4 method for signature 'DiffusionMap,missing'  
gene_relevance(  
  coords,  
  exprs,  
  ...,  
  k = 20L,  
  dims = 1:2,  
  distance = NULL,  
  smooth = TRUE,  
  remove_outliers = FALSE,  
  verbose = FALSE  
)  
  
## S4 method for signature 'matrix,dMatrixOrMatrix'  
gene_relevance(  
  coords,  
  exprs,  
  ...,  
  pcs = NULL,  
  knn_params = list(),  
  weights = 1,  
  k,  
  dims,  
  distance,  
  smooth,  
  remove_outliers,
```

```
    verbose
  )
```

### Arguments

|                              |                                                                                                                                                                                                                      |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>coords</code>          | A <a href="#">DiffusionMap</a> object or a cells $\times$ dims <a href="#">matrix</a> .                                                                                                                              |
| <code>exprs</code>           | An cells $\times$ genes <a href="#">matrix</a> . Only provide if <code>coords</code> is no <a href="#">DiffusionMap</a> .                                                                                            |
| <code>...</code>             | Unused. All parameters to the right of the <code>...</code> have to be specified by name.                                                                                                                            |
| <code>k</code>               | Number of nearest neighbors to use                                                                                                                                                                                   |
| <code>dims</code>            | Index into columns of coord                                                                                                                                                                                          |
| <code>distance</code>        | Distance measure to use for the nearest neighbor search.                                                                                                                                                             |
| <code>smooth</code>          | Smoothing parameters <code>c(window, alpha)</code> (see <a href="#">smth.gaussian</a> ). Alternatively <a href="#">TRUE</a> to use the <a href="#">smoother defaults</a> or <a href="#">FALSE</a> to skip smoothing, |
| <code>remove_outliers</code> | Remove cells that are only within one other cell's nearest neighbor, as they tend to get large norms.                                                                                                                |
| <code>verbose</code>         | If <a href="#">TRUE</a> , log additional info to the console                                                                                                                                                         |
| <code>pcs</code>             | A cell $\times$ n_pcs matrix of principal components to use for the distances.                                                                                                                                       |
| <code>knn_params</code>      | A <a href="#">list</a> of parameters for <a href="#">find_knn</a> .                                                                                                                                                  |
| <code>weights</code>         | Weights for the partial derivatives. A vector of the same length as <code>dims</code> .                                                                                                                              |

### Value

A `GeneRelevance` object:

### Slots

|                            |                                                                                                                                                                                |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>coords</code>        | A cells $\times$ dims <a href="#">matrix</a> or <a href="#">sparseMatrix</a> of coordinates (e.g. diffusion components), reduced to the dimensions passed as <code>dims</code> |
| <code>exprs</code>         | A cells $\times$ genes matrix of expressions                                                                                                                                   |
| <code>partials</code>      | Array of partial derivatives wrt to considered dimensions in reduced space (genes $\times$ cells $\times$ dimensions)                                                          |
| <code>partials_norm</code> | Matrix with norm of aforementioned derivatives. (n_genes $\times$ cells)                                                                                                       |
| <code>nn_index</code>      | Matrix of k nearest neighbor indices. (cells $\times$ k)                                                                                                                       |
| <code>dims</code>          | Column index for plotted dimensions. Can <a href="#">character</a> , <a href="#">numeric</a> or <a href="#">logical</a>                                                        |
| <code>distance</code>      | Distance measure used in the nearest neighbor search. See <a href="#">find_knn</a>                                                                                             |
| <code>smooth_window</code> | Smoothing window used (see <a href="#">smth.gaussian</a> )                                                                                                                     |
| <code>smooth_alpha</code>  | Smoothing kernel width used (see <a href="#">smth.gaussian</a> )                                                                                                               |

### See Also

[Gene Relevance methods](#), [Gene Relevance plotting](#): `plot_differential_map`/`plot_gene_relevance`

## Examples

```
data(guo_norm)
dm <- DiffusionMap(guo_norm)
gr <- gene_relevance(dm)

m <- t(Biobase::exprs(guo_norm))
gr_pca <- gene_relevance(prcomp(m)$x, m)
# now plot them!
```

---

guo

*Guo et al. mouse embryonic stem cell qPCR data*

---

## Description

Gene expression data of 48 genes and an annotation column \$num\_cells containing the cell stage at which the embryos were harvested.

## Usage

```
data(guo)
data(guo_norm)
```

## Format

An [ExpressionSet](#) with 48 features, 428 observations and 2 [phenoData](#) annotations.

## Details

The data is normalized using the mean of two housekeeping genes. The difference between guo and guo\_norm is the LoD being set to 10 in the former, making it usable with the censor\_val parameter of [DiffusionMap](#).

## Value

an [ExpressionSet](#) with 48 features and 428 observations containing qPCR Ct values and a "num.cells" observation annotation.

## Author(s)

Guoji Guo, Mikael Huss, Guo Qing Tong, Chaoyang Wang, Li Li Sun, Neil D. Clarke, Paul Robson  
<robsonp@gis.a-star.edu.sg>

## References

<http://www.sciencedirect.com/science/article/pii/S1534580710001103>

---

|         |                      |
|---------|----------------------|
| l_which | <i>Logical which</i> |
|---------|----------------------|

---

### Description

Inverse of [which](#). Converts an array of numeric or character indices to a logical index array. This function is useful if you need to perform logical operation on an index array but are only given numeric indices.

### Usage

```
l_which(idx, nms = seq_len(len), len = length(nms), useNames = TRUE)
```

### Arguments

|          |                                                                    |
|----------|--------------------------------------------------------------------|
| idx      | Numeric or character indices.                                      |
| nms      | Array of names or a sequence. Required if idx is a character array |
| len      | Length of output array. Alternative to nms if idx is numeric       |
| useNames | Use the names of nms or idx                                        |

### Details

Either nms or len has to be specified.

### Value

Logical vector of length len or the same length as nms

### Examples

```
all(l_which(2, len = 3L) == c(FALSE, TRUE, FALSE))
all(l_which(c('a', 'c'), letters[1:3]) == c(TRUE, FALSE, TRUE))
```

---

|                   |                                       |
|-------------------|---------------------------------------|
| plot.DiffusionMap | <i>3D or 2D plot of diffusion map</i> |
|-------------------|---------------------------------------|

---

### Description

If you want to plot the eigenvalues, simply `plot(eigenvalues(dm)[start:end], ...)`

**Usage**

```

plot.DiffusionMap(
  x,
  dims = 1:3,
  new_dcs = if (!is.null(new_data)) dm_predict(x, new_data),
  new_data = NULL,
  col = NULL,
  col_by = NULL,
  col_limits = NULL,
  col_new = "red",
  pal = NULL,
  pal_new = NULL,
  ...,
  ticks = FALSE,
  axes = TRUE,
  box = FALSE,
  legend_main = col_by,
  legend_opts = list(),
  interactive = FALSE,
  draw_legend = !is.null(col_by) || (length(col) > 1 && !is.character(col)),
  consec_col = TRUE,
  col_na = "grey",
  plot_more = function(p, ..., rescale = NULL) p
)

## S4 method for signature 'DiffusionMap,numeric'
plot(x, y, ...)

## S4 method for signature 'DiffusionMap,missing'
plot(x, y, ...)

```

**Arguments**

|            |                                                                                                                                                                                                                                  |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | A <a href="#">DiffusionMap</a>                                                                                                                                                                                                   |
| dims, y    | Diffusion components (eigenvectors) to plot (default: first three components; 1:3)                                                                                                                                               |
| new_dcs    | An optional matrix also containing the rows specified with y and plotted. (default: no more points)                                                                                                                              |
| new_data   | A data set in the same format as x that is used to create <code>new_dcs &lt;- dm_predict(dif, new_data)</code>                                                                                                                   |
| col        | Single color string or vector of discrete or categoric values to be mapped to colors. E.g. a column of the data matrix used for creation of the diffusion map. (default: <a href="#">cluster_louvain</a> if igraph is installed) |
| col_by     | Specify a <code>dataset(x)</code> or <code>phenoData(dataset(x))</code> column to use as color                                                                                                                                   |
| col_limits | If col is a continuous (=double) vector, this can be overridden to map the color range differently than from min to max (e.g. specify <code>c(0, 1)</code> )                                                                     |

|             |                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| col_new     | If new_dcs is given, it will take on this color. A vector is also possible. (default: red)                                                                                                                                                                                                                                                                                            |
| pal         | Palette used to map the col vector to colors. (default: use <a href="#">hcl.colors</a> for continuous and <a href="#">palette()</a> for discrete data)                                                                                                                                                                                                                                |
| pal_new     | Palette used to map the col_new vector to colors. (default: see pal argument)                                                                                                                                                                                                                                                                                                         |
| ...         | Parameters passed to <a href="#">plot</a> , <a href="#">scatterplot3d</a> , or <a href="#">plot3d</a> (if interactive == TRUE)                                                                                                                                                                                                                                                        |
| ticks       | logical. If TRUE, show axis ticks (default: FALSE)                                                                                                                                                                                                                                                                                                                                    |
| axes        | logical. If TRUE, draw plot axes (default: Only if ticks is TRUE)                                                                                                                                                                                                                                                                                                                     |
| box         | logical. If TRUE, draw plot frame (default: TRUE or the same as axes if specified)                                                                                                                                                                                                                                                                                                    |
| legend_main | Title of legend. (default: nothing unless col_by is given)                                                                                                                                                                                                                                                                                                                            |
| legend_opts | Other <a href="#">colorlegend</a> options (default: empty list)                                                                                                                                                                                                                                                                                                                       |
| interactive | Use <a href="#">plot3d</a> to plot instead of <a href="#">scatterplot3d</a> ?                                                                                                                                                                                                                                                                                                         |
| draw_legend | logical. If TRUE, draw color legend (default: TRUE if col_by is given or col is given and a vector to be mapped)                                                                                                                                                                                                                                                                      |
| consec_col  | If col or col_by refers to an integer column, with gaps (e.g. <code>c(5, 0, 0, 3)</code> ) use the palette color consecutively (e.g. <code>c(3, 1, 1, 2)</code> )                                                                                                                                                                                                                     |
| col_na      | Color for NA in the data. specify NA to hide.                                                                                                                                                                                                                                                                                                                                         |
| plot_more   | Function that will be called while the plot margins are temporarily changed (its p argument is the rgl or scatterplot3d instance or NULL, its rescale argument is NULL, a list(from = c(a, b), to = c(c, d)), or an array of shape $from to \times dims \times min max$ , i.e. $2 \times length(dims) \times 2$ . In case of 2d plotting, it should take and return a ggplot2 object. |

## Details

If you specify negative numbers as diffusion components (e.g. `plot(dm, c(-1, 2))`), then the corresponding components will be flipped.

## Value

The return value of the underlying call is returned, i.e. a scatterplot3d or rgl object.

## Examples

```
data(guo)
plot(DiffusionMap(guo))
```



plot.DPT

*Plot DPT***Description**

Plots diffusion components from a Diffusion Map and the accompanying Diffusion Pseudo Time ([DPT](#))

**Usage**

```
plot.DPT(
  x,
  root = NULL,
  paths_to = integer(0L),
  dcs = 1:2,
  divide = integer(0L),
  w_width = 0.1,
  col_by = "dpt",
  col_path = rev(palette()),
  col_tip = "red",
  ...,
  col = NULL,
  legend_main = col_by
)

## S4 method for signature 'DPT,numeric'
plot(x, y, ...)

## S4 method for signature 'DPT,missing'
plot(x, y, ...)
```

**Arguments**

|          |                                                                                                     |
|----------|-----------------------------------------------------------------------------------------------------|
| x        | A <a href="#">DPT</a> object.                                                                       |
| paths_to | Numeric Branch IDs. Are used as target(s) for the path(s) to draw.                                  |
| dcs      | The dimensions to use from the DiffusionMap                                                         |
| divide   | If col_by = 'branch', this specifies which branches to divide. (see <a href="#">branch_divide</a> ) |
| w_width  | Window width for smoothing the path (see <a href="#">smth.gaussian</a> )                            |
| col_by   | Color by 'dpt' (DPT starting at branches[[1]]), 'branch', or a variable of the data.                |
| col_path | Colors for the path or a function creating n colors                                                 |
| col_tip  | Color for branch tips                                                                               |
| ...      | Graphical parameters supplied to <a href="#">plot.DiffusionMap</a>                                  |
| col      | See <a href="#">plot.DiffusionMap</a> . This overrides col_by                                       |

|             |                                                                                                                                                     |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| legend_main | See <a href="#">plot.DiffusionMap</a> .                                                                                                             |
| y, root     | Root branch ID. Will be used as the start of the DPT. (default: lowest branch ID) (If longer than size 1, will be interpreted as c(root, branches)) |

**Value**

The return value of the underlying call is returned, i.e. a scatterplot3d or rgl object for 3D plots.

**Examples**

```
data(guo_norm)
dm <- DiffusionMap(guo_norm)
dpt <- DPT(dm)
plot(dpt)
plot(dpt, 2L, col_by = 'branch')
plot(dpt, 1L, 2:3, col_by = 'num_cells')
plot(dpt, col_by = 'DPT3')
```

---

|             |                                           |
|-------------|-------------------------------------------|
| plot.Sigmas | <i>Plot <a href="#">Sigmas</a> object</i> |
|-------------|-------------------------------------------|

---

**Description**

Plot [Sigmas](#) object

**Usage**

```
## S4 method for signature 'Sigmas,missing'
plot(
  x,
  col = par("fg"),
  col_highlight = "#E41A1C",
  col_line = "#999999",
  type = c("b", "b"),
  pch = c(par("pch"), 4L),
  only_dim = FALSE,
  ...,
  xlab = NULL,
  ylab = NULL,
  main = ""
)
```

**Arguments**

|     |                                                   |
|-----|---------------------------------------------------|
| x   | Sigmas object to plot                             |
| col | Vector of bar colors or single color for all bars |

|               |                                                                                                                            |
|---------------|----------------------------------------------------------------------------------------------------------------------------|
| col_highlight | Color for highest bar. Overrides col                                                                                       |
| col_line      | Color for the line and its axis                                                                                            |
| type          | Plot type of both lines. Can be a vector of length 2 to specify both separately (default: 'b' aka “both lines and points”) |
| pch           | Point identifier for both lines. Can be a vector of length 2 to specify both separately (default: par(pch) and 4 (a '×'))  |
| only_dim      | logical. If TRUE, only plot the derivative line                                                                            |
| ...           | Options passed to the call to plot                                                                                         |
| xlab          | X label. NULL to use default                                                                                               |
| ylab          | Either one y label or y labels for both plots. NULL to use both defaults, a NULL in a list of length 2 to use one default. |
| main          | Title of the plot                                                                                                          |

**Value**

This method plots a Sigma object to the current device and returns nothing/NULL

**Examples**

```
data(guo)
sigs <- find_sigmas(guo)
plot(sigs)
```

---

plot\_differential\_map *Plot gene relevance or differential map*

---

**Description**

plot(gene\_relevance, 'Gene') plots the differential map of this/these gene(s), plot(gene\_relevance) a relevance map of a selection of genes. Alternatively, you can use plot\_differential\_map or plot\_gene\_relevance on a [GeneRelevance](#) or [DiffusionMap](#) object, or with two matrices.

**Usage**

```
plot_differential_map(
  coords,
  exprs,
  ...,
  genes,
  dims = 1:2,
  pal = hcl.colors,
  faceter = facet_wrap(~Gene)
)
```

```

## S4 method for signature 'matrix,matrix'
plot_differential_map(
  coords,
  exprs,
  ...,
  genes,
  dims = 1:2,
  pal = hcl.colors,
  faceter = facet_wrap(~Gene)
)

## S4 method for signature 'DiffusionMap,missing'
plot_differential_map(
  coords,
  exprs,
  ...,
  genes,
  dims = 1:2,
  pal = hcl.colors,
  faceter = facet_wrap(~Gene)
)

## S4 method for signature 'GeneRelevance,missing'
plot_differential_map(
  coords,
  exprs,
  ...,
  genes,
  dims = 1:2,
  pal = hcl.colors,
  faceter = facet_wrap(~Gene)
)

plot_gene_relevance(
  coords,
  exprs,
  ...,
  iter_smooth = 2L,
  n_top = 10L,
  genes = NULL,
  dims = 1:2,
  pal = palette(),
  col_na = "grey",
  limit = TRUE
)

## S4 method for signature 'matrix,matrix'
plot_gene_relevance(

```

```
    coords,
    exprs,
    ...,
    iter_smooth = 2L,
    n_top = 10L,
    genes = NULL,
    dims = 1:2,
    pal = palette(),
    col_na = "grey",
    limit = TRUE
)

## S4 method for signature 'DiffusionMap,missing'
plot_gene_relevance(
  coords,
  exprs,
  ...,
  iter_smooth = 2L,
  n_top = 10L,
  genes = NULL,
  dims = 1:2,
  pal = palette(),
  col_na = "grey",
  limit = TRUE
)

## S4 method for signature 'GeneRelevance,missing'
plot_gene_relevance(
  coords,
  exprs,
  ...,
  iter_smooth = 2L,
  n_top = 10L,
  genes = NULL,
  dims = 1:2,
  pal = palette(),
  col_na = "grey",
  limit = TRUE
)

plot_gene_relevance_rank(
  coords,
  exprs,
  ...,
  genes,
  dims = 1:2,
  n_top = 10L,
  pal = c("#3B99B1", "#F5191C"),
```

```

    bins = 10L,
    faceter = facet_wrap(~Gene)
)

## S4 method for signature 'matrix,matrix'
plot_gene_relevance_rank(
  coords,
  exprs,
  ...,
  genes,
  dims = 1:2,
  n_top = 10L,
  pal = c("#3B99B1", "#F5191C"),
  bins = 10L,
  faceter = facet_wrap(~Gene)
)

## S4 method for signature 'DiffusionMap,missing'
plot_gene_relevance_rank(
  coords,
  exprs,
  ...,
  genes,
  dims = 1:2,
  n_top = 10L,
  pal = c("#3B99B1", "#F5191C"),
  bins = 10L,
  faceter = facet_wrap(~Gene)
)

## S4 method for signature 'GeneRelevance,missing'
plot_gene_relevance_rank(
  coords,
  exprs,
  ...,
  genes,
  dims = 1:2,
  n_top = 10L,
  pal = c("#3B99B1", "#F5191C"),
  bins = 10L,
  faceter = facet_wrap(~Gene)
)

## S4 method for signature 'GeneRelevance,character'
plot(x, y, ...)

## S4 method for signature 'GeneRelevance,numeric'
plot(x, y, ...)

```

```
## S4 method for signature 'GeneRelevance,missing'
plot(x, y, ...)
```

### Arguments

|             |                                                                                                                                                                                       |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| coords      | A <a href="#">DiffusionMap</a> / <a href="#">GeneRelevance</a> object or a cells $\times$ dims <a href="#">matrix</a> .                                                               |
| exprs       | An cells $\times$ genes <a href="#">matrix</a> . Only provide if coords is a matrix.                                                                                                  |
| ...         | Passed to <a href="#">plot_differential_map</a> / <a href="#">plot_gene_relevance</a> .                                                                                               |
| genes       | Genes to base relevance map on (vector of strings). You can also pass an index into the gene names (vector of numbers or logicals with length > 1). The default NULL means all genes. |
| dims        | Names or indices of dimensions to plot. When not plotting a <a href="#">GeneRelevance</a> object, the relevance for the dimensions 1:max(dims) will be calculated.                    |
| pal         | Palette. Either A colormap function or a list of colors.                                                                                                                              |
| faceter     | A ggplot faceter like <a href="#">facet_wrap</a> (~ Gene).                                                                                                                            |
| iter_smooth | Number of label smoothing iterations to perform on relevance map. The higher the more homogenous and the less local structure.                                                        |
| n_top       | Number the top n genes per cell count towards the score defining which genes to return and plot in the relevance map.                                                                 |
| col_na      | Color for cells that end up with no most relevant gene.                                                                                                                               |
| limit       | Limit the amount of displayed gene labels to the amount of available colors in pal?                                                                                                   |
| bins        | Number of hexagonal bins for <a href="#">plot_gene_relevance_rank</a> .                                                                                                               |
| x           | <a href="#">GeneRelevance</a> object.                                                                                                                                                 |
| y           | Gene name(s) or index/indices to create differential map for. (integer or character)                                                                                                  |

### Value

ggplot2 plot, when plotting a relevance map with a list member \$ids containing the gene IDs used.

### See Also

[gene\\_relevance](#), [Gene Relevance methods](#)

### Examples

```
data(guo_norm)
dm <- DiffusionMap(guo_norm)
gr <- gene_relevance(dm)
plot(gr) # or plot_gene_relevance(dm)
plot(gr, 'Fgf4') # or plot_differential_map(dm, 'Fgf4')

guo_norm_mat <- t(Biobase::exprs(guo_norm))
pca <- prcomp(guo_norm_mat)$x
```

```
plot_gene_relevance(pca, guo_norm_mat, dims = 2:3)
plot_differential_map(pca, guo_norm_mat, genes = c('Fgf4', 'Nanog'))
```

---

|                 |                            |
|-----------------|----------------------------|
| projection_dist | <i>Projection distance</i> |
|-----------------|----------------------------|

---

## Description

Projection distance

## Usage

```
projection_dist(dm, new_dcs = NULL, ..., new_data, verbose = FALSE)
```

## Arguments

|          |                                                                                                                                                                                             |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| dm       | A <a href="#">DiffusionMap</a> object.                                                                                                                                                      |
| new_dcs  | Diffusion component matrix of which to calculate the distance to the data.                                                                                                                  |
| ...      | Passed to <a href="#">proxy::dist</a> if new_data was passed.                                                                                                                               |
| new_data | New data points to project into the diffusion map. Can be a <a href="#">matrix</a> , <a href="#">data.frame</a> , <a href="#">ExpressionSet</a> , or <a href="#">SingleCellExperiment</a> . |
| verbose  | If <a href="#">TRUE</a> , log additional info to the console.                                                                                                                               |

## Value

A vector of distances each new data point has to the existing data.

## Examples

```
data(guo_norm)
g2_32 <- guo_norm[, guo_norm$num_cells < 64]
g64 <- guo_norm[, guo_norm$num_cells == 64]
dm <- DiffusionMap(g2_32)
d <- projection_dist(dm, new_data = g64)
```



---

|             |                                      |
|-------------|--------------------------------------|
| random_root | <i>Find a random root cell index</i> |
|-------------|--------------------------------------|

---

**Description**

Finds a cell that has the maximum DPT distance from a randomly selected one.

**Usage**

```
random_root(dm_or_dpt)
```

**Arguments**

dm\_or\_dpt      A [DiffusionMap](#) or [DPT](#) object

**Value**

A cell index

**Examples**

```
data(guo)
dm <- DiffusionMap(guo)
random_root(dm)
```

---

|              |                      |
|--------------|----------------------|
| Sigmas-class | <i>Sigmas Object</i> |
|--------------|----------------------|

---

**Description**

Holds the information about how the sigma parameter for a [DiffusionMap](#) was obtained, and in this way provides a plotting function for the [find\\_sigmas](#) heuristic. You should not need to create a [Sigmas](#) object yourself. Provide sigma to [DiffusionMap](#) instead or use [find\\_sigmas](#).

**Usage**

```
Sigmas(...)

## S4 method for signature 'Sigmas'
optimal_sigma(object)

## S4 method for signature 'Sigmas'
print(x)

## S4 method for signature 'Sigmas'
show(object)
```

**Arguments**

object, x            [Sigmas](#) object  
 ...                See “**Slots**” below

**Details**

A [Sigmas](#) object is either created by [find\\_sigmas](#) or by specifying the sigma parameter to [DiffusionMap](#).

In the second case, if the sigma parameter is just a number, the resulting [Sigmas](#) object has all slots except of `optimal_sigma` set to NULL.

**Value**

[Sigmas](#) creates an object of the same class

`optimal_sigma` retrieves the numeric value of the optimal sigma or local sigmas

**Slots**

`log_sigmas` Vector of length  $m$  containing the  $\log_{10}$  of the  $\sigma$ s

`dim_norms` Vector of length  $m - 1$  containing the average dimensionality  $\langle p \rangle$  for the respective kernel widths

`optimal_sigma` Multiple local sigmas or the mean of the two global  $\sigma$ s around the highest  $\langle p \rangle$  (`c(optimal_idx, optimal_idx+1L)`)

`optimal_idx` The index of the highest  $\langle p \rangle$ .

`avrd_norms` Vector of length  $m$  containing the average dimensionality for the corresponding sigma.

**See Also**

[find\\_sigmas](#), the function to determine a locally optimal sigma and returning this class

**Examples**

```
data(guo)
sigs <- find_sigmas(guo, verbose = FALSE)
optimal_sigma(sigs)
print(sigs)
```

---

updateObject methods    *Update old destiny objects to a newer version.*

---

**Description**

Handles [DiffusionMap](#), [Sigmas](#), and [GeneRelevance](#).

**Usage**

```
## S4 method for signature 'DiffusionMap'  
updateObject(object, ..., verbose = FALSE)
```

```
## S4 method for signature 'Sigmas'  
updateObject(object, ..., verbose = FALSE)
```

```
## S4 method for signature 'GeneRelevance'  
updateObject(object, ..., verbose = FALSE)
```

**Arguments**

|         |                                                 |
|---------|-------------------------------------------------|
| object  | An object created with an older destiny release |
| ...     | ignored                                         |
| verbose | tells what is being updated                     |

**Value**

A [DiffusionMap](#) or [Sigmas](#) object that is valid when used with the current destiny release

# Index

- \* **data**
  - guo, [29](#)
  - [,DPT,index,index,logicalOrMissing-method (DPT matrix methods), [15](#)
  - [,DPT,index,missing,logicalOrMissing-method (DPT matrix methods), [15](#)
  - [,DPT,missing,index,logicalOrMissing-method (DPT matrix methods), [15](#)
  - [,DPT,missing,missing,logicalOrMissing-method (DPT matrix methods), [15](#)
  - [.DPT (DPT matrix methods), [15](#)
  - [[,DPT,character,missing-method (Extraction methods), [20](#)
  - [[,DPT,index,index-method (DPT matrix methods), [15](#)
  - [[,DiffusionMap,character,missing-method (Extraction methods), [20](#)
  - [[.DPT (Extraction methods), [20](#)
  - [[.DiffusionMap (Extraction methods), [20](#)
  - \$.DPT-method (Extraction methods), [20](#)
  - \$.DiffusionMap-method (Extraction methods), [20](#)
  - \$.DPT (Extraction methods), [20](#)
  - \$.DiffusionMap (Extraction methods), [20](#)
- as.data.frame, [4](#), [18](#)
- as.data.frame,DiffusionMap-method (Coercion methods), [3](#)
- as.data.frame,DPT-method (Coercion methods), [3](#)
- as.data.frame.DiffusionMap (Coercion methods), [3](#)
- as.data.frame.DPT (Coercion methods), [3](#)
- as.ExpressionSet (ExpressionSet helper methods), [19](#)
- as.ExpressionSet,data.frame-method (ExpressionSet helper methods), [19](#)
- as.matrix, [18](#)
- as.matrix,DPT-method (Coercion methods), [3](#)
- as.matrix.DPT, [16](#)
- as.matrix.DPT (Coercion methods), [3](#)
- branch\_divide, [18](#), [33](#)
- branch\_divide (DPT methods), [17](#)
- character, [26](#), [28](#)
- cluster\_louvain, [31](#)
- Coercion methods, [3](#), [11](#), [12](#), [21](#)
- colorlegend, [4](#), [32](#)
- continuous\_scale, [7](#)
- cube\_helix, [6](#)
- data.frame, [12](#), [13](#), [15](#), [20](#), [24](#), [40](#)
- data:guo (guo), [29](#)
- data:guo\_norm (guo), [29](#)
- dataset (destiny generics), [9](#)
- dataset,DiffusionMap-method (DiffusionMap accession methods), [10](#)
- dataset,DPT-method (DPT methods), [17](#)
- dataset,GeneRelevance-method (Gene Relevance methods), [25](#)
- dataset.DPT (DPT methods), [17](#)
- dataset.GeneRelevance (Gene Relevance methods), [25](#)
- dataset<- (destiny generics), [9](#)
- dataset<-,DiffusionMap-method (DiffusionMap accession methods), [10](#)
- dataset<-,DPT-method (DPT methods), [17](#)
- dataset<-,GeneRelevance-method (Gene Relevance methods), [25](#)
- defaults, [28](#)
- destiny, [8](#)
- destiny generics, [9](#)
- destiny-package (destiny), [8](#)
- dgCMatrx, [23](#)

- DiffusionMap, [3](#), [4](#), [8–10](#), [12](#), [15](#), [18](#), [21](#), [22](#), [24](#), [25](#), [27–29](#), [31](#), [35](#), [39–43](#)
- DiffusionMap (DiffusionMap-class), [12](#)
- DiffusionMap accession methods, [4](#), [10](#), [12](#), [21](#)
- DiffusionMap methods, [4](#), [10](#), [11](#), [11](#), [14](#), [21](#)
- DiffusionMap-class, [12](#)
- dim,DPT-method (DPT matrix methods), [15](#)
- dim.DPT (DPT matrix methods), [15](#)
- discrete\_scale, [7](#)
- dist, [13](#)
- distance (destiny generics), [9](#)
- distance, DiffusionMap-method (DiffusionMap accession methods), [10](#)
- distance, GeneRelevance-method (Gene Relevance methods), [25](#)
- distance<- (destiny generics), [9](#)
- distance<-, DiffusionMap-method (DiffusionMap accession methods), [10](#)
- distance<-, GeneRelevance-method (Gene Relevance methods), [25](#)
- dm\_predict, [15](#), [31](#)
- double, [23](#)
- DPT, [3](#), [4](#), [13](#), [16](#), [17](#), [20](#), [21](#), [25](#), [33](#), [41](#)
- DPT (DPT-class), [18](#)
- DPT matrix methods, [15](#)
- DPT methods, [17](#)
- DPT-class, [18](#)
- dsCMatrix, [23](#)
- eig\_decomp, [19](#)
- eigenvalues (destiny generics), [9](#)
- eigenvalues, DiffusionMap-method (DiffusionMap accession methods), [10](#)
- eigenvalues<- (destiny generics), [9](#)
- eigenvalues<-, DiffusionMap-method (DiffusionMap accession methods), [10](#)
- eigenvectors (destiny generics), [9](#)
- eigenvectors, DiffusionMap-method (DiffusionMap accession methods), [10](#)
- eigenvectors<- (destiny generics), [9](#)
- eigenvectors<-, DiffusionMap-method (DiffusionMap accession methods), [10](#)
- eigs, [19](#)
- ExpressionSet, [12](#), [15](#), [19](#), [20](#), [24](#), [29](#), [40](#)
- ExpressionSet helper methods, [19](#)
- Extract, [21](#)
- Extraction methods, [4](#), [11](#), [12](#), [20](#)
- facet\_wrap, [39](#)
- factor, [26](#)
- FALSE, [28](#)
- featureNames, GeneRelevance-method (Gene Relevance methods), [25](#)
- featureNames.GeneRelevance (Gene Relevance methods), [25](#)
- featureNames<-, GeneRelevance, characterOrFactor-method (Gene Relevance methods), [25](#)
- find\_dm\_k, [13](#), [22](#)
- find\_knn, [13](#), [14](#), [22](#), [28](#)
- find\_sigmas, [13](#), [14](#), [23](#), [41](#), [42](#)
- find\_tips, [25](#)
- fortify, [4](#)
- fortify.DiffusionMap (Coercion methods), [3](#)
- fortify.DPT (Coercion methods), [3](#)
- Gene Relevance methods, [25](#), [28](#), [39](#)
- Gene Relevance plotting, [26](#), [28](#)
- Gene Relevance plotting (plot\_differential\_map), [35](#)
- gene\_relevance, [26](#), [39](#)
- gene\_relevance (GeneRelevance-class), [27](#)
- gene\_relevance, DiffusionMap, missing-method (GeneRelevance-class), [27](#)
- gene\_relevance, matrix, dMatrixOrMatrix-method (GeneRelevance-class), [27](#)
- GeneRelevance, [35](#), [39](#), [43](#)
- GeneRelevance-class, [27](#)
- ggplot, [4](#)
- guides, [7](#)
- guo, [29](#)
- guo\_norm (guo), [29](#)
- hcl.colors, [6](#), [32](#)
- hns\_w\_knn, [23](#)
- integer, [18](#), [23](#)
- l\_which, [30](#)
- list, [23](#), [28](#)
- logical, [16](#), [18](#), [28](#)

matrix, [12](#), [15](#), [18](#), [23](#), [24](#), [28](#), [39](#), [40](#)

names, [21](#)

names, DiffusionMap-method (Extraction methods), [20](#)

names, DPT-method (Extraction methods), [20](#)

names.DiffusionMap (Extraction methods), [20](#)

names.DPT (Extraction methods), [20](#)

ncol, DPT-method (DPT matrix methods), [15](#)

ncol.DPT (DPT matrix methods), [15](#)

nrow, DPT-method (DPT matrix methods), [15](#)

nrow.DPT (DPT matrix methods), [15](#)

Numeric, [16](#)

numeric, [13](#), [28](#)

optimal\_sigma, [14](#)

optimal\_sigma (destiny generics), [9](#)

optimal\_sigma, DiffusionMap-method (DiffusionMap accession methods), [10](#)

optimal\_sigma, Sigmas-method (Sigmas-class), [41](#)

palette, [4](#), [32](#)

par, [5](#)

phenoData, [29](#)

plot, [8](#), [32](#)

plot, DiffusionMap, missing-method (plot.DiffusionMap), [30](#)

plot, DiffusionMap, numeric-method (plot.DiffusionMap), [30](#)

plot, DPT, missing-method (plot.DPT), [33](#)

plot, DPT, numeric-method (plot.DPT), [33](#)

plot, GeneRelevance, character-method (plot\_differential\_map), [35](#)

plot, GeneRelevance, missing-method (plot\_differential\_map), [35](#)

plot, GeneRelevance, numeric-method (plot\_differential\_map), [35](#)

plot, Sigmas, missing-method (plot.Sigmas), [34](#)

plot.DiffusionMap, [8](#), [30](#), [33](#), [34](#)

plot.DPT, [17](#), [33](#)

plot.Sigmas, [34](#)

plot3d, [32](#)

plot\_differential\_map, [35](#)

plot\_differential\_map, DiffusionMap, missing-method (plot\_differential\_map), [35](#)

plot\_differential\_map, GeneRelevance, missing-method (plot\_differential\_map), [35](#)

plot\_differential\_map, matrix, matrix-method (plot\_differential\_map), [35](#)

plot\_gene\_relevance (plot\_differential\_map), [35](#)

plot\_gene\_relevance, DiffusionMap, missing-method (plot\_differential\_map), [35](#)

plot\_gene\_relevance, GeneRelevance, missing-method (plot\_differential\_map), [35](#)

plot\_gene\_relevance, matrix, matrix-method (plot\_differential\_map), [35](#)

plot\_gene\_relevance\_rank (plot\_differential\_map), [35](#)

plot\_gene\_relevance\_rank, DiffusionMap, missing-method (plot\_differential\_map), [35](#)

plot\_gene\_relevance\_rank, GeneRelevance, missing-method (plot\_differential\_map), [35](#)

plot\_gene\_relevance\_rank, matrix, matrix-method (plot\_differential\_map), [35](#)

print, DiffusionMap-method (DiffusionMap methods), [11](#)

print, GeneRelevance-method (Gene Relevance methods), [25](#)

print, Sigmas-method (Sigmas-class), [41](#)

print.DiffusionMap (DiffusionMap methods), [11](#)

projection\_dist, [40](#)

proxy::dist, [15](#), [40](#)

qplot, [4](#)

random\_root, [41](#)

read.ExpressionSet (ExpressionSet helper methods), [19](#)

read.table, [20](#)

scale\_color\_cube\_helix (cube\_helix), [6](#)

scale\_colour\_cube\_helix (cube\_helix), [6](#)

scale\_fill\_cube\_helix (cube\_helix), [6](#)

scatterplot3d, [32](#)

set.seed, [19](#)

show, DiffusionMap-method (DiffusionMap methods), [11](#)

show, GeneRelevance-method (Gene Relevance methods), [25](#)

show, Sigmas-method (Sigmas-class), [41](#)

show.DiffusionMap (DiffusionMap  
methods), [11](#)  
Sigmas, [9](#), [10](#), [13](#), [14](#), [24](#), [34](#), [42](#), [43](#)  
Sigmas (Sigmas-class), [41](#)  
sigmas (destiny generics), [9](#)  
sigmas, DiffusionMap-method  
(DiffusionMap accession  
methods), [10](#)  
Sigmas-class, [41](#)  
Sigmas-methods (Sigmas-class), [41](#)  
sigmas<- (destiny generics), [9](#)  
sigmas<-, DiffusionMap-method  
(DiffusionMap accession  
methods), [10](#)  
SingleCellExperiment, [12](#), [15](#), [24](#), [40](#)  
smoother, [28](#)  
smth.gaussian, [28](#), [33](#)  
sparseMatrix, [13](#), [28](#)  
  
text, [5](#)  
the plot method for the DiffusionMap,  
[15](#)  
tips (DPT methods), [17](#)  
TRUE, [16](#), [28](#), [40](#)  
  
updateObject methods, [43](#)  
updateObject, DiffusionMap-method  
(updateObject methods), [43](#)  
updateObject, GeneRelevance-method  
(updateObject methods), [43](#)  
updateObject, Sigmas-method  
(updateObject methods), [43](#)  
updateObject.DiffusionMap  
(updateObject methods), [43](#)  
updateObject.GeneRelevance  
(updateObject methods), [43](#)  
updateObject.Sigmas (updateObject  
methods), [43](#)  
  
which, [30](#)