

# Package ‘celda’

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**Title** Cellular Latent Dirichlet Allocation

**Version** 1.25.0

**Description** Celda is a suite of Bayesian hierarchical models for clustering single-cell RNA-sequencing (scRNA-seq) data. It is able to perform ``bi-clustering" and simultaneously cluster genes into gene modules and cells into cell subpopulations. It also contains DecontX, a novel Bayesian method to computationally estimate and remove RNA contamination in individual cells without empty droplet information. A variety of scRNA-seq data visualization functions is also included.

**Depends** R (>= 4.0), SingleCellExperiment, Matrix

**VignetteBuilder** knitr

**Imports** plyr, foreach, ggplot2, RColorBrewer, grid, scales, gtable, grDevices, graphics, matrixStats, doParallel, digest, methods, reshape2, S4Vectors, data.table, Rcpp, RcppEigen, uwot, enrichR, SummarizedExperiment, MCMCprecision, ggrepel, Rtsne, withr, scatter (>= 1.14.4), scran, dbscan, DelayedArray, stringr, ComplexHeatmap, gridExtra, circlize, dendextend, ggdendro, pROC

**Suggests** testthat, knitr, roxygen2, rmarkdown, biomaRt, covr, BiocManager, BiocStyle, TENxPBMCDData, singleCellTK, M3DExampleData

**LinkingTo** Rcpp, RcppEigen

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---

|                 |                                     |
|-----------------|-------------------------------------|
| appendCeldaList | <i>Append two celdaList objects</i> |
|-----------------|-------------------------------------|

---

### Description

Returns a single celdaList representing the combination of two provided celdaList objects.

### Usage

```
appendCeldaList(list1, list2)
```

### Arguments

|       |                                              |
|-------|----------------------------------------------|
| list1 | A celda_list object                          |
| list2 | A celda_list object to be joined with list_1 |

### Value

A celdaList object. This object contains all resList entries and runParam records from both lists.

### Examples

```
data(celdaCGGridSearchRes)
appendedList <- appendCeldaList(
  celdaCGGridSearchRes,
  celdaCGGridSearchRes
)
```

---

|                 |                         |
|-----------------|-------------------------|
| availableModels | <i>available models</i> |
|-----------------|-------------------------|

---

### Description

available models

### Usage

```
availableModels
```

### Format

An object of class character of length 3.

---

|                   |                               |
|-------------------|-------------------------------|
| bestLogLikelihood | <i>Get the log-likelihood</i> |
|-------------------|-------------------------------|

---

**Description**

Retrieves the final log-likelihood from all iterations of Gibbs sampling used to generate a celdaModel.

**Usage**

```
bestLogLikelihood(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
bestLogLikelihood(x, altExpName = "featureSubset")

## S4 method for signature 'celdaModel'
bestLogLikelihood(x)
```

**Arguments**

|            |                                                                                                                                                                      |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a> , <a href="#">celda_G</a> , or <a href="#">celda_CG</a> , or a celda model object. |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                        |

**Value**

Numeric. The log-likelihood at the final step of Gibbs sampling used to generate the model.

**Examples**

```
data(sceCeldaCG)
bestLogLikelihood(sceCeldaCG)
data(celdaCGMod)
bestLogLikelihood(celdaCGMod)
```

---

|       |                     |
|-------|---------------------|
| celda | <i>Celda models</i> |
|-------|---------------------|

---

**Description**

List of available Celda models with corresponding descriptions.

**Usage**

```
celda()
```

**Value**

None

**Examples**

`celda()`

---

|                                   |                             |
|-----------------------------------|-----------------------------|
| <code>celdaCGGridSearchRes</code> | <i>celdaCGGridSearchRes</i> |
|-----------------------------------|-----------------------------|

---

**Description**

Example results of old `celdaGridSearch` on `celdaCGSim`

**Usage**

`celdaCGGridSearchRes`

**Format**

An object as returned from old `celdaGridSearch()`

---

|                         |                   |
|-------------------------|-------------------|
| <code>celdaCGMod</code> | <i>celdaCGmod</i> |
|-------------------------|-------------------|

---

**Description**

`celda_CG` model object generated from `celdaCGSim` using old `celda_CG` function.

**Usage**

`celdaCGMod`

**Format**

A `celda_CG` object

---

|                         |                   |
|-------------------------|-------------------|
| <code>celdaCGSim</code> | <i>celdaCGSim</i> |
|-------------------------|-------------------|

---

**Description**

An deprecated example of simulated count matrix from the `celda_CG` model.

**Usage**

`celdaCGSim`

**Format**

A list of counts and properties as returned from old `simulateCells()`.

---

|               |                                                                                                                           |
|---------------|---------------------------------------------------------------------------------------------------------------------------|
| celdaClusters | <i>Get or set the cell cluster labels from a celda <a href="#">SingleCellExperiment</a> object or celda model object.</i> |
|---------------|---------------------------------------------------------------------------------------------------------------------------|

---

## Description

Return or set the cell cluster labels determined by [celda\\_C](#) or [celda\\_CG](#) models.

## Usage

```
celdaClusters(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
celdaClusters(x, altExpName = "featureSubset")

## S4 method for signature 'celdaModel'
celdaClusters(x)

celdaClusters(x, altExpName = "featureSubset") <- value

## S4 replacement method for signature 'SingleCellExperiment'
celdaClusters(x, altExpName = "featureSubset") <- value
```

## Arguments

|            |                                                                                                                                                                                                                                                                                                                                                                                            |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | Can be one of <ul style="list-style-type: none"> <li>A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a>, or <a href="#">celda_CG</a>, with the matrix located in the useAssay assay slot. The a <a href="#">altExp</a> slot with name altExpName will be used. Rows represent features and columns represent cells.</li> <li>Celda model object.</li> </ul> |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                                                              |
| value      | Character vector of cell cluster labels for replacements. Works only if x is a <a href="#">SingleCellExperiment</a> object.                                                                                                                                                                                                                                                                |

## Value

One of

- Character vector if x is a [SingleCellExperiment](#) object. Contains cell cluster labels for each cell in x.
- List if x is a celda model object. Contains cell cluster labels (for [celda\\_C](#) and [celdaCG](#) Models) and/or feature module labels (for [celda\\_G](#) and [celdaCG](#) Models).

## Examples

```
data(sceCeldaCG)
celdaClusters(sceCeldaCG)
data(celdaCGMod)
celdaClusters(celdaCGMod)
```

---

`celdaCMod`*celdaCMod*

---

**Description**

Old celda\_C results generated from celdaCSim

**Usage**

`celdaCMod`

**Format**

A celda\_C object

---

`celdaCSim`*celdaCSim*

---

**Description**

An old example simulated count matrix from the celda\_C model.

**Usage**

`celdaCSim`

**Format**

A list of counts and properties as returned from old simulateCells().

---

`celdaGMod`*celdaGMod*

---

**Description**

Old celda\_G results generated from celdaGsim

**Usage**

`celdaGMod`

**Format**

A celda\_G object



---

celdaGridSearch*Run Celda in parallel with multiple parameters*

---

## Description

Run Celda with different combinations of parameters and multiple chains in parallel. The variable [availableModels](#) contains the potential models that can be utilized. Different parameters to be tested should be stored in a list and passed to the argument `paramsTest`. Fixed parameters to be used in all models, such as `sampleLabel`, can be passed as a list to the argument `paramsFixed`. When `verbose = TRUE`, output from each chain will be sent to a log file but not be displayed in `stdout`.

## Usage

```
celdaGridSearch(  
  x,  
  useAssay = "counts",  
  altExpName = "featureSubset",  
  model,  
  paramsTest,  
  paramsFixed = NULL,  
  maxIter = 200,  
  nchains = 3,  
  cores = 1,  
  bestOnly = TRUE,  
  seed = 12345,  
  perplexity = TRUE,  
  verbose = TRUE,  
  logfilePrefix = "Celda"  
)  
  
## S4 method for signature 'SingleCellExperiment'  
celdaGridSearch(  
  x,  
  useAssay = "counts",  
  altExpName = "featureSubset",  
  model,  
  paramsTest,  
  paramsFixed = NULL,  
  maxIter = 200,  
  nchains = 3,  
  cores = 1,  
  bestOnly = TRUE,  
  seed = 12345,  
  perplexity = TRUE,  
  verbose = TRUE,  
  logfilePrefix = "Celda"  
)  
  
## S4 method for signature 'matrix'  
celdaGridSearch(  
  x,
```

```

    useAssay = "counts",
    altExpName = "featureSubset",
    model,
    paramsTest,
    paramsFixed = NULL,
    maxIter = 200,
    nchains = 3,
    cores = 1,
    bestOnly = TRUE,
    seed = 12345,
    perplexity = TRUE,
    verbose = TRUE,
    logfilePrefix = "Celda"
  )

```

## Arguments

|               |                                                                                                                                                                                                                                                                    |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x             | A numeric <a href="#">matrix</a> of counts or a <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.                                                                |
| useAssay      | A string specifying the name of the <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                                                           |
| altExpName    | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                      |
| model         | Celda model. Options available in <a href="#">availableModels</a> .                                                                                                                                                                                                |
| paramsTest    | List. A list denoting the combinations of parameters to run in a celda model. For example, <code>list(K = seq(5, 10), L = seq(15, 20))</code> will run all combinations of K from 5 to 10 and L from 15 to 20 in model <a href="#">celda_CG</a> .                  |
| paramsFixed   | List. A list denoting additional parameters to use in each celda model. Default NULL.                                                                                                                                                                              |
| maxIter       | Integer. Maximum number of iterations of sampling to perform. Default 200.                                                                                                                                                                                         |
| nchains       | Integer. Number of random cluster initializations. Default 3.                                                                                                                                                                                                      |
| cores         | Integer. The number of cores to use for parallel estimation of chains. Default 1.                                                                                                                                                                                  |
| bestOnly      | Logical. Whether to return only the chain with the highest log likelihood per combination of parameters or return all chains. Default TRUE.                                                                                                                        |
| seed          | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. Seed values <code>seq(seed, (seed + nchains - 1))</code> will be supplied to each chain in nchains. If NULL, no calls to <a href="#">with_seed</a> are made. |
| perplexity    | Logical. Whether to calculate perplexity for each model. If FALSE, then perplexity can be calculated later with <a href="#">resamplePerplexity</a> . Default TRUE.                                                                                                 |
| verbose       | Logical. Whether to print log messages during celda chain execution. Default TRUE.                                                                                                                                                                                 |
| logfilePrefix | Character. Prefix for log files from worker threads and main process. Default "Celda".                                                                                                                                                                             |

## Value

A [SingleCellExperiment](#) object. Function parameter settings and celda model results are stored in the [metadata](#) "celda\_grid\_search" slot.

**See Also**

[celda\\_G](#) for feature clustering, [celda\\_C](#) for clustering of cells, and [celda\\_CG](#) for simultaneous clustering of features and cells. [subsetCeldaList](#) can subset the `celdaList` object. [selectBestModel](#) can get the best model for each combination of parameters.

**Examples**

```
## Not run:
data(celdaGSim)
## Run various combinations of parameters with 'celdaGridSearch'
celdaCGGridSearchRes <- celdaGridSearch(celdaGSim$counts,
  model = "celda_CG",
  paramsTest = list(K = seq(4, 6), L = seq(9, 11)),
  paramsFixed = list(sampleLabel = celdaGSim$sampleLabel),
  bestOnly = TRUE,
  nchains = 1,
  cores = 1)

## End(Not run)
```

---

celdaGSim

*celdaGSim*


---

**Description**

An old example simulated count matrix from the `celda_G` model.

**Usage**

```
celdaGSim
```

**Format**

A list of counts and properties as returned from `old.simulateCells()`

---

celdaHeatmap

*Plot celda Heatmap*


---

**Description**

Render a stylable heatmap of count data based on `celda` clustering results.

## Usage

```

celdaHeatmap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  featureIx = NULL,
  nfeatures = 25,
  ...
)

## S4 method for signature 'SingleCellExperiment'
celdaHeatmap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  featureIx = NULL,
  nfeatures = 25,
  ...
)

```

## Arguments

|            |                                                                                                                                                                                                                        |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sce        | A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a> , <a href="#">celda_G</a> , or <a href="#">celda_CG</a> .                                                                            |
| useAssay   | A string specifying which <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                         |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                          |
| featureIx  | Integer vector. Select features for display in heatmap. If NULL, no subsetting will be performed. Default NULL. <b>Only used for sce containing celda_C model result returned by <a href="#">celda_C</a>.</b>          |
| nfeatures  | Integer. Maximum number of features to select for each gene module. Default 25. <b>Only used for sce containing celda_CG or celda_G model results returned by <a href="#">celda_CG</a> or <a href="#">celda_G</a>.</b> |
| ...        | Additional parameters passed to <a href="#">plotHeatmap</a> .                                                                                                                                                          |

## Value

list A list containing dendrogram information and the heatmap grob

## See Also

‘[celdaTsne\(\)](#)’ for generating 2-dimensional tSNE coordinates

## Examples

```

data(sceCeldaCG)
celdaHeatmap(sceCeldaCG)

```

---

|            |                                                                                 |
|------------|---------------------------------------------------------------------------------|
| celdaModel | <i>Get celda model from a celda <a href="#">SingleCellExperiment</a> object</i> |
|------------|---------------------------------------------------------------------------------|

---

### Description

Return the celda model for sce returned by [celda\\_C](#), [celda\\_G](#) or [celda\\_CG](#).

### Usage

```
celdaModel(sce, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
celdaModel(sce, altExpName = "featureSubset")
```

### Arguments

sce                    A [SingleCellExperiment](#) object returned by [celda\\_C](#), [celda\\_G](#), or [celda\\_CG](#).  
altExpName            The name for the [altExp](#) slot to use. Default "featureSubset".

### Value

Character. The celda model. Can be one of "celda\_C", "celda\_G", or "celda\_CG".

### Examples

```
data(sceCeldaCG)
celdaModel(sceCeldaCG)
```

---

|              |                                                                                                       |
|--------------|-------------------------------------------------------------------------------------------------------|
| celdaModules | <i>Get or set the feature module labels from a celda <a href="#">SingleCellExperiment</a> object.</i> |
|--------------|-------------------------------------------------------------------------------------------------------|

---

### Description

Return or set the feature module cluster labels determined by [celda\\_G](#) or [celda\\_CG](#) models.

### Usage

```
celdaModules(sce, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
celdaModules(sce, altExpName = "featureSubset")

celdaModules(sce, altExpName = "featureSubset") <- value

## S4 replacement method for signature 'SingleCellExperiment'
celdaModules(sce, altExpName = "featureSubset") <- value
```

**Arguments**

|            |                                                                                                                                                                                                                            |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sce        | A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_G</a> , or <a href="#">celda_CG</a> , with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells. |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                              |
| value      | Character vector of feature module labels for replacements. Works only if x is a <a href="#">SingleCellExperiment</a> object.                                                                                              |

**Value**

Character vector. Contains feature module labels for each feature in x.

**Examples**

```
data(sceCeldaCG)
celdaModules(sceCeldaCG)
```

---

celdaPerplexity

*Get perplexity for every model in a celdaList*


---

**Description**

Returns perplexity for each model in a celdaList as calculated by 'perplexity().'

**Usage**

```
celdaPerplexity(celdaList)
```

**Arguments**

|           |                               |
|-----------|-------------------------------|
| celdaList | An object of class celdaList. |
|-----------|-------------------------------|

**Value**

List. Contains one celdaModel object for each of the parameters specified in the 'runParams()' of the provided celda list.

**Examples**

```
data(celdaCGGridSearchRes)
celdaCGGridModelPerplexities <- celdaPerplexity(celdaCGGridSearchRes)
```

---

celdaPerplexity,celdaList-method

*Get perplexity for every model in a celdaList*


---

## Description

Returns perplexity for each model in a celdaList as calculated by 'perplexity().'

## Usage

```
## S4 method for signature 'celdaList'
celdaPerplexity(celdaList)
```

## Arguments

celdaList      An object of class celdaList.

## Value

List. Contains one celdaModel object for each of the parameters specified in the 'runParams()' of the provided celda list.

## Examples

```
data(celdaCGGridSearchRes)
celdaCGGridModelPerplexities <- celdaPerplexity(celdaCGGridSearchRes)
```

---

celdaProbabilityMap      *Probability map for a celda model*


---

## Description

Renders probability and relative expression heatmaps to visualize the relationship between features and cell populations (or cell populations and samples).

## Usage

```
celdaProbabilityMap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  level = c("cellPopulation", "sample"),
  ncols = 100,
  col2 = circlize::colorRamp2(c(-2, 0, 2), c("#1E90FF", "#FFFFFF", "#CD2626")),
  title1 = "Absolute probability",
  title2 = "Relative expression",
  showColumnNames = TRUE,
  showRowNames = TRUE,
  rowNamesgp = grid::gpar(fontsize = 8),
  colNamesgp = grid::gpar(fontsize = 12),
```

```

clusterRows = FALSE,
clusterColumns = FALSE,
showHeatmapLegend = TRUE,
heatmapLegendParam = list(title = NULL, legend_height = grid::unit(6, "cm")),
...
)

## S4 method for signature 'SingleCellExperiment'
celdaProbabilityMap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  level = c("cellPopulation", "sample"),
  ncols = 100,
  col2 = circlize::colorRamp2(c(-2, 0, 2), c("#1E90FF", "#FFFFFF", "#CD2626")),
  title1 = "Absolute probability",
  title2 = "Relative expression",
  showColumnNames = TRUE,
  showRowNames = TRUE,
  rowNamesgp = grid::gpar(fontsize = 8),
  colNamesgp = grid::gpar(fontsize = 12),
  clusterRows = FALSE,
  clusterColumns = FALSE,
  showHeatmapLegend = TRUE,
  heatmapLegendParam = list(title = NULL, legend_height = grid::unit(6, "cm")),
  ...
)

```

## Arguments

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sce             | A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a> , <a href="#">celda_G</a> , or <a href="#">celda_CG</a> .                                                                                                                                                                                                                                                                    |
| useAssay        | A string specifying which <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                                                                                                                                                                                                                 |
| altExpName      | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                                                                                  |
| level           | Character. One of "cellPopulation" or "Sample". "cellPopulation" will display the absolute probabilities and relative normalized expression of each module in each cell population. level = "cellPopulation" <b>only works for celda_CG sce objects</b> . "sample" will display the absolute probabilities and relative normalized abundance of each cell population in each sample. Default "cellPopulation". |
| ncols           | The number of colors (>1) to be in the color palette of the absolute probability heatmap.                                                                                                                                                                                                                                                                                                                      |
| col2            | Passed to col argument of <a href="#">Heatmap</a> . Set color boundaries and colors for the relative expression heatmap.                                                                                                                                                                                                                                                                                       |
| title1          | Passed to column_title argument of <a href="#">Heatmap</a> . Figure title for the absolute probability heatmap.                                                                                                                                                                                                                                                                                                |
| title2          | Passed to column_title argument of <a href="#">Heatmap</a> . Figure title for the relative expression heatmap.                                                                                                                                                                                                                                                                                                 |
| showColumnNames | Passed to show_column_names argument of <a href="#">Heatmap</a> . Show column names.                                                                                                                                                                                                                                                                                                                           |
| showRowNames    | Passed to show_row_names argument of <a href="#">Heatmap</a> . Show row names.                                                                                                                                                                                                                                                                                                                                 |



|                    |                                                                                                 |
|--------------------|-------------------------------------------------------------------------------------------------|
| rowNamesgp         | Passed to row_names_gp argument of <a href="#">Heatmap</a> . Set row name font.                 |
| colNamesgp         | Passed to column_names_gp argument of <a href="#">Heatmap</a> . Set column name font.           |
| clusterRows        | Passed to cluster_rows argument of <a href="#">Heatmap</a> . Cluster rows.                      |
| clusterColumns     | Passed to cluster_columns argument of <a href="#">Heatmap</a> . Cluster columns.                |
| showHeatmapLegend  | Passed to show_heatmap_legend argument of <a href="#">Heatmap</a> . Show heatmap legend.        |
| heatmapLegendParam | Passed to heatmap_legend_param argument of <a href="#">Heatmap</a> . Heatmap legend parameters. |
| ...                | Additional parameters passed to <a href="#">Heatmap</a> .                                       |

**Value**

A [HeatmapList](#) object containing 2 [Heatmap](#)-class objects

**See Also**

[celda\\_C](#) for clustering cells. [celda\\_CG](#) for clustering features and cells

**Examples**

```
data(sceCeldaCG)
celdaProbabilityMap(sceCeldaCG)
```

---

|            |                                                     |
|------------|-----------------------------------------------------|
| celdatosce | <i>Convert old celda model object to SCE object</i> |
|------------|-----------------------------------------------------|

---

**Description**

Convert a old celda model object (celda\_C, celda\_G, or celda\_CG object) to a [SingleCellExperiment](#) object containing celda model information in metadata slot. Counts matrix is stored in the "counts" assay slot in assays.

**Usage**

```
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'celda_C'
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
  altExpName = "featureSubset"
)
```

```
## S4 method for signature 'celda_G'
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'celda_CG'
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'celdaList'
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
  altExpName = "featureSubset"
)
```

### Arguments

|            |                                                                                                                                                             |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| celdaModel | A celdaModel or celdaList object generated using older versions of celda.                                                                                   |
| counts     | A numeric <a href="#">matrix</a> of counts used to generate celdaModel. Dimensions and MD5 checksum will be checked by <a href="#">compareCountMatrix</a> . |
| useAssay   | A string specifying the name of the <a href="#">assay</a> slot to use. Default "counts".                                                                    |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                               |

### Value

A [SingleCellExperiment](#) object. Function parameter settings are stored in the [metadata](#) "celda\_parameters" slot. Columns celda\_sample\_label and celda\_cell\_cluster in [colData](#) contain sample labels and celda cell population clusters. Column celda\_feature\_module in [rowData](#) contain feature modules.

### Examples

```
data(celdaCMod, celdaCSim)
sce <- celdatosce(celdaCMod, celdaCSim$counts)
data(celdaGMod, celdaGSim)
sce <- celdatosce(celdaGMod, celdaGSim$counts)
data(celdaCGMod, celdaCGSim)
sce <- celdatosce(celdaCGMod, celdaCGSim$counts)
data(celdaCGGridSearchRes, celdaCGSim)
sce <- celdatosce(celdaCGGridSearchRes, celdaCGSim$counts)
```

---

|           |                                                                                                     |
|-----------|-----------------------------------------------------------------------------------------------------|
| celdaTsne | <i>t-Distributed Stochastic Neighbor Embedding (t-SNE) dimension reduction for celda sce object</i> |
|-----------|-----------------------------------------------------------------------------------------------------|

---

## Description

Embeds cells in two dimensions using [Rtsne](#) based on a celda model. For `celda_C` sce objects, PCA on the normalized counts is used to reduce the number of features before applying t-SNE. For `celda_CG` and `celda_G` sce objects, tSNE is run on module probabilities to reduce the number of features instead of using PCA. Module probabilities are square-root transformed before applying tSNE.

## Usage

```
celdaTsne(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  maxCells = NULL,
  minClusterSize = 100,
  initialDims = 20,
  modules = NULL,
  perplexity = 20,
  maxIter = 2500,
  normalize = "proportion",
  scaleFactor = NULL,
  transformationFun = sqrt,
  seed = 12345
)

## S4 method for signature 'SingleCellExperiment'
celdaTsne(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  maxCells = NULL,
  minClusterSize = 100,
  initialDims = 20,
  modules = NULL,
  perplexity = 20,
  maxIter = 2500,
  normalize = "proportion",
  scaleFactor = NULL,
  transformationFun = sqrt,
  seed = 12345
)
```

## Arguments

|                       |                                                                                                                                    |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <code>sce</code>      | A <a href="#">SingleCellExperiment</a> object returned by <code>celda_C</code> , <code>celda_G</code> , or <code>celda_CG</code> . |
| <code>useAssay</code> | A string specifying which <a href="#">assay</a> slot to use. Default "counts".                                                     |

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| altExpName        | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| maxCells          | Integer. Maximum number of cells to plot. Cells will be randomly subsampled if <code>ncol(counts) &gt; maxCells</code> . Larger numbers of cells requires more memory. If NULL, no subsampling will be performed. Default NULL.                                                                                                                                                                                                                                                                                                     |
| minClusterSize    | Integer. Do not subsample cell clusters below this threshold. Default 100.                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| initialDims       | Integer. PCA will be used to reduce the dimensionality of the dataset. The top 'initialDims' principal components will be used for tSNE. Default 20.                                                                                                                                                                                                                                                                                                                                                                                |
| modules           | Integer vector. Determines which feature modules to use for tSNE. If NULL, all modules will be used. Default NULL.                                                                                                                                                                                                                                                                                                                                                                                                                  |
| perplexity        | Numeric. Perplexity parameter for tSNE. Default 20.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| maxIter           | Integer. Maximum number of iterations in tSNE generation. Default 2500.                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| normalize         | Character. Passed to <a href="#">normalizeCounts</a> in normalization step. Divides counts by the library sizes for each cell. One of 'proportion', 'cpm', 'median', or 'mean'. 'proportion' uses the total counts for each cell as the library size. 'cpm' divides the library size of each cell by one million to produce counts per million. 'median' divides the library size of each cell by the median library size across all cells. 'mean' divides the library size of each cell by the mean library size across all cells. |
| scaleFactor       | Numeric. Sets the scale factor for cell-level normalization. This scale factor is multiplied to each cell after the library size of each cell had been adjusted in <code>normalize</code> . Default NULL which means no scale factor is applied.                                                                                                                                                                                                                                                                                    |
| transformationFun | Function. Applies a transformation such as 'sqrt', 'log', 'log2', 'log10', or 'log1p'. If NULL, no transformation will be applied. Occurs after applying normalization and scale factor. Default NULL.                                                                                                                                                                                                                                                                                                                              |
| seed              | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                                                                                                                                                                                                                                                                                                                                      |

### Value

sce with t-SNE coordinates (columns "celda\_tSNE1" & "celda\_tSNE2") added to [reducedDim](#)(sce, "celda\_tSNE").

### Examples

```
data(sceCeldaCG)
tsneRes <- celdaTsne(sceCeldaCG)
```

---

|           |                                                                                                      |
|-----------|------------------------------------------------------------------------------------------------------|
| celdaUmap | <i>Uniform Manifold Approximation and Projection (UMAP) dimension reduction for celda sce object</i> |
|-----------|------------------------------------------------------------------------------------------------------|

---

### Description

Embeds cells in two dimensions using [umap](#) based on a celda model. For celda\_C sce objects, PCA on the normalized counts is used to reduce the number of features before applying UMAP. For celda\_CG sce object, UMAP is run on module probabilities to reduce the number of features instead of using PCA. Module probabilities are square-root transformed before applying UMAP.

**Usage**

```

celdaUmap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  maxCells = NULL,
  minClusterSize = 100,
  modules = NULL,
  seed = 12345,
  nNeighbors = 30,
  minDist = 0.75,
  spread = 1,
  pca = TRUE,
  initialDims = 50,
  normalize = "proportion",
  scaleFactor = NULL,
  transformationFun = sqrt,
  cores = 1,
  ...
)

## S4 method for signature 'SingleCellExperiment'
celdaUmap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  maxCells = NULL,
  minClusterSize = 100,
  modules = NULL,
  seed = 12345,
  nNeighbors = 30,
  minDist = 0.75,
  spread = 1,
  pca = TRUE,
  initialDims = 50,
  normalize = "proportion",
  scaleFactor = NULL,
  transformationFun = sqrt,
  cores = 1,
  ...
)

```

**Arguments**

|                |                                                                                                                                                                                                                              |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sce            | A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a> , <a href="#">celda_G</a> , or <a href="#">celda_CG</a> .                                                                                  |
| useAssay       | A string specifying which <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                               |
| altExpName     | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                |
| maxCells       | Integer. Maximum number of cells to plot. Cells will be randomly subsampled if <code>ncol(sce) &gt; maxCells</code> . Larger numbers of cells requires more memory. If NULL, no subsampling will be performed. Default NULL. |
| minClusterSize | Integer. Do not subsample cell clusters below this threshold. Default 100.                                                                                                                                                   |

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| modules           | Integer vector. Determines which features modules to use for UMAP. If NULL, all modules will be used. Default NULL.                                                                                                                                                                                                                                                                                                                                                                                                                 |
| seed              | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                                                                                                                                                                                                                                                                                                                                      |
| nNeighbors        | The size of local neighborhood used for manifold approximation. Larger values result in more global views of the manifold, while smaller values result in more local data being preserved. Default 30. See <a href="#">umap</a> for more information.                                                                                                                                                                                                                                                                               |
| minDist           | The effective minimum distance between embedded points. Smaller values will result in a more clustered/clumped embedding where nearby points on the manifold are drawn closer together, while larger values will result on a more even dispersal of points. Default 0.75. See <a href="#">umap</a> for more information.                                                                                                                                                                                                            |
| spread            | The effective scale of embedded points. In combination with <code>min_dist</code> , this determines how clustered/clumped the embedded points are. Default 1. See <a href="#">umap</a> for more information.                                                                                                                                                                                                                                                                                                                        |
| pca               | Logical. Whether to perform dimensionality reduction with PCA before UMAP. Only works for <code>celda_C</code> sce objects.                                                                                                                                                                                                                                                                                                                                                                                                         |
| initialDims       | Integer. Number of dimensions from PCA to use as input in UMAP. Default 50. Only works for <code>celda_C</code> sce objects.                                                                                                                                                                                                                                                                                                                                                                                                        |
| normalize         | Character. Passed to <a href="#">normalizeCounts</a> in normalization step. Divides counts by the library sizes for each cell. One of 'proportion', 'cpm', 'median', or 'mean'. 'proportion' uses the total counts for each cell as the library size. 'cpm' divides the library size of each cell by one million to produce counts per million. 'median' divides the library size of each cell by the median library size across all cells. 'mean' divides the library size of each cell by the mean library size across all cells. |
| scaleFactor       | Numeric. Sets the scale factor for cell-level normalization. This scale factor is multiplied to each cell after the library size of each cell had been adjusted in <code>normalize</code> . Default NULL which means no scale factor is applied.                                                                                                                                                                                                                                                                                    |
| transformationFun | Function. Applies a transformation such as 'sqrt', 'log', 'log2', 'log10', or 'log1p'. If NULL, no transformation will be applied. Occurs after applying normalization and scale factor. Default NULL.                                                                                                                                                                                                                                                                                                                              |
| cores             | Number of threads to use. Default 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| ...               | Additional parameters to pass to <a href="#">umap</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

### Value

sce with UMAP coordinates (columns "celda\_UMAP1" & "celda\_UMAP2") added to [reducedDim](#)(sce, "celda\_UMAP").

### Examples

```
data(sceCeldaCG)
umapRes <- celdaUmap(sceCeldaCG)
```

celda\_C

*Cell clustering with Celda***Description**

Clusters the columns of a count matrix containing single-cell data into  $K$  subpopulations. The useAssay `assay` slot in `altExpName` `altExp` slot will be used if it exists. Otherwise, the useAssay `assay` slot in `x` will be used if `x` is a `SingleCellExperiment` object.

**Usage**

```
celda_C(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  alpha = 1,
  beta = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'SingleCellExperiment'
celda_C(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  alpha = 1,
  beta = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
```

```

    zInit = NULL,
    logfile = NULL,
    verbose = TRUE
)

## S4 method for signature 'ANY'
celda_C(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  alpha = 1,
  beta = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

```

## Arguments

|             |                                                                                                                                                                                                                                                                                                                                                                                     |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x           | A <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Alternatively, any matrix-like object that can be coerced to a sparse matrix of class "dgCMatrix" can be directly used as input. The matrix will automatically be converted to a <a href="#">SingleCellExperiment</a> object. |
| useAssay    | A string specifying the name of the <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                                                                                                                                                                            |
| altExpName  | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                                                       |
| sampleLabel | Vector or factor. Denotes the sample label for each cell (column) in the count matrix.                                                                                                                                                                                                                                                                                              |
| K           | Integer. Number of cell populations.                                                                                                                                                                                                                                                                                                                                                |
| alpha       | Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Default 1.                                                                                                                                                                                                                                                                   |
| beta        | Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature in each cell population. Default 1.                                                                                                                                                                                                                                                                    |
| algorithm   | String. Algorithm to use for clustering cell subpopulations. One of 'EM' or 'Gibbs'. The EM algorithm is faster, especially for larger numbers of cells. However, more chains may be required to ensure a good solution is found. If 'EM' is selected, then 'stopIter' will be automatically set to 1. Default 'EM'.                                                                |
| stopIter    | Integer. Number of iterations without improvement in the log likelihood to stop inference. Default 10.                                                                                                                                                                                                                                                                              |



|               |                                                                                                                                                                                                                                                                                                                                                           |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| maxIter       | Integer. Maximum number of iterations of Gibbs sampling or EM to perform. Default 200.                                                                                                                                                                                                                                                                    |
| splitOnIter   | Integer. On every 'splitOnIter' iteration, a heuristic will be applied to determine if a cell population should be reassigned and another cell population should be split into two clusters. To disable splitting, set to -1. Default 10.                                                                                                                 |
| splitOnLast   | Integer. After 'stopIter' iterations have been performed without improvement, a heuristic will be applied to determine if a cell population should be reassigned and another cell population should be split into two clusters. If a split occurs, then 'stopIter' will be reset. Default TRUE.                                                           |
| seed          | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                                                                                                                                                            |
| nchains       | Integer. Number of random cluster initializations. Default 3.                                                                                                                                                                                                                                                                                             |
| zInitialize   | Character. One of 'random', 'split', or 'predefined'. With 'random', cells are randomly assigned to a populations. With 'split', cells will be split into sqrt(K) populations and then each population will be subsequently split into another sqrt(K) populations. With 'predefined', values in 'zInit' will be used to initialize 'z'. Default 'split'. |
| countChecksum | Character. An MD5 checksum for the 'counts' matrix. Default NULL.                                                                                                                                                                                                                                                                                         |
| zInit         | Integer vector. Sets initial starting values of z. 'zInit' is only used when 'zInitialize = 'predefined''. Default NULL.                                                                                                                                                                                                                                  |
| logfile       | Character. Messages will be redirected to a file named 'logfile'. If NULL, messages will be printed to stdout. Default NULL.                                                                                                                                                                                                                              |
| verbose       | Logical. Whether to print log messages. Default TRUE.                                                                                                                                                                                                                                                                                                     |

## Value

A [SingleCellExperiment](#) object. Function parameter settings are stored in the [metadata](#) "celda\_parameters" slot. Columns `celda_sample_label` and `celda_cell_cluster` in [colData](#) contain sample labels and celda cell population clusters.

## See Also

[celda\\_G](#) for feature clustering and [celda\\_CG](#) for simultaneous clustering of features and cells. [celdaGridSearch](#) can be used to run multiple values of K and multiple chains in parallel.

## Examples

```
data(celdaCSim)
sce <- celda_C(celdaCSim$counts,
  K = celdaCSim$K,
  sampleLabel = celdaCSim$sampleLabel,
  nchains = 1)
```

celda\_CG

*Cell and feature clustering with Celda***Description**

Clusters the rows and columns of a count matrix containing single-cell data into L modules and K subpopulations, respectively. The useAssay [assay](#) slot in altExpName [altExp](#) slot will be used if it exists. Otherwise, the useAssay [assay](#) slot in x will be used if x is a [SingleCellExperiment](#) object.

**Usage**

```
celda_CG(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  L,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  yInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'SingleCellExperiment'
celda_CG(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  L,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  algorithm = c("EM", "Gibbs"),
```

```

    stopIter = 10,
    maxIter = 200,
    splitOnIter = 10,
    splitOnLast = TRUE,
    seed = 12345,
    nchains = 3,
    zInitialize = c("split", "random", "predefined"),
    yInitialize = c("split", "random", "predefined"),
    countChecksum = NULL,
    zInit = NULL,
    yInit = NULL,
    logfile = NULL,
    verbose = TRUE
)

## S4 method for signature 'ANY'
celda_CG(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  L,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  yInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

```

## Arguments

|            |                                                                                                                                                                                                                                                                                                                                                                                     |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | A <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Alternatively, any matrix-like object that can be coerced to a sparse matrix of class "dgCMatrix" can be directly used as input. The matrix will automatically be converted to a <a href="#">SingleCellExperiment</a> object. |
| useAssay   | A string specifying the name of the <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                                                                                                                                                                            |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                                                       |

|               |                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sampleLabel   | Vector or factor. Denotes the sample label for each cell (column) in the count matrix.                                                                                                                                                                                                                                                                                                 |
| K             | Integer. Number of cell populations.                                                                                                                                                                                                                                                                                                                                                   |
| L             | Integer. Number of feature modules.                                                                                                                                                                                                                                                                                                                                                    |
| alpha         | Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Default 1.                                                                                                                                                                                                                                                                      |
| beta          | Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature module in each cell population. Default 1.                                                                                                                                                                                                                                                                |
| delta         | Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Default 1.                                                                                                                                                                                                                                                                                |
| gamma         | Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Default 1.                                                                                                                                                                                                                                                                      |
| algorithm     | String. Algorithm to use for clustering cell subpopulations. One of 'EM' or 'Gibbs'. The EM algorithm for cell clustering is faster, especially for larger numbers of cells. However, more chains may be required to ensure a good solution is found. Default 'EM'.                                                                                                                    |
| stopIter      | Integer. Number of iterations without improvement in the log likelihood to stop inference. Default 10.                                                                                                                                                                                                                                                                                 |
| maxIter       | Integer. Maximum number of iterations of Gibbs sampling to perform. Default 200.                                                                                                                                                                                                                                                                                                       |
| splitOnIter   | Integer. On every splitOnIter iteration, a heuristic will be applied to determine if a cell population or feature module should be reassigned and another cell population or feature module should be split into two clusters. To disable splitting, set to -1. Default 10.                                                                                                            |
| splitOnLast   | Integer. After stopIter iterations have been performed without improvement, a heuristic will be applied to determine if a cell population or feature module should be reassigned and another cell population or feature module should be split into two clusters. If a split occurs, then 'stopIter' will be reset. Default TRUE.                                                      |
| seed          | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                                                                                                                                                                                         |
| nchains       | Integer. Number of random cluster initializations. Default 3.                                                                                                                                                                                                                                                                                                                          |
| zInitialize   | Character. One of 'random', 'split', or 'predefined'. With 'random', cells are randomly assigned to a populations. With 'split', cells will be split into $\sqrt{K}$ populations and then each population will be subsequently split into another $\sqrt{K}$ populations. With 'predefined', values in <code>zInit</code> will be used to initialize <code>z</code> . Default 'split'. |
| yInitialize   | Character. One of 'random', 'split', or 'predefined'. With 'random', features are randomly assigned to a modules. With 'split', features will be split into $\sqrt{L}$ modules and then each module will be subsequently split into another $\sqrt{L}$ modules. With 'predefined', values in <code>yInit</code> will be used to initialize <code>y</code> . Default 'split'.           |
| countChecksum | Character. An MD5 checksum for the counts matrix. Default NULL.                                                                                                                                                                                                                                                                                                                        |
| zInit         | Integer vector. Sets initial starting values of <code>z</code> . 'zInit' is only used when 'zInitialize = 'predefined''. Default NULL.                                                                                                                                                                                                                                                 |
| yInit         | Integer vector. Sets initial starting values of <code>y</code> . 'yInit' is only be used when 'yInitialize = "predefined"'. Default NULL.                                                                                                                                                                                                                                              |

|         |                                                                                                                              |
|---------|------------------------------------------------------------------------------------------------------------------------------|
| logfile | Character. Messages will be redirected to a file named 'logfile'. If NULL, messages will be printed to stdout. Default NULL. |
| verbose | Logical. Whether to print log messages. Default TRUE.                                                                        |

### Value

A [SingleCellExperiment](#) object. Function parameter settings are stored in [metadata](#) "celda\_parameters" in [altExp](#) slot. In [altExp](#) slot, columns [celda\\_sample\\_label](#) and [celda\\_cell\\_cluster](#) in [colData](#) contain sample labels and celda cell population clusters. Column [celda\\_feature\\_module](#) in [rowData](#) contains feature modules.

### See Also

[celda\\_G](#) for feature clustering and [celda\\_C](#) for clustering cells. [celdaGridSearch](#) can be used to run multiple values of K/L and multiple chains in parallel.

### Examples

```
data(celdaCGSim)
sce <- celda_CG(celdaCGSim$counts,
  K = celdaCGSim$K,
  L = celdaCGSim$L,
  sampleLabel = celdaCGSim$sampleLabel,
  nchains = 1)
```

---

|         |                                      |
|---------|--------------------------------------|
| celda_G | <i>Feature clustering with Celda</i> |
|---------|--------------------------------------|

---

### Description

Clusters the rows of a count matrix containing single-cell data into L modules. The useAssay [assay](#) slot in [altExpName](#) [altExp](#) slot will be used if it exists. Otherwise, the useAssay [assay](#) slot in x will be used if x is a [SingleCellExperiment](#) object.

### Usage

```
celda_G(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  L,
  beta = 1,
  delta = 1,
  gamma = 1,
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
```

```

    yInit = NULL,
    logfile = NULL,
    verbose = TRUE
)

## S4 method for signature 'SingleCellExperiment'
celda_G(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  L,
  beta = 1,
  delta = 1,
  gamma = 1,
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  yInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'ANY'
celda_G(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  L,
  beta = 1,
  delta = 1,
  gamma = 1,
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  yInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

```

## Arguments

**x** A [SingleCellExperiment](#) with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Alternatively, any matrix-

like object that can be coerced to a sparse matrix of class "dgCMatrix" can be directly used as input. The matrix will automatically be converted to a [SingleCellExperiment](#) object.

|               |                                                                                                                                                                                                                                                                                                                                                 |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| useAssay      | A string specifying the name of the <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                                                                                                                                        |
| altExpName    | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                   |
| L             | Integer. Number of feature modules.                                                                                                                                                                                                                                                                                                             |
| beta          | Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature module in each cell. Default 1.                                                                                                                                                                                                                                    |
| delta         | Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Default 1.                                                                                                                                                                                                                                         |
| gamma         | Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Default 1.                                                                                                                                                                                                                               |
| stopIter      | Integer. Number of iterations without improvement in the log likelihood to stop inference. Default 10.                                                                                                                                                                                                                                          |
| maxIter       | Integer. Maximum number of iterations of Gibbs sampling to perform. Default 200.                                                                                                                                                                                                                                                                |
| splitOnIter   | Integer. On every 'splitOnIter' iteration, a heuristic will be applied to determine if a feature module should be reassigned and another feature module should be split into two clusters. To disable splitting, set to -1. Default 10.                                                                                                         |
| splitOnLast   | Integer. After 'stopIter' iterations have been performed without improvement, a heuristic will be applied to determine if a cell population should be reassigned and another cell population should be split into two clusters. If a split occurs, then 'stopIter' will be reset. Default TRUE.                                                 |
| seed          | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                                                                                                                                                  |
| nchains       | Integer. Number of random cluster initializations. Default 3.                                                                                                                                                                                                                                                                                   |
| yInitialize   | Character. One of 'random', 'split', or 'predefined'. With 'random', features are randomly assigned to a modules. With 'split', features will be split into sqrt(L) modules and then each module will be subsequently split into another sqrt(L) modules. With 'predefined', values in 'yInit' will be used to initialize 'y'. Default 'split'. |
| countChecksum | Character. An MD5 checksum for the 'counts' matrix. Default NULL.                                                                                                                                                                                                                                                                               |
| yInit         | Integer vector. Sets initial starting values of y. 'yInit' can only be used when 'yInitialize = 'predefined''. Default NULL.                                                                                                                                                                                                                    |
| logfile       | Character. Messages will be redirected to a file named logfile. If NULL, messages will be printed to stdout. Default NULL.                                                                                                                                                                                                                      |
| verbose       | Logical. Whether to print log messages. Default TRUE.                                                                                                                                                                                                                                                                                           |

### Value

A [SingleCellExperiment](#) object. Function parameter settings are stored in the [metadata](#) "celda\_parameters" slot. Column celda\_feature\_module in [rowData](#) contains feature modules.

### See Also

[celda\\_C](#) for cell clustering and [celda\\_CG](#) for simultaneous clustering of features and cells. [celda-GridSearch](#) can be used to run multiple values of L and multiple chains in parallel.

**Examples**

```
data(celdaGSim)
sce <- celda_G(celdaGSim$counts, L = celdaGSim$L, nchains = 1)
```

---

|                    |                                                                                     |
|--------------------|-------------------------------------------------------------------------------------|
| clusterProbability | <i>Get the conditional probabilities of cell in subpopulations from celda model</i> |
|--------------------|-------------------------------------------------------------------------------------|

---

**Description**

Calculate the conditional probability of each cell belonging to each subpopulation given all other cell cluster assignments and/or each feature belonging to each module given all other feature cluster assignments in a celda model.

**Usage**

```
clusterProbability(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  log = FALSE
)

## S4 method for signature 'SingleCellExperiment'
clusterProbability(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  log = FALSE
)
```

**Arguments**

|            |                                                                                                                                                                                                                                                      |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sce        | A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a> , <a href="#">celda_G</a> , or <a href="#">celda_CG</a> , with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells. |
| useAssay   | A string specifying which <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                                                       |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                        |
| log        | Logical. If FALSE, then the normalized conditional probabilities will be returned. If TRUE, then the unnormalized log probabilities will be returned. Default FALSE.                                                                                 |

**Value**

A list containing a matrix for the conditional cell subpopulation cluster and/or feature module probabilities.

**See Also**

'[celda\\_C\(\)](#)' for clustering cells



**Examples**

```
data(sceCeldaCG)
clusterProb <- clusterProbability(sceCeldaCG, log = TRUE)
data(sceCeldaC)
clusterProb <- clusterProbability(sceCeldaC)
```

---

|                    |                                       |
|--------------------|---------------------------------------|
| compareCountMatrix | <i>Check count matrix consistency</i> |
|--------------------|---------------------------------------|

---

**Description**

Checks if the counts matrix is the same one used to generate the celda model object by comparing dimensions and MD5 checksum.

**Usage**

```
compareCountMatrix(counts, celdaMod, errorOnMismatch = TRUE)

## S4 method for signature 'ANY,celdaModel'
compareCountMatrix(counts, celdaMod, errorOnMismatch = TRUE)

## S4 method for signature 'ANY,celdaList'
compareCountMatrix(counts, celdaMod, errorOnMismatch = TRUE)
```

**Arguments**

|                 |                                                                                           |
|-----------------|-------------------------------------------------------------------------------------------|
| counts          | Integer , Numeric, or Sparse matrix. Rows represent features and columns represent cells. |
| celdaMod        | A celdaModel or celdaList object.                                                         |
| errorOnMismatch | Logical. Whether to throw an error in the event of a mismatch. Default TRUE.              |

**Value**

Returns TRUE if provided count matrix matches the one used in the celda object and/or errorOnMismatch = FALSE, FALSE otherwise.

**Examples**

```
data(celdaCGSim, celdaCGMod)
compareCountMatrix(celdaCGSim$counts, celdaCGMod, errorOnMismatch = FALSE)
data(celdaCGSim, celdaCGGridSearchRes)
compareCountMatrix(celdaCGSim$counts, celdaCGGridSearchRes,
  errorOnMismatch = FALSE)
```

---

|                  |                         |
|------------------|-------------------------|
| contaminationSim | <i>contaminationSim</i> |
|------------------|-------------------------|

---

**Description**

A toy contamination data generated by [simulateContamination](#)

**Usage**

```
contaminationSim
```

**Format**

A list

---

|               |                                                                |
|---------------|----------------------------------------------------------------|
| countChecksum | <i>Get the MD5 hash of the count matrix from the celdaList</i> |
|---------------|----------------------------------------------------------------|

---

**Description**

Returns the MD5 hash of the count matrix used to generate the celdaList.

**Usage**

```
countChecksum(celdaList)
```

**Arguments**

|           |                               |
|-----------|-------------------------------|
| celdaList | An object of class celdaList. |
|-----------|-------------------------------|

**Value**

A character string of length 32 containing the MD5 digest of the count matrix.

**Examples**

```
data(celdaCGGridSearchRes)
countChecksum <- countChecksum(celdaCGGridSearchRes)
```

---

countChecksum,celdaList-method

*Get the MD5 hash of the count matrix from the celdaList*


---

### Description

Returns the MD5 hash of the count matrix used to generate the celdaList.

### Usage

```
## S4 method for signature 'celdaList'
countChecksum(celdaList)
```

### Arguments

celdaList      An object of class celdaList.

### Value

A character string of length 32 containing the MD5 digest of the count matrix.

### Examples

```
data(celdaCGGridSearchRes)
countChecksum <- countChecksum(celdaCGGridSearchRes)
```

---

decontX

*Contamination estimation with decontX*


---

### Description

Identifies contamination from factors such as ambient RNA in single cell genomic datasets.

### Usage

```
decontX(x, ...)

## S4 method for signature 'SingleCellExperiment'
decontX(
  x,
  assayName = "counts",
  z = NULL,
  batch = NULL,
  background = NULL,
  bgAssayName = NULL,
  bgBatch = NULL,
  maxIter = 500,
  delta = c(10, 10),
  estimateDelta = TRUE,
  convergence = 0.001,
```

```

    iterLogLik = 10,
    varGenes = 5000,
    dbscanEps = 1,
    seed = 12345,
    logfile = NULL,
    verbose = TRUE
)

## S4 method for signature 'ANY'
decontX(
  x,
  z = NULL,
  batch = NULL,
  background = NULL,
  bgBatch = NULL,
  maxIter = 500,
  delta = c(10, 10),
  estimateDelta = TRUE,
  convergence = 0.001,
  iterLogLik = 10,
  varGenes = 5000,
  dbscanEps = 1,
  seed = 12345,
  logfile = NULL,
  verbose = TRUE
)

```

### Arguments

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>           | A numeric matrix of counts or a <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under <code>assayName</code> . Cells in each batch will be subsetting and converted to a sparse matrix of class <code>dgCMatrix</code> from package <a href="#">Matrix</a> before analysis. This object should only contain filtered cells after cell calling. Empty cell barcodes (low expression droplets before cell calling) are not needed to run <code>DecontX</code> . |
| <code>...</code>         | For the generic, further arguments to pass to each method.                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <code>assayName</code>   | Character. Name of the assay to use if <code>x</code> is a <a href="#">SingleCellExperiment</a> .                                                                                                                                                                                                                                                                                                                                                                                            |
| <code>z</code>           | Numeric or character vector. Cell cluster labels. If <code>NULL</code> , PCA will be used to reduce the dimensionality of the dataset initially, <a href="#">'umap'</a> from the <a href="#">'uwot'</a> package will be used to further reduce the dataset to 2 dimensions and the <a href="#">'dbscan'</a> function from the <a href="#">'dbscan'</a> package will be used to identify clusters of broad cell types. Default <code>NULL</code> .                                            |
| <code>batch</code>       | Numeric or character vector. Batch labels for cells. If batch labels are supplied, <code>DecontX</code> is run on cells from each batch separately. Cells run in different channels or assays should be considered different batches. Default <code>NULL</code> .                                                                                                                                                                                                                            |
| <code>background</code>  | A numeric matrix of counts or a <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under <code>assayName</code> . It should have the same data format as <code>x</code> except it contains the empty droplets instead of cells. When supplied, empirical distribution of transcripts from these empty droplets will be used as the contamination distribution. Default <code>NULL</code> .                                                                       |
| <code>bgAssayName</code> | Character. Name of the assay to use if <code>background</code> is a <a href="#">SingleCellExperiment</a> . Default to same as <code>assayName</code> .                                                                                                                                                                                                                                                                                                                                       |

|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| bgBatch       | Numeric or character vector. Batch labels for background. Its unique values should be the same as those in batch, such that each batch of cells have their corresponding batch of empty droplets as background, pointed by this parameter. Default to NULL.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| maxIter       | Integer. Maximum iterations of the EM algorithm. Default 500.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| delta         | Numeric Vector of length 2. Concentration parameters for the Dirichlet prior for the contamination in each cell. The first element is the prior for the native counts while the second element is the prior for the contamination counts. These essentially act as pseudocounts for the native and contamination in each cell. If <code>estimateDelta = TRUE</code> , this is only used to produce a random sample of proportions for an initial value of contamination in each cell. Then <code>fit_dirichlet</code> is used to update delta in each iteration. If <code>estimateDelta = FALSE</code> , then delta is fixed with these values for the entire inference procedure. Fixing delta and setting a high number in the second element will force decontX to be more aggressive and estimate higher levels of contamination at the expense of potentially removing native expression. Default <code>c(10, 10)</code> . |
| estimateDelta | Boolean. Whether to update delta at each iteration.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| convergence   | Numeric. The EM algorithm will be stopped if the maximum difference in the contamination estimates between the previous and current iterations is less than this. Default 0.001.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| iterLogLik    | Integer. Calculate log likelihood every iterLogLik iteration. Default 10.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| varGenes      | Integer. The number of variable genes to use in dimensionality reduction before clustering. Variability is calculated using <code>modelGeneVar</code> function from the 'scrn' package. Used only when z is not provided. Default 5000.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| dbscanEps     | Numeric. The clustering resolution parameter used in 'dbscan' to estimate broad cell clusters. Used only when z is not provided. Default 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| seed          | Integer. Passed to <code>with_seed</code> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <code>with_seed</code> are made.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| logfile       | Character. Messages will be redirected to a file named 'logfile'. If NULL, messages will be printed to stdout. Default NULL.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| verbose       | Logical. Whether to print log messages. Default TRUE.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

## Value

If x is a matrix-like object, a list will be returned with the following items:

**decontXcounts:** The decontaminated matrix. Values obtained from the variational inference procedure may be non-integer. However, integer counts can be obtained by rounding, e.g. `round(decontXcounts)`.

**contamination:** Percentage of contamination in each cell.

**estimates:** List of estimated parameters for each batch. If z was not supplied, then the UMAP coordinates used to generated cell cluster labels will also be stored here.

**z:** Cell population/cluster labels used for analysis.

**runParams:** List of arguments used in the function call.

If x is a [SingleCellExperiment](#), then the decontaminated counts will be stored as an assay and can be accessed with `decontXcounts(x)`. The contamination values and cluster labels will be stored in `colData(x)`. estimates and runParams will be stored in `metadata(x)$decontX`. The UMAPs used to generated cell cluster labels will be stored in `reducedDims` slot in x.

**Author(s)**

Shiyi Yang, Yuan Yin, Joshua Campbell

**Examples**

```
# Generate matrix with contamination
s <- simulateContamination(seed = 12345)

library(SingleCellExperiment)
sce <- SingleCellExperiment(list(counts = s$observedCounts))
sce <- decontX(sce)

# Plot contamination on UMAP
plotDecontXContamination(sce)

# Plot decontX cluster labels
umap <- reducedDim(sce)
plotDimReduceCluster(x = sce$decontX_clusters,
  dim1 = umap[, 1], dim2 = umap[, 2], )

# Plot percentage of marker genes detected
# in each cell cluster before decontamination
s$markers
plotDecontXMarkerPercentage(sce, markers = s$markers, assayName = "counts")

# Plot percentage of marker genes detected
# in each cell cluster after contamination
plotDecontXMarkerPercentage(sce, markers = s$markers,
  assayName = "decontXcounts")

# Plot percentage of marker genes detected in each cell
# comparing original and decontaminated counts side-by-side
plotDecontXMarkerPercentage(sce, markers = s$markers,
  assayName = c("counts", "decontXcounts"))

# Plot raw counts of individual markers genes before
# and after decontamination
plotDecontXMarkerExpression(sce, unlist(s$markers))
```

---

decontXcounts

*Get or set decontaminated counts matrix*


---

**Description**

Gets or sets the decontaminated counts matrix from a [SingleCellExperiment](#) object.

**Usage**

```
decontXcounts(object, ...)

decontXcounts(object, ...) <- value

## S4 method for signature 'SingleCellExperiment'
decontXcounts(object, ...)
```

```
## S4 replacement method for signature 'SingleCellExperiment'
decontXcounts(object, ...) <- value
```

### Arguments

|        |                                                            |
|--------|------------------------------------------------------------|
| object | A <a href="#">SingleCellExperiment</a> object.             |
| ...    | For the generic, further arguments to pass to each method. |
| value  | A matrix to save as an assay called decontXcounts          |

### Value

If getting, the assay from object with the name decontXcounts will be returned. If setting, a [SingleCellExperiment](#) object will be returned with decontXcounts listed in the assay slot.

### See Also

[assay](#) and [assay<-](#)

---

|                |                               |
|----------------|-------------------------------|
| distinctColors | <i>Create a color palette</i> |
|----------------|-------------------------------|

---

### Description

Generate a palette of 'n' distinct colors.

### Usage

```
distinctColors(
  n,
  hues = c("red", "cyan", "orange", "blue", "yellow", "purple", "green", "magenta"),
  saturationRange = c(0.7, 1),
  valueRange = c(0.7, 1)
)
```

### Arguments

|                 |                                                                                                                                                                                                                                                                                  |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| n               | Integer. Number of colors to generate.                                                                                                                                                                                                                                           |
| hues            | Character vector. Colors available from 'colors()'. These will be used as the base colors for the clustering scheme in HSV. Different saturations and values will be generated for each hue. Default c("red", "cyan", "orange", "blue", "yellow", "purple", "green", "magenta"). |
| saturationRange | Numeric vector. A vector of length 2 denoting the saturation for HSV. Values must be in [0,1]. Default: c(0.25, 1).                                                                                                                                                              |
| valueRange      | Numeric vector. A vector of length 2 denoting the range of values for HSV. Values must be in [0,1]. Default: 'c(0.5, 1)'.                                                                                                                                                        |

### Value

A vector of distinct colors that have been converted to HEX from HSV.

**Examples**

```
colorPal <- distinctColors(6) # can be used in plotting functions
```

---

|                 |                                                    |
|-----------------|----------------------------------------------------|
| eigenMatMultInt | <i>Fast matrix multiplication for double x int</i> |
|-----------------|----------------------------------------------------|

---

**Description**

Fast matrix multiplication for double x int

**Usage**

```
eigenMatMultInt(A, B)
```

**Arguments**

|   |                   |
|---|-------------------|
| A | a double matrix   |
| B | an integer matrix |

**Value**

An integer matrix representing the product of A and B

---

|                     |                                                       |
|---------------------|-------------------------------------------------------|
| eigenMatMultNumeric | <i>Fast matrix multiplication for double x double</i> |
|---------------------|-------------------------------------------------------|

---

**Description**

Fast matrix multiplication for double x double

**Usage**

```
eigenMatMultNumeric(A, B)
```

**Arguments**

|   |                   |
|---|-------------------|
| A | a double matrix   |
| B | an integer matrix |

**Value**

An integer matrix representing the product of A and B



---

|                 |                                                                                                |
|-----------------|------------------------------------------------------------------------------------------------|
| factorizeMatrix | <i>Generate factorized matrices showing each feature's influence on cell / gene clustering</i> |
|-----------------|------------------------------------------------------------------------------------------------|

---

## Description

Generates factorized matrices showing the contribution of each feature in each cell population or each cell population in each sample.

## Usage

```
factorizeMatrix(
  x,
  celdaMod,
  useAssay = "counts",
  altExpName = "featureSubset",
  type = c("counts", "proportion", "posterior")
)

## S4 method for signature 'SingleCellExperiment,ANY'
factorizeMatrix(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  type = c("counts", "proportion", "posterior")
)

## S4 method for signature 'ANY,celda_CG'
factorizeMatrix(x, celdaMod, type = c("counts", "proportion", "posterior"))

## S4 method for signature 'ANY,celda_C'
factorizeMatrix(x, celdaMod, type = c("counts", "proportion", "posterior"))

## S4 method for signature 'ANY,celda_G'
factorizeMatrix(x, celdaMod, type = c("counts", "proportion", "posterior"))
```

## Arguments

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | Can be one of <ul style="list-style-type: none"> <li>A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a>, <a href="#">celda_G</a> or <a href="#">celda_CG</a>, with the matrix located in the useAssay assay slot in altExp(x, altExpName). Rows represent features and columns represent cells.</li> <li>Integer counts matrix. Rows represent features and columns represent cells. This matrix should be the same as the one used to generate celdaMod.</li> </ul> |
| celdaMod   | Celda model object. Only works if x is an integer counts matrix.                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| useAssay   | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                                                                                                                                                                                                                                                                                                                |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                                                                                                                                                                       |

**type** Character vector. A vector containing one or more of "counts", "proportion", or "posterior". "counts" returns the raw number of counts for each factorized matrix. "proportions" returns the normalized probabilities for each factorized matrix, which are calculated by dividing the raw counts in each factorized matrix by the total counts in each column. "posterior" returns the posterior estimates which include the addition of the Dirichlet concentration parameter (essentially as a pseudocount). Default "counts".

### Value

For `celda_CG` model, A list with elements for "counts", "proportions", or "posterior" probabilities. Each element will be a list containing factorized matrices for "module", "cellPopulation", and "sample". Additionally, the contribution of each module in each individual cell will be included in the "cell" element of "counts" and "proportions" elements.

For `celda_C` model, a list with elements for "counts", "proportions", or "posterior" probabilities. Each element will be a list containing factorized matrices for "module" and "sample".

For `celda_G` model, a list with elements for "counts", "proportions", or "posterior" probabilities. Each element will be a list containing factorized matrices for "module" and "cell".

### Examples

```
data(sceCeldaCG)
factorizedMatrices <- factorizeMatrix(sceCeldaCG, type = "posterior")
data(celdaCGSim, celdaCGMod)
factorizedMatrices <- factorizeMatrix(
  celdaCGSim$counts,
  celdaCGMod,
  "posterior")
data(celdaCSim, celdaCMod)
factorizedMatrices <- factorizeMatrix(
  celdaCSim$counts,
  celdaCMod, "posterior"
)
data(celdaGSim, celdaGMod)
factorizedMatrices <- factorizeMatrix(
  celdaGSim$counts,
  celdaGMod, "posterior"
)
```

---

fastNormProp

*Fast normalization for numeric matrix*


---

### Description

Fast normalization for numeric matrix

### Usage

```
fastNormProp(R_counts, R_alpha)
```

**Arguments**

|          |                                                           |
|----------|-----------------------------------------------------------|
| R_counts | An integer matrix                                         |
| R_alpha  | A double value to be added to the matrix as a pseudocount |

**Value**

A numeric matrix where the columns have been normalized to proportions

---

|                 |                                              |
|-----------------|----------------------------------------------|
| fastNormPropLog | <i>Fast normalization for numeric matrix</i> |
|-----------------|----------------------------------------------|

---

**Description**

Fast normalization for numeric matrix

**Usage**

```
fastNormPropLog(R_counts, R_alpha)
```

**Arguments**

|          |                                                           |
|----------|-----------------------------------------------------------|
| R_counts | An integer matrix                                         |
| R_alpha  | A double value to be added to the matrix as a pseudocount |

**Value**

A numeric matrix where the columns have been normalized to proportions

---

|                  |                                              |
|------------------|----------------------------------------------|
| fastNormPropSqrt | <i>Fast normalization for numeric matrix</i> |
|------------------|----------------------------------------------|

---

**Description**

Fast normalization for numeric matrix

**Usage**

```
fastNormPropSqrt(R_counts, R_alpha)
```

**Arguments**

|          |                                                           |
|----------|-----------------------------------------------------------|
| R_counts | An integer matrix                                         |
| R_alpha  | A double value to be added to the matrix as a pseudocount |

**Value**

A numeric matrix where the columns have been normalized to proportions

---

featureModuleLookup      *Obtain the gene module of a gene of interest*

---

## Description

This function will output the corresponding feature module for a specified vector of genes from a `celda_CG` or `celda_G` `celdaModel`. Features must match the rownames of `sce`.

## Usage

```
featureModuleLookup(
  sce,
  features,
  altExpName = "featureSubset",
  exactMatch = TRUE,
  by = "rownames"
)

## S4 method for signature 'SingleCellExperiment'
featureModuleLookup(
  sce,
  features,
  altExpName = "featureSubset",
  exactMatch = TRUE,
  by = "rownames"
)
```

## Arguments

|                         |                                                                                                                                                                                                                                                                                    |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>sce</code>        | A <a href="#">SingleCellExperiment</a> object returned by <code>celda_G</code> , or <code>celda_CG</code> , with the matrix located in the <code>useAssay</code> assay slot. Rows represent features and columns represent cells.                                                  |
| <code>features</code>   | Character vector. Identify feature modules for the specified feature names. Feature must match the rownames of <code>sce</code> .                                                                                                                                                  |
| <code>altExpName</code> | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                      |
| <code>exactMatch</code> | Logical. Whether to look for exactMatch of the gene name within counts matrix. Default TRUE.                                                                                                                                                                                       |
| <code>by</code>         | Character. Where to search for features in the <code>sce</code> object. If set to "rownames" then the features will be searched for among <code>rownames(sce)</code> . This can also be set to one of the <code>colnames</code> of <code>rowData(sce)</code> . Default "rownames". |

## Value

Numeric vector containing the module numbers for each feature. If the feature was not found, then an NA value will be returned in that position. If no features were found, then an error will be given.

## Examples

```
data(sceCeldaCG)
module <- featureModuleLookup(sce = sceCeldaCG,
  features = c("Gene_1", "Gene_XXX"))
```

---

|                    |                                      |
|--------------------|--------------------------------------|
| featureModuleTable | <i>Output a feature module table</i> |
|--------------------|--------------------------------------|

---

### Description

Creates a table that contains the list of features in each feature module.

### Usage

```
featureModuleTable(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  displayName = NULL,
  outputFile = NULL
)
```

### Arguments

|             |                                                                                                                                                                                                                            |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sce         | A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_G</a> , or <a href="#">celda_CG</a> , with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells. |
| useAssay    | A string specifying which <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                             |
| altExpName  | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                              |
| displayName | Character. The column name of rowData(sce) that specifies the display names for the features. Default NULL, which displays the row names.                                                                                  |
| outputFile  | File name for feature module table. If NULL, file will not be created. Default NULL.                                                                                                                                       |

### Value

Matrix. Contains a list of features per each column (feature module)

### Examples

```
data(sceCeldaCG)
featureModuleTable(sceCeldaCG)
```

---

|                 |                                                                         |
|-----------------|-------------------------------------------------------------------------|
| findMarkersTree | <i>Generate marker decision tree from single-cell clustering output</i> |
|-----------------|-------------------------------------------------------------------------|

---

### Description

Create a decision tree that identifies gene markers for given cell populations. The algorithm uses a decision tree procedure to generate a set of rules for each cell cluster defined by single-cell clustering. Splits are determined by one of two metrics at each split: a one-off metric to determine rules for identifying clusters by a single feature, and a balanced metric to determine rules for identifying sets of similar clusters.

**Usage**

```
findMarkersTree(
  features,
  class,
  oneoffMetric = c("modified F1", "pairwise AUC"),
  metaclusters,
  featureLabels,
  counts,
  celda,
  seurat,
  threshold = 0.9,
  reuseFeatures = FALSE,
  altSplit = TRUE,
  consecutiveOneoff = FALSE,
  autoMetaclusters = TRUE,
  seed = 12345
)
```

**Arguments**

|                   |                                                                                                                                                                                                                                                                              |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| features          | features-by-samples numeric matrix, e.g. counts matrix.                                                                                                                                                                                                                      |
| class             | Vector of cell cluster labels.                                                                                                                                                                                                                                               |
| oneoffMetric      | A character string. What one-off metric to run, either ‘modified F1’ or ‘pairwise AUC’. Default is ‘modified F1’.                                                                                                                                                            |
| metaclusters      | List where each element is a metacluster (e.g. known cell type) and all the clusters within that metacluster (e.g. subtypes).                                                                                                                                                |
| featureLabels     | Vector of feature assignments, e.g. which cluster does each gene belong to? Useful when using clusters of features (e.g. gene modules or Seurat PCs) and user wishes to expand tree results to individual features (e.g. score individual genes within marker gene modules). |
| counts            | Numeric counts matrix. Useful when using clusters of features (e.g. gene modules) and user wishes to expand tree results to individual features (e.g. score individual genes within marker gene modules). Row names should be individual feature names.                      |
| celda             | A <i>celda_CG</i> or <i>celda_C</i> object. Counts matrix has to be provided as well.                                                                                                                                                                                        |
| seurat            | A seurat object. Note that the seurat functions <i>RunPCA</i> and <i>FindClusters</i> must have been run on the object.                                                                                                                                                      |
| threshold         | Numeric between 0 and 1. The threshold for the oneoff metric. Smaller values will result in more one-off splits. Default is 0.90.                                                                                                                                            |
| reuseFeatures     | Logical. Whether or not a feature can be used more than once on the same cluster. Default is TRUE.                                                                                                                                                                           |
| altSplit          | Logical. Whether or not to force a marker for clusters that are solely defined by the absence of markers. Default is TRUE.                                                                                                                                                   |
| consecutiveOneoff | Logical. Whether or not to allow one-off splits at consecutive branches. Default is FALSE.                                                                                                                                                                                   |
| autoMetaclusters  | Logical. Whether to identify metaclusters prior to creating the tree based on the distance between clusters in a UMAP dimensionality reduction projection.                                                                                                                   |

|      |                                                                                                         |
|------|---------------------------------------------------------------------------------------------------------|
|      | A metacluster is simply a large cluster that includes several clusters within it. Default is TRUE.      |
| seed | Numeric. Seed used to enable reproducible UMAP results for identifying meta-clusters. Default is 12345. |

## Value

A named list with six elements:

- rules - A named list with one data frame for every label. Each data frame has five columns and gives the set of rules for distinguishing each label.
  - feature - Marker feature, e.g. marker gene name.
  - direction - Relationship to feature value. -1 if cluster is down-regulated for this feature, 1 if cluster is up-regulated.
  - stat - The performance value returned by the splitting metric for this split.
  - statUsed - Which performance metric was used. "Split" if information gain and "One-off" if one-off.
  - level - The level of the tree at which is rule was defined. 1 is the level of the first split of the tree.
  - metacluster - Optional. If metaclusters were used, the metacluster this rule is applied to.
- dendro - A dendrogram object of the decision tree output. Plot with plotDendro()
- classLabels - A vector of the class labels used in the model, i.e. cell cluster labels.
- metaclusterLabels - A vector of the metacluster labels used in the model
- prediction - A character vector of label of predictions of the training data using the final model. "MISSING" if label prediction was ambiguous.
- performance - A named list denoting the training performance of the model:
  - accuracy - (number correct/number of samples) for the whole set of samples.
  - balAcc - mean sensitivity across all clusters
  - meanPrecision - mean precision across all clusters
  - correct - the number of correct predictions of each cluster
  - sizes - the number of actual counts of each cluster
  - sensitivity - the sensitivity of the prediciton of each cluster
  - precision - the precision of the prediciton of each cluster

## Examples

```
# Generate simulated single-cell dataset using celda
sce <- celda::simulateCells("celda_CG", K = 4, L = 10, G = 100)

# Select top features
sce <- selectFeatures(sce)

# Celda clustering into 5 clusters & 10 modules
sce <- celda_CG(sce, K=5, L=10, verbose=FALSE)

# Get features matrix and cluster assignments
factorizedCounts <- factorizeMatrix(sce, type = "counts")
featureMatrix <- factorizedCounts$counts$cell
classes <- as.integer(celdaClusters(sce))
```

```
# Generate Decision Tree
DecTree <- findMarkersTree(featureMatrix, classes)

# Plot dendrogram
plotDendro(DecTree)
```

---

geneSetEnrich

*Gene set enrichment*


---

## Description

Identify and return significantly-enriched terms for each gene module in a Celda object or a [SingleCellExperiment](#) object. Performs gene set enrichment analysis for Celda identified modules using the [enrichr](#).

## Usage

```
geneSetEnrich(
  x,
  celdaModel,
  useAssay = "counts",
  altExpName = "featureSubset",
  databases,
  fdr = 0.05
)

## S4 method for signature 'SingleCellExperiment'
geneSetEnrich(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  databases,
  fdr = 0.05
)

## S4 method for signature 'matrix'
geneSetEnrich(x, celdaModel, databases, fdr = 0.05)
```

## Arguments

|            |                                                                                                                                                                                                                                                                                                 |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | A numeric <a href="#">matrix</a> of counts or a <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Rownames of the matrix or <a href="#">SingleCellExperiment</a> object should be gene names. |
| celdaModel | Celda object of class celda_G or celda_CG.                                                                                                                                                                                                                                                      |
| useAssay   | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                                                                                                            |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                   |
| databases  | Character vector. Name of reference database. Available databases can be viewed by <a href="#">listEnrichrDbs</a> .                                                                                                                                                                             |



**fdr** False discovery rate (FDR). Numeric. Cutoff value for adjusted p-value, terms with FDR below this value are considered significantly enriched.

### Value

List of length 'L' where each member contains the significantly enriched terms for the corresponding module.

### Author(s)

Ahmed Youssef, Zhe Wang

### Examples

```
library(M3DExampleData)
counts <- M3DExampleData::Mmus_example_list$data
# subset 500 genes for fast clustering
counts <- counts[seq(1501, 2000), ]
# cluster genes into 10 modules for quick demo
sce <- celda_G(x = as.matrix(counts), L = 10, verbose = FALSE)
gse <- geneSetEnrich(sce,
  databases = c("GO_Biological_Process_2018", "GO_Molecular_Function_2018"))
```

---

|              |                                                                                 |
|--------------|---------------------------------------------------------------------------------|
| getDecisions | <i>Gets cluster estimates using rules generated by 'celda::findMarkersTree'</i> |
|--------------|---------------------------------------------------------------------------------|

---

### Description

Get decisions for a matrix of features. Estimate cell cluster membership using feature matrix input.

### Usage

```
getDecisions(rules, features)
```

### Arguments

|                 |                                                                                                                 |
|-----------------|-----------------------------------------------------------------------------------------------------------------|
| <b>rules</b>    | List object. The 'rules' element from 'findMarkersTree' output. Returns NA if cluster estimation was ambiguous. |
| <b>features</b> | A L(features) by N(samples) numeric matrix.                                                                     |

### Value

A character vector of label predictions.

logLikelihood

*Calculate the Log-likelihood of a celda model***Description**

Calculate the log-likelihood for cell population and feature module cluster assignments on the count matrix, per celda model.

**Usage**

```
logLikelihood(x, celdaMod, useAssay = "counts", altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment,ANY'
logLikelihood(x, useAssay = "counts", altExpName = "featureSubset")

## S4 method for signature 'matrix,celda_C'
logLikelihood(x, celdaMod)

## S4 method for signature 'matrix,celda_G'
logLikelihood(x, celdaMod)

## S4 method for signature 'matrix,celda_CG'
logLikelihood(x, celdaMod)
```

**Arguments**

|            |                                                                                                                                                                                                                                                      |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a> , <a href="#">celda_G</a> , or <a href="#">celda_CG</a> , with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells. |
| celdaMod   | celda model object. Ignored if x is a <a href="#">SingleCellExperiment</a> object.                                                                                                                                                                   |
| useAssay   | A string specifying which <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                                                       |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                        |

**Value**

The log-likelihood of the cluster assignment for the provided [SingleCellExperiment](#).

**See Also**

'[celda\\_C\(\)](#)' for clustering cells

**Examples**

```
data(sceCeldaC, sceCeldaCG)
loglikC <- logLikelihood(sceCeldaC)
loglikCG <- logLikelihood(sceCeldaCG)
```

---

|                      |                                   |
|----------------------|-----------------------------------|
| logLikelihoodHistory | <i>Get log-likelihood history</i> |
|----------------------|-----------------------------------|

---

**Description**

Retrieves the complete log-likelihood from all iterations of Gibbs sampling used to generate a celda model.

**Usage**

```
logLikelihoodHistory(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
logLikelihoodHistory(x, altExpName = "featureSubset")

## S4 method for signature 'celdaModel'
logLikelihoodHistory(x)
```

**Arguments**

|            |                                                                                                                                                                      |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a> , <a href="#">celda_G</a> , or <a href="#">celda_CG</a> , or a celda model object. |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                        |

**Value**

Numeric. The log-likelihood at each step of Gibbs sampling used to generate the model.

**Examples**

```
data(sceCeldaCG)
logLikelihoodHistory(sceCeldaCG)
data(celdaCGMod)
logLikelihoodHistory(celdaCGMod)
```

---

|             |                                                             |
|-------------|-------------------------------------------------------------|
| matrixNames | <i>Get feature, cell and sample names from a celdaModel</i> |
|-------------|-------------------------------------------------------------|

---

**Description**

Retrieves the row, column, and sample names used to generate a celdaModel.

**Usage**

```
matrixNames(celdaMod)

## S4 method for signature 'celdaModel'
matrixNames(celdaMod)
```

**Arguments**

celdaMod                      celdaModel. Options available in ‘celda::availableModels’.

**Value**

List. Contains row, column, and sample character vectors corresponding to the values provided when the celdaModel was generated.

**Examples**

```
data(celdaCGMod)
matrixNames(celdaCGMod)
```

---

|               |                                   |
|---------------|-----------------------------------|
| moduleHeatmap | <i>Heatmap for featureModules</i> |
|---------------|-----------------------------------|

---

**Description**

Renders a heatmap for selected featureModule. Cells are ordered from those with the lowest probability of the module on the left to the highest probability on the right. Features are ordered from those with the highest probability in the module on the top to the lowest probability on the bottom.

**Usage**

```
moduleHeatmap(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  modules = NULL,
  featureModule = NULL,
  col = circlize::colorRamp2(c(-2, 0, 2), c("#1E90FF", "#FFFFFF", "#CD2626")),
  topCells = 100,
  topFeatures = NULL,
  normalizedCounts = NA,
  normalize = "proportion",
  transformationFun = sqrt,
  scaleRow = scale,
  showFeatureNames = TRUE,
  displayName = NULL,
  trim = c(-2, 2),
  rowFontSize = NULL,
  showHeatmapLegend = FALSE,
  showTopAnnotationLegend = FALSE,
  showTopAnnotationName = FALSE,
  topAnnotationHeight = 5,
  showModuleLabel = TRUE,
  moduleLabel = "auto",
  moduleLabelSize = NULL,
  byrow = TRUE,
  top = NA,
```

```

    unit = "mm",
    ncol = NULL,
    useRaster = TRUE,
    returnAsList = FALSE,
    ...
)

## S4 method for signature 'SingleCellExperiment'
moduleHeatmap(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  modules = NULL,
  featureModule = NULL,
  col = circlize::colorRamp2(c(-2, 0, 2), c("#1E90FF", "#FFFFFF", "#CD2626")),
  topCells = 100,
  topFeatures = NULL,
  normalizedCounts = NA,
  normalize = "proportion",
  transformationFun = sqrt,
  scaleRow = scale,
  showFeatureNames = TRUE,
  displayName = NULL,
  trim = c(-2, 2),
  rowFontSize = NULL,
  showHeatmapLegend = FALSE,
  showTopAnnotationLegend = FALSE,
  showTopAnnotationName = FALSE,
  topAnnotationHeight = 5,
  showModuleLabel = TRUE,
  moduleLabel = "auto",
  moduleLabelSize = NULL,
  byrow = TRUE,
  top = NA,
  unit = "mm",
  ncol = NULL,
  useRaster = TRUE,
  returnAsList = FALSE,
  ...
)

```

## Arguments

|               |                                                                                                                                                                                                                                                                                        |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x             | A numeric <a href="#">matrix</a> of counts or a <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Celda results must be present under <code>metadata(altExp(x, altExpName))</code> . |
| useAssay      | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                                                                                                   |
| altExpName    | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                          |
| modules       | Integer Vector. The featureModule(s) to display. Multiple modules can be included in a vector. Default NULL which plots all module heatmaps.                                                                                                                                           |
| featureModule | Same as modules. Either can be used to specify the modules to display.                                                                                                                                                                                                                 |

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| col                     | Passed to <a href="#">Heatmap</a> . Set color boundaries and colors.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| topCells                | Integer. Number of cells with the highest and lowest probabilities for each module to include in the heatmap. For example, if topCells = 50, the 50 cells with the lowest probabilities and the 50 cells with the highest probabilities for each featureModule will be included. If NULL, all cells will be plotted. Default 100.                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| topFeatures             | Integer. Plot 'topFeatures' features with the highest probabilities in the module heatmap for each featureModule. If NULL, plot all features in the module. Default NULL.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| normalizedCounts        | Integer matrix. Rows represent features and columns represent cells. If you have a normalized matrix result from <a href="#">normalizeCounts</a> , you can pass through the result here to skip the normalization step in this function. Make sure the colnames and rownames match the object in x. This matrix should correspond to one generated from this count matrix assay(altExp(x, altExpName), i = useAssay). If NA, normalization will be carried out in the following form normalizeCounts(assay(altExp(x, altExpName), i = useAssay), normalize = "proportion", transformationFun = sqrt). Use of this parameter is particularly useful for plotting many module heatmaps, where normalizing the counts matrix repeatedly would be too time consuming. Default NA. |
| normalize               | Character. Passed to <a href="#">normalizeCounts</a> if normalizedCounts is NA. Divides counts by the library sizes for each cell. One of 'proportion', 'cpm', 'median', or 'mean'. 'proportion' uses the total counts for each cell as the library size. 'cpm' divides the library size of each cell by one million to produce counts per million. 'median' divides the library size of each cell by the median library size across all cells. 'mean' divides the library size of each cell by the mean library size across all cells. Default "proportion".                                                                                                                                                                                                                 |
| transformationFun       | Function. Passed to <a href="#">normalizeCounts</a> if normalizedCounts is NA. Applies a transformation such as <a href="#">sqrt</a> , <a href="#">log</a> , <a href="#">log2</a> , <a href="#">log10</a> , or <a href="#">log1p</a> . If NULL, no transformation will be applied. Occurs after normalization. Default <a href="#">sqrt</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| scaleRow                | Function. Which function to use to scale each individual row. Set to NULL to disable. Occurs after normalization and log transformation. For example, <a href="#">scale</a> will Z-score transform each row. Default <a href="#">scale</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| showFeatureNames        | Logical. Whether feature names should be displayed. Default TRUE.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| displayName             | Character. The column name of rowData(altExp(x, altExpName)) that specifies the display names for the features. Default NULL, which displays the row names. Only works if showFeatureNames is TRUE and x is a <a href="#">SingleCellExperiment</a> object.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| trim                    | Numeric vector. Vector of length two that specifies the lower and upper bounds for plotting the data. This threshold is applied after row scaling. Set to NULL to disable. Default c(-2, 2).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| rowFontSize             | Numeric. Font size for feature names. If NULL, then the size will automatically be determined. Default NULL.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| showHeatmapLegend       | Passed to <a href="#">Heatmap</a> . Show legend for expression levels.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| showTopAnnotationLegend | Passed to <a href="#">HeatmapAnnotation</a> . Show legend for cell annotation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| showTopAnnotationName   | Passed to <a href="#">HeatmapAnnotation</a> . Show heatmap top annotation name.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

|                     |                                                                                                                                                                                                                                                      |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| topAnnotationHeight | Passed to <a href="#">HeatmapAnnotation</a> . Column annotation height. <a href="#">rowAnnotation</a> . Show legend for module annotation.                                                                                                           |
| showModuleLabel     | Show left side module labels.                                                                                                                                                                                                                        |
| moduleLabel         | The left side row titles for module heatmap. Must be vector of the same length as featureModule. Default "auto", which automatically pulls module labels from x.                                                                                     |
| moduleLabelSize     | Passed to <a href="#">gpar</a> . The size of text (in points).                                                                                                                                                                                       |
| byrow               | Passed to <a href="#">matrix</a> . logical. If FALSE (the default) the figure panel is filled by columns, otherwise the figure panel is filled by rows.                                                                                              |
| top                 | Passed to <a href="#">marrangeGrob</a> . The title for each page.                                                                                                                                                                                    |
| unit                | Passed to <a href="#">unit</a> . Single character object defining the unit of all dimensions defined.                                                                                                                                                |
| ncol                | Integer. Number of columns of module heatmaps. If NULL, then this will be automatically calculated so that the number of columns and rows will be approximately the same. Default NULL.                                                              |
| useRaster           | Boolean. Rasterizing will make the heatmap a single object and reduced the memory of the plot and the size of a file. If NULL, then rasterization will be automatically determined by the underlying <a href="#">Heatmap</a> function. Default TRUE. |
| returnAsList        | Boolean. If TRUE, then a list of plots will be returned instead of a single multi-panel figure. These plots can be displayed using the <a href="#">grid.draw</a> function. Default FALSE.                                                            |
| ...                 | Additional parameters passed to <a href="#">Heatmap</a> .                                                                                                                                                                                            |

### Value

A list object if plotting more than one module heatmaps. Otherwise a [HeatmapList](#) object is returned.

### Examples

```
data(sceCeldaCG)
moduleHeatmap(sceCeldaCG, displayName = "rownames")
```

---

|         |                                                                       |
|---------|-----------------------------------------------------------------------|
| nonzero | <i>get row and column indices of none zero elements in the matrix</i> |
|---------|-----------------------------------------------------------------------|

---

### Description

get row and column indices of none zero elements in the matrix

### Usage

```
nonzero(R_counts)
```

### Arguments

|          |          |
|----------|----------|
| R_counts | A matrix |
|----------|----------|

**Value**

An integer matrix where each row is a row, column indices pair

---

|                 |                                    |
|-----------------|------------------------------------|
| normalizeCounts | <i>Normalization of count data</i> |
|-----------------|------------------------------------|

---

**Description**

Performs normalization, transformation, and/or scaling of a counts matrix

**Usage**

```
normalizeCounts(
  counts,
  normalize = c("proportion", "cpm", "median", "mean"),
  scaleFactor = NULL,
  transformationFun = NULL,
  scaleFun = NULL,
  pseudocountNormalize = 0,
  pseudocountTransform = 0
)
```

**Arguments**

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| counts               | Integer, Numeric or Sparse matrix. Rows represent features and columns represent cells.                                                                                                                                                                                                                                                                                                                                                                            |
| normalize            | Character. Divides counts by the library sizes for each cell. One of 'proportion', 'cpm', 'median', or 'mean'. 'proportion' uses the total counts for each cell as the library size. 'cpm' divides the library size of each cell by one million to produce counts per million. 'median' divides the library size of each cell by the median library size across all cells. 'mean' divides the library size of each cell by the mean library size across all cells. |
| scaleFactor          | Numeric. Sets the scale factor for cell-level normalization. This scale factor is multiplied to each cell after the library size of each cell had been adjusted in normalize. Default NULL which means no scale factor is applied.                                                                                                                                                                                                                                 |
| transformationFun    | Function. Applies a transformation such as <a href="#">sqrt</a> , <a href="#">log</a> , <a href="#">log2</a> , <a href="#">log10</a> , or <a href="#">log1p</a> . If NULL, no transformation will be applied. Occurs after normalization. Default NULL.                                                                                                                                                                                                            |
| scaleFun             | Function. Scales the rows of the normalized and transformed count matrix. For example, 'scale' can be used to z-score normalize the rows. Default NULL.                                                                                                                                                                                                                                                                                                            |
| pseudocountNormalize | Numeric. Add a pseudocount to counts before normalization. Default 0.                                                                                                                                                                                                                                                                                                                                                                                              |
| pseudocountTransform | Numeric. Add a pseudocount to normalized counts before applying the transformation function. Adding a pseudocount can be useful before applying a log transformation. Default 0.                                                                                                                                                                                                                                                                                   |



**Value**

Numeric Matrix. A normalized matrix.

**Examples**

```
data(celdaCGSim)
normalizedCounts <- normalizeCounts(celdaCGSim$counts, "proportion",
  pseudocountNormalize = 1)
```

---

|        |                                                              |
|--------|--------------------------------------------------------------|
| params | <i>Get parameter values provided for celdaModel creation</i> |
|--------|--------------------------------------------------------------|

---

**Description**

Retrieves the K/L, model priors (e.g. alpha, beta), and count matrix checksum parameters provided during the creation of the provided celdaModel.

**Usage**

```
params(celdaMod)

## S4 method for signature 'celdaModel'
params(celdaMod)
```

**Arguments**

celdaMod            celdaModel. Options available in `celda::availableModels`.

**Value**

List. Contains the model-specific parameters for the provided celda model object depending on its class.

**Examples**

```
data(celdaCGMod)
params(celdaCGMod)
```

---

|            |                                                  |
|------------|--------------------------------------------------|
| perplexity | <i>Calculate the perplexity of a celda model</i> |
|------------|--------------------------------------------------|

---

**Description**

Perplexity is a statistical measure of how well a probability model can predict new data. Lower perplexity indicates a better model.

**Usage**

```

perplexity(
  x,
  celdaMod,
  useAssay = "counts",
  altExpName = "featureSubset",
  newCounts = NULL
)

## S4 method for signature 'SingleCellExperiment,ANY'
perplexity(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  newCounts = NULL
)

## S4 method for signature 'ANY,celda_CG'
perplexity(x, celdaMod, newCounts = NULL)

## S4 method for signature 'ANY,celda_C'
perplexity(x, celdaMod, newCounts = NULL)

## S4 method for signature 'ANY,celda_G'
perplexity(x, celdaMod, newCounts = NULL)

```

**Arguments**

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | Can be one of <ul style="list-style-type: none"> <li>A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a>, <a href="#">celda_G</a> or <a href="#">celda_CG</a>, with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells.</li> <li>Integer counts matrix. Rows represent features and columns represent cells. This matrix should be the same as the one used to generate celdaMod.</li> </ul> |
| celdaMod   | Celda model object. Only works if x is an integer counts matrix.                                                                                                                                                                                                                                                                                                                                                                                                           |
| useAssay   | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                                                                                                                                                                                                                                                                                       |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                                                                                                                                              |
| newCounts  | A new counts matrix used to calculate perplexity. If NULL, perplexity will be calculated for the matrix in useAssay slot in x. Default NULL.                                                                                                                                                                                                                                                                                                                               |

**Value**

Numeric. The perplexity for the provided x (and celdaModel).

**Examples**

```

data(sceCeldaCG)
perplexity <- perplexity(sceCeldaCG)
data(celdaCGSim, celdaCGMod)
perplexity <- perplexity(celdaCGSim$counts, celdaCGMod)

```

```
data(celdaCSim, celdaCMod)
perplexity <- perplexity(celdaCSim$counts, celdaCMod)
data(celdaGSim, celdaGMod)
perplexity <- perplexity(celdaGSim$counts, celdaGMod)
```

---

|                 |                                       |
|-----------------|---------------------------------------|
| plotCeldaViolin | <i>Feature Expression Violin Plot</i> |
|-----------------|---------------------------------------|

---

## Description

Outputs a violin plot for feature expression data.

## Usage

```
plotCeldaViolin(
  x,
  celdaMod,
  features,
  displayName = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  exactMatch = TRUE,
  plotDots = TRUE,
  dotSize = 0.1
)

## S4 method for signature 'SingleCellExperiment'
plotCeldaViolin(
  x,
  features,
  displayName = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  exactMatch = TRUE,
  plotDots = TRUE,
  dotSize = 0.1
)

## S4 method for signature 'ANY'
plotCeldaViolin(
  x,
  celdaMod,
  features,
  exactMatch = TRUE,
  plotDots = TRUE,
  dotSize = 0.1
)
```

## Arguments

|   |                                                                                                                                                                                |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x | Numeric matrix or a <a href="#">SingleCellExperiment</a> object with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|             |                                                                                                                                                                                                           |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| celdaMod    | Celda object of class "celda_G" or "celda_CG". Used only if x is a matrix object.                                                                                                                         |
| features    | Character vector. Uses these genes for plotting.                                                                                                                                                          |
| displayName | Character. The column name of rowData(x) that specifies the display names for the features. Default NULL, which displays the row names. Only works if x is a <a href="#">SingleCellExperiment</a> object. |
| useAssay    | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                      |
| altExpName  | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                             |
| exactMatch  | Logical. Whether an exact match or a partial match using grep() is used to look up the feature in the rownames of the counts matrix. Default TRUE.                                                        |
| plotDots    | Boolean. If TRUE, the expression of features will be plotted as points in addition to the violin curve. Default TRUE.                                                                                     |
| dotSize     | Numeric. Size of points if plotDots = TRUE. Default 0.1.                                                                                                                                                  |

**Value**

Violin plot for each feature, grouped by celda cluster

**Examples**

```
data(sceCeldaCG)
plotCeldaViolin(x = sceCeldaCG, features = "Gene_1")
data(celdaCGSim, celdaCGMod)
plotCeldaViolin(x = celdaCGSim$counts,
  celdaMod = celdaCGMod,
  features = "Gene_1")
```

---

plotDecontXContamination

*Plots contamination on UMAP coordinates*

---

**Description**

A scatter plot of the UMAP dimensions generated by DecontX with cells colored by the estimated percentation of contamination.

**Usage**

```
plotDecontXContamination(
  x,
  batch = NULL,
  colorScale = c("blue", "green", "yellow", "orange", "red"),
  size = 1
)
```

**Arguments**

|            |                                                                                                                                                                                            |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | Either a <a href="#">SingleCellExperiment</a> with decontX results stored in <code>metadata(x)\$decontX</code> or the result from running decontX on a count matrix.                       |
| batch      | Character. Batch of cells to plot. If NULL, then the first batch in the list will be selected. Default NULL.                                                                               |
| colorScale | Character vector. Contains the color spectrum to be passed to <code>scale_colour_gradientn</code> from package 'ggplot2'. Default <code>c("blue","green","yellow","orange","red")</code> . |
| size       | Numeric. Size of points in the scatterplot. Default 1.                                                                                                                                     |

**Value**

Returns a ggplot object.

**Author(s)**

Shiyi Yang, Joshua Campbell

**See Also**

See [decontX](#) for a full example of how to estimate and plot contamination.

---

plotDecontXMarkerExpression

*Plots expression of marker genes before and after decontamination*

---

**Description**

Generates a violin plot that shows the counts of marker genes in cells across specific clusters or cell types. Can be used to view the expression of marker genes in different cell types before and after decontamination with [decontX](#).

**Usage**

```
plotDecontXMarkerExpression(
  x,
  markers,
  groupClusters = NULL,
  assayName = c("counts", "decontXcounts"),
  z = NULL,
  exactMatch = TRUE,
  by = "rownames",
  log1p = FALSE,
  ncol = NULL,
  plotDots = FALSE,
  dotSize = 0.1
)
```

**Arguments**

|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x             | Either a <a href="#">SingleCellExperiment</a> or a matrix-like object of counts.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| markers       | Character Vector or List. A character vector or list of character vectors with the names of the marker genes of interest.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| groupClusters | List. A named list that allows cell clusters labels coded in z to be regrouped and renamed on the fly. For example, <code>list(Tcells=c(1, 2), Bcells=7)</code> would recode clusters 1 and 2 to "Tcells" and cluster 7 to "Bcells". Note that if this is used, clusters in z not found in groupClusters will be excluded. Default NULL.                                                                                                                                                                                                                                                                                     |
| assayName     | Character vector. Name(s) of the assay(s) to plot if x is a <a href="#">SingleCellExperiment</a> . If more than one assay is listed, then side-by-side violin plots will be generated. Default <code>c("counts", "decontXcounts")</code> .                                                                                                                                                                                                                                                                                                                                                                                   |
| z             | Character, Integer, or Vector. Indicates the cluster labels for each cell. If x is a <a href="#">SingleCellExperiment</a> and z = NULL, then the cluster labels from <code>decontX</code> will be retrieved from the <code>colData</code> of x (i.e. <code>colData(x)\$decontX_clusters</code> ). If z is a single character or integer, then that column will be retrieved from <code>colData</code> of x. (i.e. <code>colData(x)[, z]</code> ). If x is a counts matrix, then z will need to be a vector the same length as the number of columns in x that indicate the cluster to which each cell belongs. Default NULL. |
| exactMatch    | Boolean. Whether to only identify exact matches for the markers or to identify partial matches using <a href="#">grep</a> . See <a href="#">retrieveFeatureIndex</a> for more details. Default TRUE.                                                                                                                                                                                                                                                                                                                                                                                                                         |
| by            | Character. Where to search for the markers if x is a <a href="#">SingleCellExperiment</a> . See <a href="#">retrieveFeatureIndex</a> for more details. If x is a matrix, then this must be set to "rownames". Default "rownames".                                                                                                                                                                                                                                                                                                                                                                                            |
| log1p         | Boolean. Whether to apply the function <code>log1p</code> to the data before plotting. This function will add a pseudocount of 1 and then log transform the expression values. Default FALSE.                                                                                                                                                                                                                                                                                                                                                                                                                                |
| ncol          | Integer. Number of columns to make in the plot. Default NULL.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| plotDots      | Boolean. If TRUE, the expression of features will be plotted as points in addition to the violin curve. Default FALSE.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| dotSize       | Numeric. Size of points if <code>plotDots = TRUE</code> . Default 0.1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

**Value**

Returns a ggplot object.

**Author(s)**

Shiyi Yang, Joshua Campbell

**See Also**

See [decontX](#) for a full example of how to estimate and plot contamination.

---

plotDecontXMarkerPercentage

*Plots percentage of cells cell types expressing markers*


---

## Description

Generates a barplot that shows the percentage of cells within clusters or cell types that have detectable levels of given marker genes. Can be used to view the expression of marker genes in different cell types before and after decontamination with [decontX](#).

## Usage

```
plotDecontXMarkerPercentage(
  x,
  markers,
  groupClusters = NULL,
  assayName = c("counts", "decontXcounts"),
  z = NULL,
  threshold = 1,
  exactMatch = TRUE,
  by = "rownames",
  ncol = round(sqrt(length(markers))),
  labelBars = TRUE,
  labelSize = 3
)
```

## Arguments

|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x             | Either a <a href="#">SingleCellExperiment</a> or a matrix-like object of counts.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| markers       | List. A named list indicating the marker genes for each cell type of interest. Multiple markers can be supplied for each cell type. For example, <code>list(Tcell_Markers=c("CD3E", "CD3D"), Bcell_Markers=c("CD79A", "CD79B", "MS4A1"))</code> would specify markers for human T-cells and B-cells. A cell will be considered "positive" for a cell type if it has a count greater than threshold for at least one of the marker genes in the list.                                                                                                                                                 |
| groupClusters | List. A named list that allows cell clusters labels coded in z to be regrouped and renamed on the fly. For example, <code>list(Tcells=c(1, 2), Bcells=7)</code> would recode clusters 1 and 2 to "Tcells" and cluster 7 to "Bcells". Note that if this is used, clusters in z not found in groupClusters will be excluded from the barplot. Default NULL.                                                                                                                                                                                                                                            |
| assayName     | Character vector. Name(s) of the assay(s) to plot if x is a <a href="#">SingleCellExperiment</a> . If more than one assay is listed, then side-by-side barplots will be generated. Default <code>c("counts", "decontXcounts")</code> .                                                                                                                                                                                                                                                                                                                                                               |
| z             | Character, Integer, or Vector. Indicates the cluster labels for each cell. If x is a <a href="#">SingleCellExperiment</a> and z = NULL, then the cluster labels from <a href="#">decontX</a> will be retrieved from the colData of x (i.e. <code>colData(x)\$decontX_clusters</code> ). If z is a single character or integer, then that column will be retrieved from colData of x. (i.e. <code>colData(x)[,z]</code> ). If x is a counts matrix, then z will need to be a vector the same length as the number of columns in x that indicate the cluster to which each cell belongs. Default NULL. |

|            |                                                                                                                                                                                                                                   |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| threshold  | Numeric. Markers greater than or equal to this value will be considered detected in a cell. Default 1.                                                                                                                            |
| exactMatch | Boolean. Whether to only identify exact matches for the markers or to identify partial matches using <a href="#">grep</a> . See <a href="#">retrieveFeatureIndex</a> for more details. Default TRUE.                              |
| by         | Character. Where to search for the markers if x is a <a href="#">SingleCellExperiment</a> . See <a href="#">retrieveFeatureIndex</a> for more details. If x is a matrix, then this must be set to "rownames". Default "rownames". |
| ncol       | Integer. Number of columns to make in the plot. Default <code>round(sqrt(length(markers)))</code> .                                                                                                                               |
| labelBars  | Boolean. Whether to display percentages above each bar Default TRUE.                                                                                                                                                              |
| labelSize  | Numeric. Size of the percentage labels in the barplot. Default 3.                                                                                                                                                                 |

### Value

Returns a ggplot object.

### Author(s)

Shiyi Yang, Joshua Campbell

### See Also

See [decontX](#) for a full example of how to estimate and plot contamination.

---

plotDendro

*Plots dendrogram of findMarkersTree output*

---

### Description

Generates a dendrogram of the rules and performance (optional) of the decision tree generated by `findMarkersTree()`.

### Usage

```
plotDendro(
  tree,
  classLabel = NULL,
  addSensPrec = FALSE,
  maxFeaturePrint = 4,
  leafSize = 10,
  boxSize = 2,
  boxColor = "black"
)
```



**Arguments**

|                 |                                                                                                                                    |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------|
| tree            | List object. The output of findMarkersTree()                                                                                       |
| classLabel      | A character value. The name of a specific label to draw the path and rules. If NULL (default), the tree for all clusters is shown. |
| addSensPrec     | Logical. Print training sensitivities and precisions for each cluster below leaf label? Default is FALSE.                          |
| maxFeaturePrint | Numeric value. Maximum number of markers to print at a given split. Default is 4.                                                  |
| leafSize        | Numeric value. Size of text below each leaf. Default is 24.                                                                        |
| boxSize         | Numeric value. Size of rule labels. Default is 7.                                                                                  |
| boxColor        | Character value. Color of rule labels. Default is black.                                                                           |

**Value**

A ggplot2 object

**Examples**

```
# Generate simulated single-cell dataset using celda
sce <- celda::simulateCells("celda_CG", K = 4, L = 10, G = 100)

# Select top features
sce <- selectFeatures(sce)

# Celda clustering into 5 clusters & 10 modules
sce <- celda_CG(sce, K=5, L=10, verbose=FALSE)

# Get features matrix and cluster assignments
factorizedCounts <- factorizeMatrix(sce, type = "counts")
featureMatrix <- factorizedCounts$counts$cell
classes <- as.integer(celdaClusters(sce))

# Generate Decision Tree
DecTree <- findMarkersTree(featureMatrix, classes)

# Plot dendrogram
plotDendro(DecTree)
```

---

plotDimReduceCluster    *Plotting the cell labels on a dimension reduction plot*

---

**Description**

Create a scatterplot for each row of a normalized gene expression matrix where x and y axis are from a data dimension reduction tool. The cells are colored by "celda\_cell\_cluster" column in colData(altExp(x, altExpName)) if x is a [SingleCellExperiment](#) object, or x if x is a integer vector of cell cluster labels.

**Usage**

```

plotDimReduceCluster(
  x,
  reducedDimName,
  altExpName = "featureSubset",
  dim1 = NULL,
  dim2 = NULL,
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  specificClusters = NULL,
  labelClusters = FALSE,
  groupBy = NULL,
  labelSize = 3.5
)

## S4 method for signature 'SingleCellExperiment'
plotDimReduceCluster(
  x,
  reducedDimName,
  altExpName = "featureSubset",
  dim1 = 1,
  dim2 = 2,
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  specificClusters = NULL,
  labelClusters = FALSE,
  groupBy = NULL,
  labelSize = 3.5
)

## S4 method for signature 'vector'
plotDimReduceCluster(
  x,
  dim1,
  dim2,
  size = 0.5,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  specificClusters = NULL,
  labelClusters = FALSE,
  groupBy = NULL,
  labelSize = 3.5
)

```

**Arguments**

**x** Integer vector of cell cluster labels or a [SingleCellExperiment](#) object containing cluster labels for each cell in "celda\_cell\_cluster" column in colData(x).

**reducedDimName** The name of the dimension reduction slot in reducedDimNames(x) if x is a [SingleCellExperiment](#) object. Ignored if both dim1 and dim2 are set.

|                  |                                                                                                                                                                                                                                                                           |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| altExpName       | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                             |
| dim1             | Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the x-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the x-axis. Default 1. |
| dim2             | Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the y-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the y-axis. Default 2. |
| size             | Numeric. Sets size of point on plot. Default 0.5.                                                                                                                                                                                                                         |
| xlab             | Character vector. Label for the x-axis. Default NULL.                                                                                                                                                                                                                     |
| ylab             | Character vector. Label for the y-axis. Default NULL.                                                                                                                                                                                                                     |
| specificClusters | Numeric vector. Only color cells in the specified clusters. All other cells will be grey. If NULL, all clusters will be colored. Default NULL.                                                                                                                            |
| labelClusters    | Logical. Whether the cluster labels are plotted. Default FALSE.                                                                                                                                                                                                           |
| groupBy          | Character vector. Contains sample labels for each cell. If NULL, all samples will be plotted together. Default NULL.                                                                                                                                                      |
| labelSize        | Numeric. Sets size of label if labelClusters is TRUE. Default 3.5.                                                                                                                                                                                                        |

**Value**

The plot as a ggplot object

**Examples**

```
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceCluster(x = sce,
  reducedDimName = "celda_tSNE",
  specificClusters = c(1, 2, 3))
library(SingleCellExperiment)
data(sceCeldaCG, celdaCGMod)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceCluster(x = celdaClusters(celdaCGMod)$z,
  dim1 = reducedDim(altExp(sce), "celda_tSNE")[, 1],
  dim2 = reducedDim(altExp(sce), "celda_tSNE")[, 2],
  specificClusters = c(1, 2, 3))
```

---

plotDimReduceFeature    *Plotting feature expression on a dimension reduction plot*

---

**Description**

Create a scatterplot for each row of a normalized gene expression matrix where x and y axis are from a data dimension reduction tool. The cells are colored by expression of the specified feature.

**Usage**

```

plotDimReduceFeature(
  x,
  features,
  reducedDimName = NULL,
  displayName = NULL,
  dim1 = NULL,
  dim2 = NULL,
  headers = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  normalize = FALSE,
  zscore = TRUE,
  exactMatch = TRUE,
  trim = c(-2, 2),
  limits = c(-2, 2),
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  ncol = NULL,
  decreasing = FALSE
)

## S4 method for signature 'SingleCellExperiment'
plotDimReduceFeature(
  x,
  features,
  reducedDimName = NULL,
  displayName = NULL,
  dim1 = 1,
  dim2 = 2,
  headers = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  normalize = FALSE,
  zscore = TRUE,
  exactMatch = TRUE,
  trim = c(-2, 2),
  limits = c(-2, 2),
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  ncol = NULL,
  decreasing = FALSE
)

```

```

)

## S4 method for signature 'ANY'
plotDimReduceFeature(
  x,
  features,
  dim1,
  dim2,
  headers = NULL,
  normalize = FALSE,
  zscore = TRUE,
  exactMatch = TRUE,
  trim = c(-2, 2),
  limits = c(-2, 2),
  size = 0.5,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  ncol = NULL,
  decreasing = FALSE
)

```

### Arguments

|                |                                                                                                                                                                                                                                                                           |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x              | Numeric matrix or a <a href="#">SingleCellExperiment</a> object with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.                                                                                            |
| features       | Character vector. Features in the rownames of counts to plot.                                                                                                                                                                                                             |
| reducedDimName | The name of the dimension reduction slot in reducedDimNames(x) if x is a <a href="#">SingleCellExperiment</a> object. If NULL, then both dim1 and dim2 need to be set. Default NULL.                                                                                      |
| displayName    | Character. The column name of rowData(x) that specifies the display names for the features. Default NULL, which displays the row names. Only works if x is a <a href="#">SingleCellExperiment</a> object. Overwrites headers.                                             |
| dim1           | Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the x-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the x-axis. Default 1. |
| dim2           | Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the y-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the y-axis. Default 2. |
| headers        | Character vector. If NULL, the corresponding rownames are used as labels. Otherwise, these headers are used to label the features. Only works if displayName is NULL and exactMatch is FALSE.                                                                             |
| useAssay       | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                                                                                      |

|            |                                                                                                                                                                                                                                                                                         |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                           |
| normalize  | Logical. Whether to normalize the columns of 'counts'. Default FALSE.                                                                                                                                                                                                                   |
| zscore     | Logical. Whether to scale each feature to have a mean 0 and standard deviation of 1. Default TRUE.                                                                                                                                                                                      |
| exactMatch | Logical. Whether an exact match or a partial match using <code>grep()</code> is used to look up the feature in the rownames of the counts matrix. Default TRUE.                                                                                                                         |
| trim       | Numeric vector. Vector of length two that specifies the lower and upper bounds for the data. This threshold is applied after row scaling. Set to NULL to disable. Default <code>c(-1, 1)</code> .                                                                                       |
| limits     | Passed to <a href="#">scale_colour_gradient2</a> . The range of color scale.                                                                                                                                                                                                            |
| size       | Numeric. Sets size of point on plot. Default 1.                                                                                                                                                                                                                                         |
| xlab       | Character vector. Label for the x-axis. If <code>reducedDimName</code> is used, then this will be set to the column name of the first dimension of that object. Default "Dimension_1".                                                                                                  |
| ylab       | Character vector. Label for the y-axis. If <code>reducedDimName</code> is used, then this will be set to the column name of the second dimension of that object. Default "Dimension_2".                                                                                                 |
| colorLow   | Character. A color available from 'colors()'. The color will be used to signify the lowest values on the scale.                                                                                                                                                                         |
| colorMid   | Character. A color available from 'colors()'. The color will be used to signify the midpoint on the scale.                                                                                                                                                                              |
| colorHigh  | Character. A color available from 'colors()'. The color will be used to signify the highest values on the scale.                                                                                                                                                                        |
| midpoint   | Numeric. The value indicating the midpoint of the diverging color scheme. If NULL, defaults to the mean with 10 percent of values trimmed. Default 0.                                                                                                                                   |
| ncol       | Integer. Passed to <a href="#">facet_wrap</a> . Specify the number of columns for facet wrap.                                                                                                                                                                                           |
| decreasing | logical. Specifies the order of plotting the points. If FALSE, the points will be plotted in increasing order where the points with largest values will be on top. TRUE otherwise. If NULL, no sorting is performed. Points will be plotted in their current order in x. Default FALSE. |

## Value

The plot as a ggplot object

## Examples

```
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceFeature(x = sce,
  reducedDimName = "celda_tSNE",
  normalize = TRUE,
  features = c("Gene_98", "Gene_99"),
  exactMatch = TRUE)
library(SingleCellExperiment)
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceFeature(x = counts(sce),
  dim1 = reducedDim(altExp(sce), "celda_tSNE")[, 1],
  dim2 = reducedDim(altExp(sce), "celda_tSNE")[, 2],
```

```

normalize = TRUE,
features = c("Gene_98", "Gene_99"),
exactMatch = TRUE)

```

---

|                   |                                             |
|-------------------|---------------------------------------------|
| plotDimReduceGrid | <i>Mapping the dimension reduction plot</i> |
|-------------------|---------------------------------------------|

---

## Description

Creates a scatterplot given two dimensions from a data dimension reduction tool (e.g tSNE) output.

## Usage

```

plotDimReduceGrid(
  x,
  reducedDimName,
  dim1 = NULL,
  dim2 = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  size = 1,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  limits = c(-2, 2),
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  varLabel = NULL,
  ncol = NULL,
  headers = NULL,
  decreasing = FALSE
)

## S4 method for signature 'SingleCellExperiment'
plotDimReduceGrid(
  x,
  reducedDimName,
  dim1 = NULL,
  dim2 = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  size = 1,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  limits = c(-2, 2),
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  varLabel = NULL,

```

```

    ncol = NULL,
    headers = NULL,
    decreasing = FALSE
  )

## S4 method for signature 'ANY'
plotDimReduceGrid(
  x,
  dim1,
  dim2,
  size = 1,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  limits = c(-2, 2),
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  varLabel = NULL,
  ncol = NULL,
  headers = NULL,
  decreasing = FALSE
)

```

### Arguments

|                |                                                                                                                                                                                       |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x              | Numeric matrix or a <a href="#">SingleCellExperiment</a> object with the matrix located in the assay slot under useAssay. Each row of the matrix will be plotted as a separate facet. |
| reducedDimName | The name of the dimension reduction slot in reducedDimNames(x) if x is a <a href="#">SingleCellExperiment</a> object. Ignored if both dim1 and dim2 are set.                          |
| dim1           | Numeric vector. Second dimension from data dimension reduction output.                                                                                                                |
| dim2           | Numeric vector. Second dimension from data dimension reduction output.                                                                                                                |
| useAssay       | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                  |
| altExpName     | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                         |
| size           | Numeric. Sets size of point on plot. Default 1.                                                                                                                                       |
| xlab           | Character vector. Label for the x-axis. Default 'Dimension_1'.                                                                                                                        |
| ylab           | Character vector. Label for the y-axis. Default 'Dimension_2'.                                                                                                                        |
| limits         | Passed to <a href="#">scale_colour_gradient2</a> . The range of color scale.                                                                                                          |
| colorLow       | Character. A color available from 'colors()'. The color will be used to signify the lowest values on the scale. Default "blue4".                                                      |
| colorMid       | Character. A color available from 'colors()'. The color will be used to signify the midpoint on the scale. Default "grey90".                                                          |
| colorHigh      | Character. A color available from 'colors()'. The color will be used to signify the highest values on the scale. Default "firebrick1".                                                |
| midpoint       | Numeric. The value indicating the midpoint of the diverging color scheme. If NULL, defaults to the mean with 10 percent of values trimmed. Default 0.                                 |
| varLabel       | Character vector. Title for the color legend.                                                                                                                                         |



|            |                                                                                                                                                                                                                                                                                         |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ncol       | Integer. Passed to <a href="#">facet_wrap</a> . Specify the number of columns for facet wrap.                                                                                                                                                                                           |
| headers    | Character vector. If 'NULL', the corresponding rownames are used as labels. Otherwise, these headers are used to label the genes.                                                                                                                                                       |
| decreasing | logical. Specifies the order of plotting the points. If FALSE, the points will be plotted in increasing order where the points with largest values will be on top. TRUE otherwise. If NULL, no sorting is performed. Points will be plotted in their current order in x. Default FALSE. |

**Value**

The plot as a ggplot object

**Examples**

```
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceGrid(x = sce,
  reducedDimName = "celda_tSNE",
  xlab = "Dimension1",
  ylab = "Dimension2",
  varLabel = "tSNE")
library(SingleCellExperiment)
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceGrid(x = counts(sce),
  dim1 = reducedDim(altExp(sce), "celda_tSNE")[, 1],
  dim2 = reducedDim(altExp(sce), "celda_tSNE")[, 2],
  xlab = "Dimension1",
  ylab = "Dimension2",
  varLabel = "tSNE")
```

---

plotDimReduceModule      *Plotting Celda module probability on a dimension reduction plot*

---

**Description**

Create a scatterplot for each row of a normalized gene expression matrix where x and y axis are from a data dimension reduction tool. The cells are colored by the module probability.

**Usage**

```
plotDimReduceModule(
  x,
  reducedDimName,
  useAssay = "counts",
  altExpName = "featureSubset",
  celdaMod,
  modules = NULL,
  dim1 = NULL,
  dim2 = NULL,
  size = 0.5,
  xlab = NULL,
```

```

    ylab = NULL,
    rescale = TRUE,
    limits = c(0, 1),
    colorLow = "grey90",
    colorHigh = "firebrick1",
    ncol = NULL,
    decreasing = FALSE
  )

## S4 method for signature 'SingleCellExperiment'
plotDimReduceModule(
  x,
  reducedDimName,
  useAssay = "counts",
  altExpName = "featureSubset",
  modules = NULL,
  dim1 = 1,
  dim2 = 2,
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  rescale = TRUE,
  limits = c(0, 1),
  colorLow = "grey90",
  colorHigh = "firebrick1",
  ncol = NULL,
  decreasing = FALSE
)

## S4 method for signature 'ANY'
plotDimReduceModule(
  x,
  celldaMod,
  modules = NULL,
  dim1,
  dim2,
  size = 0.5,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  rescale = TRUE,
  limits = c(0, 1),
  colorLow = "grey90",
  colorHigh = "firebrick1",
  ncol = NULL,
  decreasing = FALSE
)

```

## Arguments

**x** Numeric matrix or a [SingleCellExperiment](#) object with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.

|                |                                                                                                                                                                                                                                                                                         |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| reducedDimName | The name of the dimension reduction slot in reducedDimNames(x) if x is a <a href="#">SingleCellExperiment</a> object. Ignored if both dim1 and dim2 are set.                                                                                                                            |
| useAssay       | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                                                                                                    |
| altExpName     | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                           |
| celdaMod       | Celda object of class "celda_G" or "celda_CG". Used only if x is a matrix object.                                                                                                                                                                                                       |
| modules        | Character vector. Module(s) from celda model to be plotted. e.g. c("1", "2").                                                                                                                                                                                                           |
| dim1           | Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the x-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the x-axis. Default 1.               |
| dim2           | Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the y-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the y-axis. Default 2.               |
| size           | Numeric. Sets size of point on plot. Default 0.5.                                                                                                                                                                                                                                       |
| xlab           | Character vector. Label for the x-axis. Default "Dimension_1".                                                                                                                                                                                                                          |
| ylab           | Character vector. Label for the y-axis. Default "Dimension_2".                                                                                                                                                                                                                          |
| rescale        | Logical. Whether rows of the matrix should be rescaled to [0, 1]. Default TRUE.                                                                                                                                                                                                         |
| limits         | Passed to <a href="#">scale_colour_gradient</a> . The range of color scale.                                                                                                                                                                                                             |
| colorLow       | Character. A color available from 'colors()'. The color will be used to signify the lowest values on the scale.                                                                                                                                                                         |
| colorHigh      | Character. A color available from 'colors()'. The color will be used to signify the highest values on the scale.                                                                                                                                                                        |
| ncol           | Integer. Passed to <a href="#">facet_wrap</a> . Specify the number of columns for facet wrap.                                                                                                                                                                                           |
| decreasing     | logical. Specifies the order of plotting the points. If FALSE, the points will be plotted in increasing order where the points with largest values will be on top. TRUE otherwise. If NULL, no sorting is performed. Points will be plotted in their current order in x. Default FALSE. |

## Value

The plot as a ggplot object

## Examples

```
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceModule(x = sce,
  reducedDimName = "celda_tSNE",
  modules = c("1", "2"))
library(SingleCellExperiment)
data(sceCeldaCG, celdaCGMod)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceModule(x = counts(sce),
  dim1 = reducedDim(altExp(sce), "celda_tSNE")[, 1],
  dim2 = reducedDim(altExp(sce), "celda_tSNE")[, 2],
  celdaMod = celdaCGMod,
  modules = c("1", "2"))
```

---

plotGridSearchPerplexity

*Visualize perplexity of a list of celda models*


---

## Description

Visualize perplexity of every model in a `celdaList`, by unique K/L combinations

## Usage

```
plotGridSearchPerplexity(x, altExpName = "featureSubset", sep = 5, alpha = 0.5)
```

```
## S4 method for signature 'SingleCellExperiment'
```

```
plotGridSearchPerplexity(x, altExpName = "featureSubset", sep = 5, alpha = 0.5)
```

```
## S4 method for signature 'celdaList'
```

```
plotGridSearchPerplexity(x, sep = 5, alpha = 0.5)
```

## Arguments

|                         |                                                                                                                                                                                                                                                                                                                                                                  |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>          | Can be one of <ul style="list-style-type: none"> <li>A <a href="#">SingleCellExperiment</a> object returned from <code>celdaGridSearch</code>, <code>recursiveSplitModule</code>, or <code>recursiveSplitCell</code>. Must contain a list named <code>"celda_grid_search"</code> in <code>metadata(x)</code>.</li> <li><code>celdaList</code> object.</li> </ul> |
| <code>altExpName</code> | The name for the <code>altExp</code> slot to use. Default <code>"featureSubset"</code> . Only works if <code>x</code> is a <a href="#">SingleCellExperiment</a> object.                                                                                                                                                                                          |
| <code>sep</code>        | Numeric. Breaks in the x axis of the resulting plot.                                                                                                                                                                                                                                                                                                             |
| <code>alpha</code>      | Numeric. Passed to <a href="#">geom_jitter</a> . Opacity of the points. Values of alpha range from 0 to 1, with lower values corresponding to more transparent colors.                                                                                                                                                                                           |

## Value

A ggplot plot object showing perplexity as a function of clustering parameters.

## Examples

```
data(sceCeldaCGGridSearch)
sce <- resamplePerplexity(sceCeldaCGGridSearch)
plotGridSearchPerplexity(sce)
data(celdaCGSim, celdaCGGridSearchRes)
## Run various combinations of parameters with 'celdaGridSearch'
celdaCGGridSearchRes <- resamplePerplexity(
  celdaCGSim$counts,
  celdaCGGridSearchRes)
plotGridSearchPerplexity(celdaCGGridSearchRes)
```

plotHeatmap

*Plots heatmap based on Celda model***Description**

Renders a heatmap based on a matrix of counts where rows are features and columns are cells.

**Usage**

```
plotHeatmap(
  counts,
  z = NULL,
  y = NULL,
  scaleRow = scale,
  trim = c(-2, 2),
  featureIx = NULL,
  cellIx = NULL,
  clusterFeature = TRUE,
  clusterCell = TRUE,
  colorScheme = c("divergent", "sequential"),
  colorSchemeSymmetric = TRUE,
  colorSchemeCenter = 0,
  col = NULL,
  annotationCell = NULL,
  annotationFeature = NULL,
  annotationColor = NULL,
  breaks = NULL,
  legend = TRUE,
  annotationLegend = TRUE,
  annotationNamesFeature = TRUE,
  annotationNamesCell = TRUE,
  showNamesFeature = FALSE,
  showNamesCell = FALSE,
  rowGroupOrder = NULL,
  colGroupOrder = NULL,
  hclustMethod = "ward.D2",
  treeheightFeature = ifelse(clusterFeature, 50, 0),
  treeheightCell = ifelse(clusterCell, 50, 0),
  silent = FALSE,
  ...
)
```

**Arguments**

|          |                                                                                                                                                                                            |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| counts   | Numeric or sparse matrix. Normalized counts matrix where rows represent features and columns represent cells. .                                                                            |
| z        | Numeric vector. Denotes cell population labels.                                                                                                                                            |
| y        | Numeric vector. Denotes feature module labels.                                                                                                                                             |
| scaleRow | Function. A function to scale each individual row. Set to NULL to disable. Occurs after normalization and log transformation. Default is 'scale' and thus will Z-score transform each row. |

|                        |                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| trim                   | Numeric vector. Vector of length two that specifies the lower and upper bounds for the data. This threshold is applied after row scaling. Set to NULL to disable. Default c(-2,2).                                                                                                                                                                                                       |
| featureIdx             | Integer vector. Select features for display in heatmap. If NULL, no subsetting will be performed. Default NULL.                                                                                                                                                                                                                                                                          |
| cellIdx                | Integer vector. Select cells for display in heatmap. If NULL, no subsetting will be performed. Default NULL.                                                                                                                                                                                                                                                                             |
| clusterFeature         | Logical. Determines whether rows should be clustered. Default TRUE.                                                                                                                                                                                                                                                                                                                      |
| clusterCell            | Logical. Determines whether columns should be clustered. Default TRUE.                                                                                                                                                                                                                                                                                                                   |
| colorScheme            | Character. One of "divergent" or "sequential". A "divergent" scheme is best for highlighting relative data (denoted by 'colorSchemeCenter') such as gene expression data that has been normalized and centered. A "sequential" scheme is best for highlighting data that are ordered low to high such as raw counts or probabilities. Default "divergent".                               |
| colorSchemeSymmetric   | Logical. When the colorScheme is "divergent" and the data contains both positive and negative numbers, TRUE indicates that the color scheme should be symmetric from $[-\max(\text{abs}(\text{data})), \max(\text{abs}(\text{data}))]$ . For example, if the data ranges goes from -1.5 to 2, then setting this to TRUE will force the color scheme to range from -2 to 2. Default TRUE. |
| colorSchemeCenter      | Numeric. Indicates the center of a "divergent" colorScheme. Default 0.                                                                                                                                                                                                                                                                                                                   |
| col                    | Color for the heatmap.                                                                                                                                                                                                                                                                                                                                                                   |
| annotationCell         | Data frame. Additional annotations for each cell will be shown in the column color bars. The format of the data frame should be one row for each cell and one column for each annotation. Numeric variables will be displayed as continuous color bars and factors will be displayed as discrete color bars. Default NULL.                                                               |
| annotationFeature      | A data frame for the feature annotations (rows).                                                                                                                                                                                                                                                                                                                                         |
| annotationColor        | List. Contains color scheme for all annotations. See '?pheatmap' for more details.                                                                                                                                                                                                                                                                                                       |
| breaks                 | Numeric vector. A sequence of numbers that covers the range of values in the normalized 'counts'. Values in the normalized 'matrix' are assigned to each bin in 'breaks'. Each break is assigned to a unique color from 'col'. If NULL, then breaks are calculated automatically. Default NULL.                                                                                          |
| legend                 | Logical. Determines whether legend should be drawn. Default TRUE.                                                                                                                                                                                                                                                                                                                        |
| annotationLegend       | Logical. Whether legend for all annotations should be drawn. Default TRUE.                                                                                                                                                                                                                                                                                                               |
| annotationNamesFeature | Logical. Whether the names for features should be shown. Default TRUE.                                                                                                                                                                                                                                                                                                                   |
| annotationNamesCell    | Logical. Whether the names for cells should be shown. Default TRUE.                                                                                                                                                                                                                                                                                                                      |
| showNamesFeature       | Logical. Specifies if feature names should be shown. Default TRUE.                                                                                                                                                                                                                                                                                                                       |
| showNamesCell          | Logical. Specifies if cell names should be shown. Default FALSE.                                                                                                                                                                                                                                                                                                                         |
| rowGroupOrder          | Vector. Specifies the order of feature clusters when semisupervised clustering is performed on the y labels.                                                                                                                                                                                                                                                                             |

|                   |                                                                                                                                                                                         |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| colGroupOrder     | Vector. Specifies the order of cell clusters when semisupervised clustering is performed on the z labels.                                                                               |
| hclustMethod      | Character. Specifies the method to use for the 'hclust' function. See '?hclust' for possible values. Default "ward.D2".                                                                 |
| treeheightFeature | Numeric. Width of the feature dendrogram. Set to 0 to disable plotting of this dendrogram. Default: if clusterFeature == TRUE, then treeheightFeature = 50, else treeheightFeature = 0. |
| treeheightCell    | Numeric. Height of the cell dendrogram. Set to 0 to disable plotting of this dendrogram. Default: if clusterCell == TRUE, then treeheightCell = 50, else treeheightCell = 0.            |
| silent            | Logical. Whether to plot the heatmap.                                                                                                                                                   |
| ...               | Other arguments to be passed to underlying pheatmap function.                                                                                                                           |

**Value**

list A list containing dendrogram information and the heatmap grob

**Examples**

```
data(celdaCGSim, celdaCGMod)
plotHeatmap(celdaCGSim$counts,
  z = celdaClusters(celdaCGMod)$z, y = celdaClusters(celdaCGMod)$y
)
```

---

|                   |                                                    |
|-------------------|----------------------------------------------------|
| plotMarkerHeatmap | <i>Generate heatmap for a marker decision tree</i> |
|-------------------|----------------------------------------------------|

---

**Description**

Creates heatmap for a specified branch point in a marker tree.

**Usage**

```
plotMarkerHeatmap(
  tree,
  counts,
  branchPoint,
  featureLabels,
  topFeatures = 10,
  silent = FALSE
)
```

**Arguments**

|             |                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------|
| tree        | A decision tree from CELDA's <i>findMarkersTree</i> function.                                               |
| counts      | Numeric matrix. Gene-by-cell counts matrix.                                                                 |
| branchPoint | Character. Name of branch point to plot heatmap for. Name should match those in <i>tree\$branchPoints</i> . |

|               |                                                                                                                                                                                                                                                                      |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| featureLabels | List of feature cluster assignments. Length should be equal to number of rows in counts matrix, and formatting should match that used in <i>findMarkersTree()</i> . Required when using clusters of features and not previously provided to <i>findMarkersTree()</i> |
| topFeatures   | Integer. Number of genes to plot per marker module. Genes are sorted based on their AUC for their respective cluster. Default is 10.                                                                                                                                 |
| silent        | Logical. Whether to avoid plotting heatmap to screen. Default is FALSE.                                                                                                                                                                                              |

**Value**

A heatmap visualizing the counts matrix for the cells and genes at the specified branch point.

**Examples**

```
sce <- celda::simulateCells("celda_CG", K = 4, L = 10, G = 100)

# Select top features
sce <- selectFeatures(sce)

# Celda clustering into 5 clusters & 10 modules
sce <- celda_CG(sce, K=5, L=10, verbose=FALSE)

# Get features matrix and cluster assignments
factorizedCounts <- factorizeMatrix(sce, type = "counts")
featureMatrix <- factorizedCounts$counts$cell
classes <- as.integer(celdaClusters(sce))

# Generate Decision Tree
DecTree <- findMarkersTree(featureMatrix, classes)

# Plot example heatmap
plotMarkerHeatmap(DecTree, featureMatrix, branchPoint = "top_level",
  featureLabels = rownames(featureMatrix))
```

---

plotRPC

---

*Visualize perplexity differences of a list of celda models*


---

**Description**

Visualize perplexity differences of every model in a *celdaList*, by unique K/L combinations.

**Usage**

```
plotRPC(x, altExpName = "featureSubset", sep = 5, alpha = 0.5)

## S4 method for signature 'SingleCellExperiment'
plotRPC(x, altExpName = "featureSubset", sep = 5, alpha = 0.5)

## S4 method for signature 'celdaList'
plotRPC(x, sep = 5, alpha = 0.5)
```



**Arguments**

|            |                                                                                                                                                                                                                                                                                                                                                     |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | Can be one of <ul style="list-style-type: none"> <li>A <a href="#">SingleCellExperiment</a> object returned from <code>celdaGridSearch</code>, <code>recursiveSplitModule</code>, or <code>recursiveSplitCell</code>. Must contain a list named "celda_grid_search" in <code>metadata(x)</code>.</li> <li><code>celdaList</code> object.</li> </ul> |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                       |
| sep        | Numeric. Breaks in the x axis of the resulting plot.                                                                                                                                                                                                                                                                                                |
| alpha      | Numeric. Passed to <a href="#">geom_jitter</a> . Opacity of the points. Values of alpha range from 0 to 1, with lower values corresponding to more transparent colors.                                                                                                                                                                              |

**Value**

A ggplot plot object showing perplexity differences as a function of clustering parameters.

**Examples**

```
data(sceCeldaCGGridSearch)
sce <- resamplePerplexity(sceCeldaCGGridSearch)
plotRPC(sce)
data(celdaCGSim, celdaCGGridSearchRes)
## Run various combinations of parameters with 'celdaGridSearch'
celdaCGGridSearchRes <- resamplePerplexity(
  celdaCGSim$counts,
  celdaCGGridSearchRes)
plotRPC(celdaCGGridSearchRes)
```

---

|                |                                     |
|----------------|-------------------------------------|
| recodeClusterY | <i>Recode feature module labels</i> |
|----------------|-------------------------------------|

---

**Description**

Recode feature module clusters using a mapping in the `from` and `to` arguments.

**Usage**

```
recodeClusterY(sce, from, to, altExpName = "featureSubset")
```

**Arguments**

|            |                                                                                                                                                                                                                    |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sce        | <a href="#">SingleCellExperiment</a> object returned from <code>celda_G</code> or <code>celda_CG</code> . Must contain column <code>celda_feature_module</code> in <code>rowData(altExp(sce, altExpName))</code> . |
| from       | Numeric vector. Unique values in the range of <code>seq(celdaModules(sce))</code> that correspond to the original module labels in <code>sce</code> .                                                              |
| to         | Numeric vector. Unique values in the range of <code>seq(celdaModules(sce))</code> that correspond to the new module labels.                                                                                        |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                      |

**Value**

@return [SingleCellExperiment](#) object with recoded feature module labels.

**Examples**

```
data(sceCeldaCG)
sceReorderedY <- recodeClusterY(sceCeldaCG, c(1, 3), c(3, 1))
```

---

|                |                                   |
|----------------|-----------------------------------|
| recodeClusterZ | <i>Recode cell cluster labels</i> |
|----------------|-----------------------------------|

---

**Description**

Recode cell subpopulation clusters using a mapping in the `from` and `to` arguments.

**Usage**

```
recodeClusterZ(sce, from, to, altExpName = "featureSubset")
```

**Arguments**

|                         |                                                                                                                                                                                                                        |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>sce</code>        | <a href="#">SingleCellExperiment</a> object returned from <a href="#">celda_C</a> or <a href="#">celda_CG</a> . Must contain column <code>celda_cell_cluster</code> in <code>colData(altExp(sce, altExpName))</code> . |
| <code>from</code>       | Numeric vector. Unique values in the range of <code>seq(max(as.integer(celdaClusters(sce, altExpName = altExpName))))</code> that correspond to the original cluster labels in <code>sce</code> .                      |
| <code>to</code>         | Numeric vector. Unique values in the range of <code>seq(max(as.integer(celdaClusters(sce, altExpName = altExpName))))</code> that correspond to the new cluster labels.                                                |
| <code>altExpName</code> | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                          |

**Value**

[SingleCellExperiment](#) object with recoded cell cluster labels.

**Examples**

```
data(sceCeldaCG)
sceReorderedZ <- recodeClusterZ(sceCeldaCG, c(1, 3), c(3, 1))
```

---

|                    |                                 |
|--------------------|---------------------------------|
| recursiveSplitCell | <i>Recursive cell splitting</i> |
|--------------------|---------------------------------|

---

## Description

Uses the [celda\\_C](#) model to cluster cells into population for range of possible K's. The cell population labels of the previous "K-1" model are used as the initial values in the current model with K cell populations. The best split of an existing cell population is found to create the K-th cluster. This procedure is much faster than randomly initializing each model with a different K. If module labels for each feature are given in 'yInit', the [celda\\_CG](#) model will be used to split cell populations based on those modules instead of individual features. Module labels will also be updated during sampling and thus may end up slightly different than yInit.

## Usage

```
recursiveSplitCell(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  initialK = 5,
  maxK = 25,
  tempL = NULL,
  yInit = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minCell = 3,
  reorder = TRUE,
  seed = 12345,
  perplexity = TRUE,
  doResampling = FALSE,
  numResample = 5,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'SingleCellExperiment'
recursiveSplitCell(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  initialK = 5,
  maxK = 25,
  tempL = NULL,
  yInit = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
```

```

    gamma = 1,
    minCell = 3,
    reorder = TRUE,
    seed = 12345,
    perplexity = TRUE,
    doResampling = FALSE,
    numResample = 5,
    logfile = NULL,
    verbose = TRUE
)

## S4 method for signature 'matrix'
recursiveSplitCell(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  initialK = 5,
  maxK = 25,
  tempL = NULL,
  yInit = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minCell = 3,
  reorder = TRUE,
  seed = 12345,
  perplexity = TRUE,
  doResampling = FALSE,
  numResample = 5,
  logfile = NULL,
  verbose = TRUE
)

```

### Arguments

|             |                                                                                                                                                                                                                                                                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x           | A numeric <a href="#">matrix</a> of counts or a <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.                                                                                                                                                         |
| useAssay    | A string specifying the name of the <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                                                                                                                                                    |
| altExpName  | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                               |
| sampleLabel | Vector or factor. Denotes the sample label for each cell (column) in the count matrix.                                                                                                                                                                                                                                                                      |
| initialK    | Integer. Initial number of cell populations to try. Default 5.                                                                                                                                                                                                                                                                                              |
| maxK        | Integer. Maximum number of cell populations to try. Default 25.                                                                                                                                                                                                                                                                                             |
| tempL       | Integer. Number of temporary modules to identify and use in cell splitting. Only used if yInit = NULL. Collapsing features to a relatively smaller number of modules will increase the speed of clustering and tend to produce better cell populations. This number should be larger than the number of true modules expected in the dataset. Default NULL. |

|              |                                                                                                                                                                                                                                                                                                                                                        |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| yInit        | Integer vector. Module labels for features. Cells will be clustered using the <a href="#">celda_CG</a> model based on the modules specified in yInit rather than the counts of individual features. While the features will be initialized to the module labels in yInit, the labels will be allowed to move within each new model with a different K. |
| alpha        | Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Default 1.                                                                                                                                                                                                                                      |
| beta         | Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature in each cell (if yInit is NULL) or to each module in each cell population (if yInit is set). Default 1.                                                                                                                                                                   |
| delta        | Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Only used if yInit is set. Default 1.                                                                                                                                                                                                                     |
| gamma        | Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Only used if yInit is set. Default 1.                                                                                                                                                                                                           |
| minCell      | Integer. Only attempt to split cell populations with at least this many cells.                                                                                                                                                                                                                                                                         |
| reorder      | Logical. Whether to reorder cell populations using hierarchical clustering after each model has been created. If FALSE, cell populations numbers will correspond to the split which created the cell populations (i.e. 'K15' was created at split 15, 'K16' was created at split 16, etc.). Default TRUE.                                              |
| seed         | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                                                                                                                                                         |
| perplexity   | Logical. Whether to calculate perplexity for each model. If FALSE, then perplexity can be calculated later with <a href="#">resamplePerplexity</a> . Default TRUE.                                                                                                                                                                                     |
| doResampling | Boolean. If TRUE, then each cell in the counts matrix will be resampled according to a multinomial distribution to introduce noise before calculating perplexity. Default FALSE.                                                                                                                                                                       |
| numResample  | Integer. The number of times to resample the counts matrix for evaluating perplexity if doResampling is set to TRUE. Default 5.                                                                                                                                                                                                                        |
| logfile      | Character. Messages will be redirected to a file named "logfile". If NULL, messages will be printed to stdout. Default NULL.                                                                                                                                                                                                                           |
| verbose      | Logical. Whether to print log messages. Default TRUE.                                                                                                                                                                                                                                                                                                  |

### Value

A [SingleCellExperiment](#) object. Function parameter settings and celda model results are stored in the `metadata` "celda\_grid\_search" slot. The models in the list will be of class `celda_C` if `yInit` = NULL or `celda_CG` if `zInit` is set.

### See Also

[recursiveSplitModule](#) for recursive splitting of feature modules.

### Examples

```
data(sceCeldaCG)
## Create models that range from K = 3 to K = 7 by recursively splitting
## cell populations into two to produce \link{celda_C} cell clustering models
sce <- recursiveSplitCell(sceCeldaCG, initialK = 3, maxK = 7)

## Alternatively, first identify features modules using
```

```
## \link{recursiveSplitModule}
moduleSplit <- recursiveSplitModule(sceCeldaCG, initialL = 3, maxL = 15)
plotGridSearchPerplexity(moduleSplit)
moduleSplitSelect <- subsetCeldaList(moduleSplit, list(L = 10))

## Then use module labels for initialization in \link{recursiveSplitCell} to
## produce \link{celda_CG} bi-clustering models
cellSplit <- recursiveSplitCell(sceCeldaCG,
  initialK = 3, maxK = 7, yInit = celdaModules(moduleSplitSelect))
plotGridSearchPerplexity(cellSplit)
sce <- subsetCeldaList(cellSplit, list(K = 5, L = 10))
data(celdaCGSim, celdaCSim)
## Create models that range from K = 3 to K = 7 by recursively splitting
## cell populations into two to produce \link{celda_C} cell clustering models
sce <- recursiveSplitCell(celdaCSim$counts, initialK = 3, maxK = 7)

## Alternatively, first identify features modules using
## \link{recursiveSplitModule}
moduleSplit <- recursiveSplitModule(celdaCGSim$counts,
  initialL = 3, maxL = 15)
plotGridSearchPerplexity(moduleSplit)
moduleSplitSelect <- subsetCeldaList(moduleSplit, list(L = 10))

## Then use module labels for initialization in \link{recursiveSplitCell} to
## produce \link{celda_CG} bi-clustering models
cellSplit <- recursiveSplitCell(celdaCGSim$counts,
  initialK = 3, maxK = 7, yInit = celdaModules(moduleSplitSelect))
plotGridSearchPerplexity(cellSplit)
sce <- subsetCeldaList(cellSplit, list(K = 5, L = 10))
```

---

recursiveSplitModule    *Recursive module splitting*

---

## Description

Uses the [celda\\_G](#) model to cluster features into modules for a range of possible L's. The module labels of the previous "L-1" model are used as the initial values in the current model with L modules. The best split of an existing module is found to create the L-th module. This procedure is much faster than randomly initializing each model with a different L.

## Usage

```
recursiveSplitModule(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  initialL = 10,
  maxL = 100,
  tempK = 100,
  zInit = NULL,
  sampleLabel = NULL,
  alpha = 1,
  beta = 1,
```

```
    delta = 1,
    gamma = 1,
    minFeature = 3,
    reorder = TRUE,
    seed = 12345,
    perplexity = TRUE,
    doResampling = FALSE,
    numResample = 5,
    verbose = TRUE,
    logfile = NULL
)

## S4 method for signature 'SingleCellExperiment'
recursiveSplitModule(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  initialL = 10,
  maxL = 100,
  tempK = 100,
  zInit = NULL,
  sampleLabel = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minFeature = 3,
  reorder = TRUE,
  seed = 12345,
  perplexity = TRUE,
  doResampling = FALSE,
  numResample = 5,
  verbose = TRUE,
  logfile = NULL
)

## S4 method for signature 'matrix'
recursiveSplitModule(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  initialL = 10,
  maxL = 100,
  tempK = 100,
  zInit = NULL,
  sampleLabel = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minFeature = 3,
  reorder = TRUE,
```

```

seed = 12345,
perplexity = TRUE,
doResampling = FALSE,
numResample = 5,
verbose = TRUE,
logfile = NULL
)

```

## Arguments

|              |                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x            | A numeric <a href="#">matrix</a> of counts or a <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.                                                                                                                                                                                |
| useAssay     | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                                                                                                                                                                                               |
| altExpName   | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                                                      |
| initialL     | Integer. Initial number of modules.                                                                                                                                                                                                                                                                                                                                                |
| maxL         | Integer. Maximum number of modules.                                                                                                                                                                                                                                                                                                                                                |
| tempK        | Integer. Number of temporary cell populations to identify and use in module splitting. Only used if zInit = NULL. Collapsing cells to a relatively smaller number of cell populations will increase the speed of module clustering and tend to produce better modules. This number should be larger than the number of true cell populations expected in the dataset. Default 100. |
| zInit        | Integer vector. Collapse cells to cell populations based on labels in zInit and then perform module splitting. If NULL, no collapsing will be performed unless tempK is specified. Default NULL.                                                                                                                                                                                   |
| sampleLabel  | Vector or factor. Denotes the sample label for each cell (column) in the count matrix. Default NULL.                                                                                                                                                                                                                                                                               |
| alpha        | Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Only used if zInit is set. Default 1.                                                                                                                                                                                                                                       |
| beta         | Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature module in each cell. Default 1.                                                                                                                                                                                                                                                                       |
| delta        | Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Default 1.                                                                                                                                                                                                                                                                            |
| gamma        | Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Default 1.                                                                                                                                                                                                                                                                  |
| minFeature   | Integer. Only attempt to split modules with at least this many features.                                                                                                                                                                                                                                                                                                           |
| reorder      | Logical. Whether to reorder modules using hierarchical clustering after each model has been created. If FALSE, module numbers will correspond to the split which created the module (i.e. 'L15' was created at split 15, 'L16' was created at split 16, etc.). Default TRUE.                                                                                                       |
| seed         | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                                                                                                                                                                                     |
| perplexity   | Logical. Whether to calculate perplexity for each model. If FALSE, then perplexity can be calculated later with <a href="#">resamplePerplexity</a> . Default TRUE.                                                                                                                                                                                                                 |
| doResampling | Boolean. If TRUE, then each cell in the counts matrix will be resampled according to a multinomial distribution to introduce noise before calculating perplexity. Default FALSE.                                                                                                                                                                                                   |



|             |                                                                                                                                 |
|-------------|---------------------------------------------------------------------------------------------------------------------------------|
| numResample | Integer. The number of times to resample the counts matrix for evaluating perplexity if doResampling is set to TRUE. Default 5. |
| verbose     | Logical. Whether to print log messages. Default TRUE.                                                                           |
| logfile     | Character. Messages will be redirected to a file named "logfile". If NULL, messages will be printed to stdout. Default NULL.    |

### Value

A [SingleCellExperiment](#) object. Function parameter settings and celda model results are stored in the `metadata` "celda\_grid\_search" slot. The models in the list will be of class [celda\\_G](#) if `zInit` = NULL or [celda\\_CG](#) if `zInit` is set.

### See Also

`recursiveSplitCell` for recursive splitting of cell populations.

### Examples

```
data(sceCeldaCG)
## Create models that range from L=3 to L=20 by recursively splitting modules
## into two
moduleSplit <- recursiveSplitModule(sceCeldaCG, initialL = 3, maxL = 20)

## Example results with perplexity
plotGridSearchPerplexity(moduleSplit)

## Select model for downstream analysis
celdaMod <- subsetCeldaList(moduleSplit, list(L = 10))
data(celdaCGSim)
## Create models that range from L=3 to L=20 by recursively splitting modules
## into two
moduleSplit <- recursiveSplitModule(celdaCGSim$counts,
  initialL = 3, maxL = 20)

## Example results with perplexity
plotGridSearchPerplexity(moduleSplit)

## Select model for downstream analysis
celdaMod <- subsetCeldaList(moduleSplit, list(L = 10))
```

---

|              |                                                                                        |
|--------------|----------------------------------------------------------------------------------------|
| reorderCelda | <i>Reorder cells populations and/or features modules using hierarchical clustering</i> |
|--------------|----------------------------------------------------------------------------------------|

---

### Description

Apply hierarchical clustering to reorder the cell populations and/or feature modules and group similar ones together based on the cosine distance of the factorized matrix from [factorizeMatrix](#).

**Usage**

```

reorderCelda(
  x,
  celdaMod,
  useAssay = "counts",
  altExpName = "featureSubset",
  method = "complete"
)

## S4 method for signature 'SingleCellExperiment,ANY'
reorderCelda(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  method = "complete"
)

## S4 method for signature 'matrix,celda_CG'
reorderCelda(x, celdaMod, method = "complete")

## S4 method for signature 'matrix,celda_C'
reorderCelda(x, celdaMod, method = "complete")

## S4 method for signature 'matrix,celda_G'
reorderCelda(x, celdaMod, method = "complete")

```

**Arguments**

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | Can be one of <ul style="list-style-type: none"> <li>A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a>, <a href="#">celda_G</a> or <a href="#">celda_CG</a>, with the matrix located in the useAssay assay slot in altExp(x, altExpName). Rows represent features and columns represent cells.</li> <li>Integer count matrix. Rows represent features and columns represent cells. This matrix should be the same as the one used to generate celdaMod.</li> </ul> |
| celdaMod   | Celda model object. Only works if x is an integer counts matrix. Ignored if x is a <a href="#">SingleCellExperiment</a> object.                                                                                                                                                                                                                                                                                                                                                                    |
| useAssay   | A string specifying which <a href="#">assay</a> slot to use if x is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                                                                                                                                                                                                                                                                                                               |
| altExpName | The name for the <a href="#">altExp</a> slot. Default "featureSubset".                                                                                                                                                                                                                                                                                                                                                                                                                             |
| method     | Passed to <a href="#">hclust</a> . The agglomeration method to be used to be used. Default "complete".                                                                                                                                                                                                                                                                                                                                                                                             |

**Value**

A [SingleCellExperiment](#) object (or Celda model object) with updated cell cluster and/or feature module labels.

**Examples**

```

data(sceCeldaCG)
reordersce <- reorderCelda(sceCeldaCG)

```

```

data(celdaCGSim, celdaCGMod)
reorderCeldaCG <- reorderCelda(celdaCGSim$counts, celdaCGMod)
data(celdaCSim, celdaCMod)
reorderCeldaC <- reorderCelda(celdaCSim$counts, celdaCMod)
data(celdaGSim, celdaGMod)
reorderCeldaG <- reorderCelda(celdaGSim$counts, celdaGMod)

```

---

reportceldaCG

*Generate an HTML report for celda\_CG*


---

## Description

reportCeldaCGRun will run [recursiveSplitModule](#) and [recursiveSplitCell](#) to find the number of modules (L) and the number of cell populations (K). A final [celda\\_CG](#) model will be selected from [recursiveSplitCell](#). After a [celda\\_CG](#) model has been fit, reportCeldaCGPlotResults can be used to create an HTML report for visualization and exploration of the [celda\\_CG](#) model results. Some of the plotting and feature selection functions require the installation of the Bioconductor package singleCellTK.

## Usage

```

reportCeldaCGRun(
  sce,
  L,
  K,
  sampleLabel = NULL,
  altExpName = "featureSubset",
  useAssay = "counts",
  initialL = 10,
  maxL = 150,
  initialK = 5,
  maxK = 50,
  minCell = 3,
  minCount = 3,
  maxFeatures = 5000,
  output_file = "CeldaCG_RunReport",
  output_sce_prefix = "celda_cg",
  output_dir = ".",
  pdf = FALSE,
  showSession = TRUE
)

reportCeldaCGPlotResults(
  sce,
  reducedDimName,
  features = NULL,
  displayName = NULL,
  altExpName = "featureSubset",
  useAssay = "counts",
  cellAnnot = NULL,
  cellAnnotLabel = NULL,

```

```

exactMatch = TRUE,
moduleFilePrefix = "module_features",
output_file = "CeldaCG_ResultReport",
output_dir = ".",
pdf = FALSE,
showSetup = TRUE,
showSession = TRUE
)

```

## Arguments

|                   |                                                                                                                                                                                                                                       |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sce               | A <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.                                                                                 |
| L                 | Integer. Final number of feature modules. See <code>celda_CG</code> for more information.                                                                                                                                             |
| K                 | Integer. Final number of cell populations. See <code>celda_CG</code> for more information.                                                                                                                                            |
| sampleLabel       | Vector or factor. Denotes the sample label for each cell (column) in the count matrix.                                                                                                                                                |
| altExpName        | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                         |
| useAssay          | A string specifying which <a href="#">assay</a> slot to use. Default "counts".                                                                                                                                                        |
| initialL          | Integer. Minimum number of modules to try. See <a href="#">recursiveSplitModule</a> for more information. Default 10.                                                                                                                 |
| maxL              | Integer. Maximum number of modules to try. See <a href="#">recursiveSplitModule</a> for more information. Default 150.                                                                                                                |
| initialK          | Integer. Initial number of cell populations to try.                                                                                                                                                                                   |
| maxK              | Integer. Maximum number of cell populations to try.                                                                                                                                                                                   |
| minCell           | Integer. Minimum number of cells required for feature selection. See <a href="#">selectFeatures</a> for more information. Default 3.                                                                                                  |
| minCount          | Integer. Minimum number of counts required for feature selection. See <a href="#">selectFeatures</a> for more information. Default 3.                                                                                                 |
| maxFeatures       | Integer. Maximum number of features to include. If the number of features after filtering for minCell and minCount are greater than maxFeature, then Seurat's VST function is used to select the top variable features. Default 5000. |
| output_file       | Character. Prefix of the html file. Default "CeldaCG_ResultReport".                                                                                                                                                                   |
| output_sce_prefix | Character. The sce object with <code>celda_CG</code> results will be saved to an <code>.rds</code> file starting with this prefix. Default <code>celda_cg</code> .                                                                    |
| output_dir        | Character. Path to save the html file. Default <code>..</code> .                                                                                                                                                                      |
| pdf               | Boolean. Whether to create PDF versions of each plot in addition to PNGs. Default FALSE.                                                                                                                                              |
| showSession       | Boolean. Whether to show the session information at the end. Default TRUE.                                                                                                                                                            |
| reducedDimName    | Character. Name of the reduced dimensional object to be used in 2-D scatter plots throughout the report. Default <code>celda_UMAP</code> .                                                                                            |
| features          | Character vector. Expression of these features will be displayed on a reduced dimensional plot defined by reducedDimName. If NULL, then no plotting of features on a reduced dimensional plot will be performed. Default NULL.        |

|                  |                                                                                                                                                                                                                                                                                      |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| displayName      | Character. The name to use for display in scatter plots and heatmaps. If NULL, then the rownames of the sce object will be used. This can also be set to the name of a column in the row data of sce or altExp(sce, altExpName). Default NULL.                                       |
| cellAnnot        | Character vector. The cell-level annotations to display on the reduced dimensional plot. These variables should be present in the column data of the sce object. Default NULL.                                                                                                       |
| cellAnnotLabel   | Character vector. Additional cell-level annotations to display on the reduced dimensional plot. Variables will be treated as categorical and labels for each group will be placed on the plot. These variables should be present in the column data of the sce object. Default NULL. |
| exactMatch       | Boolean. Whether to only identify exact matches or to identify partial matches using <a href="#">grep</a> . Default FALSE.                                                                                                                                                           |
| moduleFilePrefix | Character. The features in each module will be written to a csv file starting with this name. If NULL, then no file will be written. Default "module_features".                                                                                                                      |
| showSetup        | Boolean. Whether to show the setup code at the beginning. Default TRUE.                                                                                                                                                                                                              |

**Value**

.html file

**Examples**

```
data(sceCeldaCG)
## Not run:
library(SingleCellExperiment)
sceCeldaCG$sum <- colSums(counts(sceCeldaCG))
rowData(sceCeldaCG)$rownames <- rownames(sceCeldaCG)
sceCeldaCG <- reportCeldaCGRun(sceCeldaCG,
  initialL = 5, maxL = 20, initialK = 5,
  maxK = 20, L = 10, K = 5)
reportCeldaCGPlotResults(sce = sceCeldaCG,
  reducedDimName = "celda_UMAP",
  features = c("Gene_1", "Gene_100"),
  displayName = "rownames",
  cellAnnot="sum")

## End(Not run)
```

---

|                    |                                                                        |
|--------------------|------------------------------------------------------------------------|
| resamplePerplexity | <i>Calculate and visualize perplexity of all models in a celdaList</i> |
|--------------------|------------------------------------------------------------------------|

---

**Description**

Calculates the perplexity of each model's cluster assignments given the provided countMatrix, as well as resamplings of that count matrix, providing a distribution of perplexities and a better sense of the quality of a given K/L choice.

**Usage**

```

resamplePerplexity(
  x,
  celdaList,
  useAssay = "counts",
  altExpName = "featureSubset",
  doResampling = FALSE,
  numResample = 5,
  seed = 12345
)

## S4 method for signature 'SingleCellExperiment'
resamplePerplexity(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  doResampling = FALSE,
  numResample = 5,
  seed = 12345
)

## S4 method for signature 'ANY'
resamplePerplexity(
  x,
  celdaList,
  doResampling = FALSE,
  numResample = 5,
  seed = 12345
)

```

**Arguments**

|                           |                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>            | A numeric <a href="#">matrix</a> of counts or a <a href="#">SingleCellExperiment</a> returned from <a href="#">celdaGridSearch</a> with the matrix located in the assay slot under <code>useAssay</code> . Rows represent features and columns represent cells. Must contain "celda_grid_search" slot in <code>metadata(x)</code> if <code>x</code> is a <a href="#">SingleCellExperiment</a> object. |
| <code>celdaList</code>    | Object of class 'celdaList'. Used only if <code>x</code> is a matrix object.                                                                                                                                                                                                                                                                                                                          |
| <code>useAssay</code>     | A string specifying which <a href="#">assay</a> slot to use if <code>x</code> is a <a href="#">SingleCellExperiment</a> object. Default "counts".                                                                                                                                                                                                                                                     |
| <code>altExpName</code>   | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                                                                         |
| <code>doResampling</code> | Boolean. If TRUE, then each cell in the counts matrix will be resampled according to a multinomial distribution to introduce noise before calculating perplexity. Default FALSE.                                                                                                                                                                                                                      |
| <code>numResample</code>  | Integer. The number of times to resample the counts matrix for evaluating perplexity if <code>doResampling</code> is set to TRUE. Default 5.                                                                                                                                                                                                                                                          |
| <code>seed</code>         | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                                                                                                                                                                                                        |

**Value**

A [SingleCellExperiment](#) object or `celdaList` object with a `perplexity` property, detailing the perplexity of all K/L combinations that appeared in the `celdaList`'s models.

**Examples**

```
data(sceCeldaCGGridSearch)
sce <- resamplePerplexity(sceCeldaCGGridSearch)
plotGridSearchPerplexity(sce)
data(celdaCGSim, celdaCGGridSearchRes)
celdaCGGridSearchRes <- resamplePerplexity(
  celdaCGSim$counts,
  celdaCGGridSearchRes
)
plotGridSearchPerplexity(celdaCGGridSearchRes)
```

resList

*Get final celdaModels from a celda model SCE or celdaList object***Description**

Returns all `celda` models generated during a [celdaGridSearch](#) run.

**Usage**

```
resList(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
resList(x, altExpName = "featureSubset")

## S4 method for signature 'celdaList'
resList(x)
```

**Arguments**

`x` An object of class [SingleCellExperiment](#) or `celdaList`.

`altExpName` The name for the [altExp](#) slot to use. Default "featureSubset".

**Value**

List. Contains one `celdaModel` object for each of the parameters specified in `runParams(x)`.

**Examples**

```
data(sceCeldaCGGridSearch)
celdaCGGridModels <- resList(sceCeldaCGGridSearch)
data(celdaCGGridSearchRes)
celdaCGGridModels <- resList(celdaCGGridSearchRes)
```

---

```
retrieveFeatureIndex
```

*Retrieve row index for a set of features*

---

## Description

This will return indices of features among the rownames or rowData of a data.frame, matrix, or a [SummarizedExperiment](#) object including a [SingleCellExperiment](#). Partial matching (i.e. grepping) can be used by setting `exactMatch = FALSE`.

## Usage

```
retrieveFeatureIndex(
  features,
  x,
  by = "rownames",
  exactMatch = TRUE,
  removeNA = FALSE
)
```

## Arguments

|                         |                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>features</code>   | Character vector of feature names to find in the rows of <code>x</code> .                                                                                                                                                                                                                                                                                              |
| <code>x</code>          | A data.frame, matrix, or <a href="#">SingleCellExperiment</a> object to search.                                                                                                                                                                                                                                                                                        |
| <code>by</code>         | Character. Where to search for features in <code>x</code> . If set to "rownames" then the features will be searched for among <code>rownames(x)</code> . If <code>x</code> inherits from class <a href="#">SummarizedExperiment</a> , then <code>by</code> can be one of the fields in the row annotation data.frame (i.e. one of <code>colnames(rowData(x))</code> ). |
| <code>exactMatch</code> | Boolean. Whether to only identify exact matches or to identify partial matches using <a href="#">grep</a> .                                                                                                                                                                                                                                                            |
| <code>removeNA</code>   | Boolean. If set to FALSE, features not found in <code>x</code> will be given NA and the returned vector will be the same length as <code>features</code> . If set to TRUE, then the NA values will be removed from the returned vector. Default FALSE.                                                                                                                 |

## Value

A vector of row indices for the matching features in `x`.

## Author(s)

Yusuke Koga, Joshua Campbell

## See Also

['retrieveFeatureInfo'](#) from package 'scater' and [link{regex}](#) for how to use regular expressions when `exactMatch = FALSE`.

## Examples

```
data(celdaCGSim)
retrieveFeatureIndex(c("Gene_1", "Gene_5"), celdaCGSim$counts)
retrieveFeatureIndex(c("Gene_1", "Gene_5"), celdaCGSim$counts,
  exactMatch = FALSE)
```



---

|           |                                                                                       |
|-----------|---------------------------------------------------------------------------------------|
| runParams | <i>Get run parameters from a celda model SingleCellExperiment or celdaList object</i> |
|-----------|---------------------------------------------------------------------------------------|

---

### Description

Returns details on the clustering parameters and model priors from the celdaList object when it was created.

### Usage

```
runParams(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
runParams(x, altExpName = "featureSubset")

## S4 method for signature 'celdaList'
runParams(x)
```

### Arguments

|            |                                                                               |
|------------|-------------------------------------------------------------------------------|
| x          | An object of class <a href="#">SingleCellExperiment</a> or class celdaList.   |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset". |

### Value

Data Frame. Contains details on the various K/L parameters, chain parameters, seed, and final log-likelihoods derived for each model in the provided celdaList.

### Examples

```
data(sceCeldaCGGridSearch)
runParams(sceCeldaCGGridSearch)
data(celdaCGGridSearchRes)
runParams(celdaCGGridSearchRes)
```

---

|             |                    |
|-------------|--------------------|
| sampleCells | <i>sampleCells</i> |
|-------------|--------------------|

---

### Description

A matrix of simulated gene counts.

### Usage

```
sampleCells
```

### Format

A matrix of simulated gene counts with 10 rows (genes) and 10 columns (cells).

**Details**

A toy count matrix for use with celda.

Generated by Josh Campbell.

**Source**

<http://github.com/campbio/celda>

---

|             |                                                                                          |
|-------------|------------------------------------------------------------------------------------------|
| sampleLabel | <i>Get or set sample labels from a celda <a href="#">SingleCellExperiment</a> object</i> |
|-------------|------------------------------------------------------------------------------------------|

---

**Description**

Return or set the sample labels for the cells in sce.

**Usage**

```
sampleLabel(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
sampleLabel(x, altExpName = "featureSubset")

sampleLabel(x, altExpName = "featureSubset") <- value

## S4 replacement method for signature 'SingleCellExperiment'
sampleLabel(x, altExpName = "featureSubset") <- value

## S4 method for signature 'celdaModel'
sampleLabel(x)
```

**Arguments**

|            |                                                                                                                                                                                                                                                                                                                                                  |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | Can be one of <ul style="list-style-type: none"> <li>A <a href="#">SingleCellExperiment</a> object returned by <a href="#">celda_C</a>, <a href="#">celda_G</a>, or <a href="#">celda_CG</a>, with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells.</li> <li>A celda model object.</li> </ul> |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                    |
| value      | Character vector of sample labels for replacements. Works only if x is a <a href="#">Single-CellExperiment</a> object.                                                                                                                                                                                                                           |

**Value**

Character vector. Contains the sample labels provided at model creation, or those automatically generated by celda.

**Examples**

```
data(sceCeldaCG)
sampleLabel(sceCeldaCG)
data(celdaCGMod)
sampleLabel(celdaCGMod)
```

---

`sceCeldaC`*sceCeldaC*

---

**Description**

A [SingleCellExperiment](#) object containing the results of running [selectFeatures](#) and [celda\\_C](#) on [celdaCSim](#).

**Usage**

```
sceCeldaC
```

**Format**

A [SingleCellExperiment](#) object

**Examples**

```
data(celdaCSim)
sceCeldaC <- selectFeatures(celdaCSim$counts)
sceCeldaC <- celda_C(sceCeldaC,
  K = celdaCSim$K,
  sampleLabel = celdaCSim$sampleLabel,
  nchains = 1)
```

---

`sceCeldaCG`*sceCeldaCG*

---

**Description**

A [SingleCellExperiment](#) object containing the results of running [selectFeatures](#) and [celda\\_CG](#) on [celdaCGSim](#).

**Usage**

```
sceCeldaCG
```

**Format**

A [SingleCellExperiment](#) object

**Examples**

```
data(celdaCGSim)
sceCeldaCG <- selectFeatures(celdaCGSim$counts)
sceCeldaCG <- celda_CG(sceCeldaCG,
  K = celdaCGSim$K,
  L = celdaCGSim$L,
  sampleLabel = celdaCGSim$sampleLabel,
  nchains = 1)
```

---

sceCeldaCGGridSearch    *sceCeldaCGGridSearch*

---

### Description

A [SingleCellExperiment](#) object containing the results of running [selectFeatures](#) and [celdaGridSearch](#) on [celdaCGSim](#).

### Usage

```
sceCeldaCGGridSearch
```

### Format

A [SingleCellExperiment](#) object

### Examples

```
data(celdaCGSim)
sce <- selectFeatures(celdaCGSim$counts)
sceCeldaCGGridSearch <- celdaGridSearch(sce,
  model = "celda_CG",
  paramsTest = list(K = seq(4, 6), L = seq(9, 11)),
  paramsFixed = list(sampleLabel = celdaCGSim$sampleLabel),
  bestOnly = TRUE,
  nchains = 1,
  cores = 1,
  verbose = FALSE)
```

---

sceCeldaG    *sceCeldaG*

---

### Description

A [SingleCellExperiment](#) object containing the results of running [selectFeatures](#) and [celda\\_G](#) on [celdaGSim](#).

### Usage

```
sceCeldaG
```

### Format

A [SingleCellExperiment](#) object

### Examples

```
data(celdaGSim)
sceCeldaG <- selectFeatures(celdaGSim$counts)
sceCeldaG <- celda_G(sceCeldaG, L = celdaGSim$L, nchains = 1)
```

---

|                 |                                                         |
|-----------------|---------------------------------------------------------|
| selectBestModel | Select best chain within each combination of parameters |
|-----------------|---------------------------------------------------------|

---

## Description

Select the chain with the best log likelihood for each combination of tested parameters from a SCE object generated by [celdaGridSearch](#) or from a `celdaList` object.

## Usage

```
selectBestModel(x, asList = FALSE, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
selectBestModel(x, asList = FALSE, altExpName = "featureSubset")

## S4 method for signature 'celdaList'
selectBestModel(x, asList = FALSE)
```

## Arguments

|                         |                                                                                                                                                                                                                                                                                                                                                     |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>          | Can be one of <ul style="list-style-type: none"> <li>A <a href="#">SingleCellExperiment</a> object returned from <code>celdaGridSearch</code>, <code>recursiveSplitModule</code>, or <code>recursiveSplitCell</code>. Must contain a list named "celda_grid_search" in <code>metadata(x)</code>.</li> <li><code>celdaList</code> object.</li> </ul> |
| <code>asList</code>     | TRUE or FALSE. Whether to return the best model as a <code>celdaList</code> object or not. If FALSE, return the best model as a corresponding celda model object.                                                                                                                                                                                   |
| <code>altExpName</code> | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                                                                                                                                                                                                       |

## Value

One of

- A new [SingleCellExperiment](#) object containing one model with the best log-likelihood for each set of parameters in `metadata(x)`. If there is only one set of parameters, a new [SingleCellExperiment](#) object with the matching model stored in the `metadata` "celda\_parameters" slot will be returned. Otherwise, a new [SingleCellExperiment](#) object with the subset models stored in the `metadata` "celda\_grid\_search" slot will be returned.
- A new `celdaList` object containing one model with the best log-likelihood for each set of parameters. If only one set of parameters is in the `celdaList`, the best model will be returned directly instead of a `celdaList` object.

## See Also

[celdaGridSearch](#) [subsetCeldaList](#)

## Examples

```
data(sceCeldaCGGridSearch)
## Returns same result as running celdaGridSearch with "bestOnly = TRUE"
sce <- selectBestModel(sceCeldaCGGridSearch)
data(celdaCGGridSearchRes)
## Returns same result as running celdaGridSearch with "bestOnly = TRUE"
cgsBest <- selectBestModel(celdaCGGridSearchRes)
```

---

|                |                                                   |
|----------------|---------------------------------------------------|
| selectFeatures | <i>Simple feature selection by feature counts</i> |
|----------------|---------------------------------------------------|

---

## Description

A simple heuristic feature selection procedure. Select features with at least `minCount` counts in at least `minCell` cells. A [SingleCellExperiment](#) object with subset features will be stored in the `altExp` slot with name `altExpName`. The name of the assay slot in `altExp` will be the same as `useAssay`.

## Usage

```
selectFeatures(
  x,
  minCount = 3,
  minCell = 3,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'SingleCellExperiment'
selectFeatures(
  x,
  minCount = 3,
  minCell = 3,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'matrix'
selectFeatures(
  x,
  minCount = 3,
  minCell = 3,
  useAssay = "counts",
  altExpName = "featureSubset"
)
```

## Arguments

|                       |                                                                                                                                                                                                                   |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>        | A numeric <a href="#">matrix</a> of counts or a <a href="#">SingleCellExperiment</a> with the matrix located in the assay slot under <code>useAssay</code> . Rows represent features and columns represent cells. |
| <code>minCount</code> | Minimum number of counts required for feature selection.                                                                                                                                                          |

|            |                                                                                          |
|------------|------------------------------------------------------------------------------------------|
| minCell    | Minimum number of cells required for feature selection.                                  |
| useAssay   | A string specifying the name of the <a href="#">assay</a> slot to use. Default "counts". |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".            |

### Value

A [SingleCellExperiment](#) object with a altExpName [altExp](#) slot. Function parameter settings are stored in the [metadata](#) "select\_features" slot.

### Examples

```
data(sceCeldaCG)
sce <- selectFeatures(sceCeldaCG)
data(celdaCGSim)
sce <- selectFeatures(celdaCGSim$counts)
```

---

|              |                                               |
|--------------|-----------------------------------------------|
| semiPheatmap | <i>A function to draw clustered heatmaps.</i> |
|--------------|-----------------------------------------------|

---

### Description

A function to draw clustered heatmaps where one has better control over some graphical parameters such as cell size, etc.

The function also allows to aggregate the rows using kmeans clustering. This is advisable if number of rows is so big that R cannot handle their hierarchical clustering anymore, roughly more than 1000. Instead of showing all the rows separately one can cluster the rows in advance and show only the cluster centers. The number of clusters can be tuned with parameter kmeansK.

### Usage

```
semiPheatmap(
  mat,
  color = colorRampPalette(rev(brewer.pal(n = 7, name = "RdYlBu")))(100),
  kmeansK = NA,
  breaks = NA,
  borderColor = "grey60",
  cellWidth = NA,
  cellHeight = NA,
  scale = "none",
  clusterRows = TRUE,
  clusterCols = TRUE,
  clusteringDistanceRows = "euclidean",
  clusteringDistanceCols = "euclidean",
  clusteringMethod = "complete",
  clusteringCallback = .identity2,
  cutreeRows = NA,
  cutreeCols = NA,
  treeHeightRow = ifelse(clusterRows, 50, 0),
  treeHeightCol = ifelse(clusterCols, 50, 0),
  legend = TRUE,
  legendBreaks = NA,
```

```

legendLabels = NA,
annotationRow = NA,
annotationCol = NA,
annotation = NA,
annotationColors = NA,
annotationLegend = TRUE,
annotationNamesRow = TRUE,
annotationNamesCol = TRUE,
dropLevels = TRUE,
showRownames = TRUE,
showColnames = TRUE,
main = NA,
fontSize = 10,
fontSizeRow = fontSize,
fontSizeCol = fontSize,
displayNumbers = FALSE,
numberFormat = "%.2f",
numberColor = "grey30",
fontSizeNumber = 0.8 * fontSize,
gapsRow = NULL,
gapsCol = NULL,
labelsRow = NULL,
labelsCol = NULL,
fileName = NA,
width = NA,
height = NA,
silent = FALSE,
rowLabel,
colLabel,
rowGroupOrder = NULL,
colGroupOrder = NULL,
...
)

```

### Arguments

|             |                                                                                                                                                                                                                                                                                                 |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| mat         | numeric matrix of the values to be plotted.                                                                                                                                                                                                                                                     |
| color       | vector of colors used in heatmap.                                                                                                                                                                                                                                                               |
| kmeansK     | the number of kmeans clusters to make, if we want to aggregate the rows before drawing heatmap. If NA then the rows are not aggregated.                                                                                                                                                         |
| breaks      | Numeric vector. A sequence of numbers that covers the range of values in the normalized 'counts'. Values in the normalized 'matrix' are assigned to each bin in 'breaks'. Each break is assigned to a unique color from 'col'. If NULL, then breaks are calculated automatically. Default NULL. |
| borderColor | color of cell borders on heatmap, use NA if no border should be drawn.                                                                                                                                                                                                                          |
| cellWidth   | individual cell width in points. If left as NA, then the values depend on the size of plotting window.                                                                                                                                                                                          |
| cellHeight  | individual cell height in points. If left as NA, then the values depend on the size of plotting window.                                                                                                                                                                                         |
| scale       | character indicating if the values should be centered and scaled in either the row direction or the column direction, or none. Corresponding values are "row",                                                                                                                                  |



|                        |                                                                                                                                                                                                                                                                                                        |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        | "column" and "none".                                                                                                                                                                                                                                                                                   |
| clusterRows            | boolean values determining if rows should be clustered or hclust object,                                                                                                                                                                                                                               |
| clusterCols            | boolean values determining if columns should be clustered or hclust object.                                                                                                                                                                                                                            |
| clusteringDistanceRows | distance measure used in clustering rows. Possible values are "correlation" for Pearson correlation and all the distances supported by <a href="#">dist</a> , such as "euclidean", etc. If the value is none of the above it is assumed that a distance matrix is provided.                            |
| clusteringDistanceCols | distance measure used in clustering columns. Possible values the same as for clusteringDistanceRows.                                                                                                                                                                                                   |
| clusteringMethod       | clustering method used. Accepts the same values as <a href="#">hclust</a> .                                                                                                                                                                                                                            |
| clusteringCallback     | callback function to modify the clustering. Is called with two parameters: original hclust object and the matrix used for clustering. Must return a hclust object.                                                                                                                                     |
| cuttreeRows            | number of clusters the rows are divided into, based on the hierarchical clustering (using cutree), if rows are not clustered, the argument is ignored                                                                                                                                                  |
| cuttreeCols            | similar to cuttreeRows, but for columns                                                                                                                                                                                                                                                                |
| treeHeightRow          | the height of a tree for rows, if these are clustered. Default value 50 points.                                                                                                                                                                                                                        |
| treeHeightCol          | the height of a tree for columns, if these are clustered. Default value 50 points.                                                                                                                                                                                                                     |
| legend                 | logical to determine if legend should be drawn or not.                                                                                                                                                                                                                                                 |
| legendBreaks           | vector of breakpoints for the legend.                                                                                                                                                                                                                                                                  |
| legendLabels           | vector of labels for the legendBreaks.                                                                                                                                                                                                                                                                 |
| annotationRow          | data frame that specifies the annotations shown on left side of the heatmap. Each row defines the features for a specific row. The rows in the data and in the annotation are matched using corresponding row names. Note that color schemes takes into account if variable is continuous or discrete. |
| annotationCol          | similar to annotationRow, but for columns.                                                                                                                                                                                                                                                             |
| annotation             | deprecated parameter that currently sets the annotationCol if it is missing.                                                                                                                                                                                                                           |
| annotationColors       | list for specifying annotationRow and annotationCol track colors manually. It is possible to define the colors for only some of the features. Check examples for details.                                                                                                                              |
| annotationLegend       | boolean value showing if the legend for annotation tracks should be drawn.                                                                                                                                                                                                                             |
| annotationNamesRow     | boolean value showing if the names for row annotation tracks should be drawn.                                                                                                                                                                                                                          |
| annotationNamesCol     | boolean value showing if the names for column annotation tracks should be drawn.                                                                                                                                                                                                                       |
| dropLevels             | logical to determine if unused levels are also shown in the legend.                                                                                                                                                                                                                                    |
| showRownames           | boolean specifying if column names are be shown.                                                                                                                                                                                                                                                       |
| showColnames           | boolean specifying if column names are be shown.                                                                                                                                                                                                                                                       |
| main                   | the title of the plot                                                                                                                                                                                                                                                                                  |

|                |                                                                                                                                                                                                                                                                                                                |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| fontSize       | base fontsize for the plot                                                                                                                                                                                                                                                                                     |
| fontSizeRow    | fontsize for rownames (Default: fontsize)                                                                                                                                                                                                                                                                      |
| fontSizeCol    | fontsize for colnames (Default: fontsize)                                                                                                                                                                                                                                                                      |
| displayNumbers | logical determining if the numeric values are also printed to the cells. If this is a matrix (with same dimensions as original matrix), the contents of the matrix are shown instead of original values.                                                                                                       |
| numberFormat   | format strings (C printf style) of the numbers shown in cells. For example "%.2f" shows 2 decimal places and "%.1e" shows exponential notation (see more in <a href="#">sprintf</a> ).                                                                                                                         |
| numberColor    | color of the text                                                                                                                                                                                                                                                                                              |
| fontSizeNumber | fontsize of the numbers displayed in cells                                                                                                                                                                                                                                                                     |
| gapsRow        | vector of row indices that show where to put gaps into heatmap. Used only if the rows are not clustered. See <a href="#">cutreeRow</a> to see how to introduce gaps to clustered rows.                                                                                                                         |
| gapsCol        | similar to <a href="#">gapsRow</a> , but for columns.                                                                                                                                                                                                                                                          |
| labelsRow      | custom labels for rows that are used instead of rownames.                                                                                                                                                                                                                                                      |
| labelsCol      | similar to <a href="#">labelsRow</a> , but for columns.                                                                                                                                                                                                                                                        |
| fileName       | file path where to save the picture. Filetype is decided by the extension in the path. Currently following formats are supported: png, pdf, tiff, bmp, jpeg. Even if the plot does not fit into the plotting window, the file size is calculated so that the plot would fit there, unless specified otherwise. |
| width          | manual option for determining the output file width in inches.                                                                                                                                                                                                                                                 |
| height         | manual option for determining the output file height in inches.                                                                                                                                                                                                                                                |
| silent         | do not draw the plot (useful when using the <a href="#">gtable</a> output)                                                                                                                                                                                                                                     |
| rowLabel       | row cluster labels for semi-clustering                                                                                                                                                                                                                                                                         |
| colLabel       | column cluster labels for semi-clustering                                                                                                                                                                                                                                                                      |
| rowGroupOrder  | Vector. Specifies the order of feature clusters when semisupervised clustering is performed on the y labels.                                                                                                                                                                                                   |
| colGroupOrder  | Vector. Specifies the order of cell clusters when semisupervised clustering is performed on the z labels.                                                                                                                                                                                                      |
| ...            | graphical parameters for the text used in plot. Parameters passed to <a href="#">grid.text</a> , see <a href="#">gpar</a> .                                                                                                                                                                                    |

## Value

Invisibly a list of components

- `treeRow` the clustering of rows as [hclust](#) object
- `treeCol` the clustering of columns as [hclust](#) object
- `kmeans` the kmeans clustering of rows if parameter `kmeansK` was specified

**Author(s)**

```

Raivo Kolde <rkolde@gmail.com> ##examples # Create test matrix test = matrix(rnorm(200), 20,
10) test[seq(10), seq(1, 10, 2)] = test[seq(10), seq(1, 10, 2)] + 3 test[seq(11, 20), seq(2, 10, 2)] =
test[seq(11, 20), seq(2, 10, 2)] + 2 test[seq(15, 20), seq(2, 10, 2)] = test[seq(15, 20), seq(2, 10, 2)]
+ 4 colnames(test) = paste("Test", seq(10), sep = "") rownames(test) = paste("Gene", seq(20), sep
= "")

# Draw heatmaps pheatmap(test) pheatmap(test, kmeansK = 2) pheatmap(test, scale = "row", clus-
teringDistanceRows = "correlation") pheatmap(test, color = colorRampPalette(c("navy", "white",
"firebrick3"))(50)) pheatmap(test, cluster_row = FALSE) pheatmap(test, legend = FALSE)

# Show text within cells pheatmap(test, displayNumbers = TRUE) pheatmap(test, displayNumbers
= TRUE, numberFormat = "%.1e") pheatmap(test, displayNumbers = matrix(ifelse(test > 5, "*",
""), nrow(test))) pheatmap(test, cluster_row = FALSE, legendBreaks = seq(-1, 4), legendLabels =
c("0", "1e-4", "1e-3", "1e-2", "1e-1", "1"))

# Fix cell sizes and save to file with correct size pheatmap(test, cellWidth = 15, cellHeight = 12,
main = "Example heatmap") pheatmap(test, cellWidth = 15, cellHeight = 12, fontSize = 8, fileName
= "test.pdf")

# Generate annotations for rows and columns annotationCol = data.frame(CellType = factor(rep(c("CT1",
"CT2"), 5)), Time = seq(5)) rownames(annotationCol) = paste("Test", seq(10), sep = "")
annotationRow = data.frame(GeneClass = factor(rep(c("Path1", "Path2", "Path3"), c(10, 4, 6))))
rownames(annotationRow) = paste("Gene", seq(20), sep = "")

# Display row and color annotations pheatmap(test, annotationCol = annotationCol) pheatmap(test,
annotationCol = annotationCol, annotationLegend = FALSE) pheatmap(test, annotationCol = an-
notationCol, annotationRow = annotationRow)

# Specify colors ann_colors = list(Time = c("white", "firebrick"), CellType = c(CT1 = "#1B9E77",
CT2 = "#D95F02"), GeneClass = c(Path1 = "#7570B3", Path2 = "#E7298A", Path3 = "#66A61E"))
pheatmap(test, annotationCol = annotationCol, annotationColors = ann_colors, main = "Title")
pheatmap(test, annotationCol = annotationCol, annotationRow = annotationRow, annotationColors
= ann_colors) pheatmap(test, annotationCol = annotationCol, annotationColors = ann_colors[2])

# Gaps in heatmaps pheatmap(test, annotationCol = annotationCol, clusterRows = FALSE, gap-
sRow = c(10, 14)) pheatmap(test, annotationCol = annotationCol, clusterRows = FALSE, gapsRow
= c(10, 14), cutreeCol = 2)

# Show custom strings as row/col names labelsRow = c("", "", "", "", "", "", "", "", "", "", "", "", "",
"", "", "", "", "II10", "II15", "II1b")
pheatmap(test, annotationCol = annotationCol, labelsRow = labelsRow)

# Specifying clustering from distance matrix drows = stats::dist(test, method = "minkowski") dcols
= stats::dist(t(test), method = "minkowski") pheatmap(test, clusteringDistanceRows = drows, clus-
teringDistanceCols = dcols)

```

simulateCells

*Simulate count data from the celda generative models.***Description**

This function generates a [SingleCellExperiment](#) containing a simulated counts matrix in the "counts" assay slot, as well as various parameters used in the simulation which can be useful for running celda and are stored in metadata slot. The user must provide the desired model (one of celda\_C, celda\_G, celda\_CG) as well as any desired tuning parameters for those model's simulation functions as detailed below.

**Usage**

```
simulateCells(
  model = c("celda_CG", "celda_C", "celda_G"),
  S = 5,
  CRange = c(50, 100),
  NRange = c(500, 1000),
  C = 100,
  G = 100,
  K = 5,
  L = 10,
  alpha = 1,
  beta = 1,
  gamma = 5,
  delta = 1,
  seed = 12345
)
```

**Arguments**

|        |                                                                                                                                                                                                                 |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| model  | Character. Options available in <code>celda::availableModels</code> . Can be one of "celda_CG", "celda_C", or "celda_G". Default "celda_CG".                                                                    |
| S      | Integer. Number of samples to simulate. Default 5. Only used if model is one of "celda_CG" or "celda_C".                                                                                                        |
| CRange | Integer vector. A vector of length 2 that specifies the lower and upper bounds of the number of cells to be generated in each sample. Default c(50, 100). Only used if model is one of "celda_CG" or "celda_C". |
| NRange | Integer vector. A vector of length 2 that specifies the lower and upper bounds of the number of counts generated for each cell. Default c(500, 1000).                                                           |
| C      | Integer. Number of cells to simulate. Default 100. Only used if model is "celda_G".                                                                                                                             |
| G      | Integer. The total number of features to be simulated. Default 100.                                                                                                                                             |
| K      | Integer. Number of cell populations. Default 5. Only used if model is one of "celda_CG" or "celda_C".                                                                                                           |
| L      | Integer. Number of feature modules. Default 10. Only used if model is one of "celda_CG" or "celda_G".                                                                                                           |
| alpha  | Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Default 1. Only used if model is one of "celda_CG" or "celda_C".                                         |
| beta   | Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature module in each cell population. Default 1.                                                                                         |
| gamma  | Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Default 5. Only used if model is one of "celda_CG" or "celda_G".                                         |
| delta  | Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Default 1. Only used if model is one of "celda_CG" or "celda_G".                                                   |
| seed   | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                  |

**Value**

A [SingleCellExperiment](#) object with simulated count matrix stored in the "counts" assay slot. Function parameter settings are stored in the [metadata](#) slot. For "celda\_CG" and "celda\_C" models, columns `celda_sample_label` and `celda_cell_cluster` in [colData](#) contain simulated sample labels and cell population clusters. For "celda\_CG" and "celda\_G" models, column `celda_feature_module` in [rowData](#) contains simulated gene modules.

**Examples**

```
sce <- simulateCells()
```

---

```
simulateContamination    Simulate contaminated count matrix
```

---

**Description**

This function generates a list containing two count matrices – one for real expression, the other one for contamination, as well as other parameters used in the simulation which can be useful for running decontamination.

**Usage**

```
simulateContamination(
  C = 300,
  G = 100,
  K = 3,
  NRange = c(500, 1000),
  beta = 0.1,
  delta = c(1, 10),
  numMarkers = 3,
  seed = 12345
)
```

**Arguments**

|                         |                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>C</code>          | Integer. Number of cells to be simulated. Default 300.                                                                                                                                                                                                                                                                                            |
| <code>G</code>          | Integer. Number of genes to be simulated. Default 100.                                                                                                                                                                                                                                                                                            |
| <code>K</code>          | Integer. Number of cell populations to be simulated. Default 3.                                                                                                                                                                                                                                                                                   |
| <code>NRange</code>     | Integer vector. A vector of length 2 that specifies the lower and upper bounds of the number of counts generated for each cell. Default <code>c(500, 1000)</code> .                                                                                                                                                                               |
| <code>beta</code>       | Numeric. Concentration parameter for Phi. Default 0.1.                                                                                                                                                                                                                                                                                            |
| <code>delta</code>      | Numeric or Numeric vector. Concentration parameter for Theta. If input as a single numeric value, symmetric values for beta distribution are specified; if input as a vector of length 2, the two values will be the <code>shape1</code> and <code>shape2</code> parameters of the beta distribution respectively. Default <code>c(1, 5)</code> . |
| <code>numMarkers</code> | Integer. Number of markers for each cell population. Default 3.                                                                                                                                                                                                                                                                                   |
| <code>seed</code>       | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made.                                                                                                                                                                                    |

**Value**

A list containing the nativeMatrix (real expression), observedMatrix (real expression + contamination), as well as other parameters used in the simulation.

**Author(s)**

Shiyi Yang, Yuan Yin, Joshua Campbell

**Examples**

```
contaminationSim <- simulateContamination(K = 3, delta = c(1, 10))
```

---

splitModule

*Split celda feature module*


---

**Description**

Manually select a celda feature module to split into 2 or more modules. Useful for splitting up modules that show divergent expression of features in multiple cell clusters.

**Usage**

```
splitModule(
  x,
  module,
  useAssay = "counts",
  altExpName = "featureSubset",
  n = 2,
  seed = 12345
)

## S4 method for signature 'SingleCellExperiment'
splitModule(
  x,
  module,
  useAssay = "counts",
  altExpName = "featureSubset",
  n = 2,
  seed = 12345
)
```

**Arguments**

|            |                                                                                                                                                                |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | A <a href="#">SingleCellExperiment</a> object with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.   |
| module     | Integer. The module to be split.                                                                                                                               |
| useAssay   | A string specifying which <a href="#">assay</a> slot to use for x. Default "counts".                                                                           |
| altExpName | The name for the <a href="#">altExp</a> slot to use. Default "featureSubset".                                                                                  |
| n          | Integer. How many modules should module be split into. Default 2.                                                                                              |
| seed       | Integer. Passed to <a href="#">with_seed</a> . For reproducibility, a default value of 12345 is used. If NULL, no calls to <a href="#">with_seed</a> are made. |

**Value**

A updated [SingleCellExperiment](#) object with new feature modules stored in column `celda_feature_module` in `rowData(x)`.

**Examples**

```
data(sceCeldaCG)
# Split module 5 into 2 new modules.
sce <- splitModule(sceCeldaCG, module = 5)
```

---

|                 |                                                                         |
|-----------------|-------------------------------------------------------------------------|
| subsetCeldaList | <i>Subset celda model from SCE object returned from celdaGridSearch</i> |
|-----------------|-------------------------------------------------------------------------|

---

**Description**

Select a subset of models from a [SingleCellExperiment](#) object generated by [celdaGridSearch](#) that match the criteria in the argument `params`.

**Usage**

```
subsetCeldaList(x, params, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
subsetCeldaList(x, params, altExpName = "featureSubset")

## S4 method for signature 'celdaList'
subsetCeldaList(x, params)
```

**Arguments**

|                         |                                                                                                                                                                                                                                                                                                                                                                  |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>          | Can be one of <ul style="list-style-type: none"> <li>A <a href="#">SingleCellExperiment</a> object returned from <code>celdaGridSearch</code>, <code>recursiveSplitModule</code>, or <code>recursiveSplitCell</code>. Must contain a list named <code>"celda_grid_search"</code> in <code>metadata(x)</code>.</li> <li><code>celdaList</code> object.</li> </ul> |
| <code>params</code>     | List. List of parameters used to subset the matching celda models in list <code>"celda_grid_search"</code> in <code>metadata(x)</code> .                                                                                                                                                                                                                         |
| <code>altExpName</code> | The name for the <a href="#">altExp</a> slot to use. Default <code>"featureSubset"</code> .                                                                                                                                                                                                                                                                      |

**Value**

One of

- A new [SingleCellExperiment](#) object containing all models matching the provided criteria in `params`. If only one celda model result in the `"celda_grid_search"` slot in `metadata(x)` matches the given criteria, a new [SingleCellExperiment](#) object with the matching model stored in the `metadata` `"celda_parameters"` slot will be returned. Otherwise, a new [SingleCellExperiment](#) object with the subset models stored in the `metadata` `"celda_grid_search"` slot will be returned.
- A new `celdaList` object containing all models matching the provided criteria in `params`. If only one item in the `celdaList` matches the given criteria, the matching model will be returned directly instead of a `celdaList` object.

**See Also**

[celdaGridSearch](#) can run Celda with multiple parameters and chains in parallel. [selectBestModel](#) can get the best model for each combination of parameters.

**Examples**

```
data(sceCeldaCGGridSearch)
sceK5L10 <- subsetCeldaList(sceCeldaCGGridSearch,
  params = list(K = 5, L = 10))
data(celdaCGGridSearchRes)
resK5L10 <- subsetCeldaList(celdaCGGridSearchRes,
  params = list(K = 5, L = 10))
```

---

topRank

*Identify features with the highest influence on clustering.*


---

**Description**

topRank() can quickly identify the top ‘n’ rows for each column of a matrix. For example, this can be useful for identifying the top ‘n’ features per cell.

**Usage**

```
topRank(matrix, n = 25, margin = 2, threshold = 0, decreasing = TRUE)
```

**Arguments**

|            |                                                                                                                                                 |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| matrix     | Numeric matrix.                                                                                                                                 |
| n          | Integer. Maximum number of items above ‘threshold’ returned for each ranked row or column.                                                      |
| margin     | Integer. Dimension of ‘matrix’ to rank, with 1 for rows, 2 for columns. Default 2.                                                              |
| threshold  | Numeric. Only return ranked rows or columns in the matrix that are above this threshold. If NULL, then no threshold will be applied. Default 0. |
| decreasing | Logical. Specifies if the rank should be decreasing. Default TRUE.                                                                              |

**Value**

List. The ‘index’ variable provides the top ‘n’ row (feature) indices contributing the most to each column (cell). The ‘names’ variable provides the rownames corresponding to these indexes.

**Examples**

```
data(sampleCells)
topRanksPerCell <- topRank(sampleCells, n = 5)
topFeatureNamesForCell <- topRanksPerCell$names[1]
```



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