

# Package ‘graphite’

September 21, 2023

**Version** 1.46.0

**Date** 2022-04-19

**Title** GRAPH Interaction from pathway Topological Environment

**Description** Graph objects from pathway topology derived from KEGG, Panther, PathBank, PharmGKB, Reactome SMPDB and WikiPathways databases.

**License** AGPL-3

**URL** <https://github.com/sales-lab/graphite>

**BugReports** <https://github.com/sales-lab/graphite/issues>

**Depends** R (>= 4.2), methods

**Imports** AnnotationDbi, graph (>= 1.67.1), httr, rappdirs, stats, utils, graphics, rlang, purrr

**Suggests** checkmate, a4Preproc, ALL, BiocStyle, clipper, codetools, hgu133plus2.db, hgu95av2.db, impute, knitr, org.Hs.eg.db, parallel, R.rsp, RCy3, rmarkdown, SPIA (>= 2.2), testthat, topologyGSA (>= 1.4.0)

**Collate** pathway.R fetch.R conversion.R plot.R utils.R clipper.R graph.R spia.R tables.R topologygsa.R build.R

**VignetteBuilder** R.rsp

**biocViews** Pathways, ThirdPartyClient, GraphAndNetwork, Network, Reactome, KEGG, Metabolomics

**git\_url** <https://git.bioconductor.org/packages/graphite>

**git\_branch** RELEASE\_3\_17

**git\_last\_commit** c59c522

**git\_last\_commit\_date** 2023-04-25

**Date/Publication** 2023-09-21

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**R topics documented:**

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---

as.list.PathwayList    *Conversion of PathwayLists into lists.*

---

**Description**

Converts a [PathwayList](#) into a list of [Pathways](#).

**Usage**

```
## S3 method for class 'PathwayList'
as.list(x, ...)
```

**Arguments**

x                    a [PathwayList](#) object  
 ...                  extra arguments to as.list

**Value**

A list of pathways.

**Author(s)**

Gabriele Sales

**See Also**

[PathwayList](#)

## Examples

```
as.list(pathways("hsapiens", "kegg"))
```

---

buildPathway	<i>Build a Pathway object.</i>
--------------	--------------------------------

---

## Description

This function creates a new object of type Pathway given a data frame describing its edges.

## Usage

```
buildPathway(id, title, species, database, proteinEdges,  
             metaboliteEdges = NULL, mixedEdges = NULL,  
             timestamp = NULL)
```

## Arguments

id	the pathway identifier.
title	the title of the pathway.
species	the species the pathway belongs to.
database	the name of the database the pathway derives from.
proteinEdges	a data.frame of edges between proteins (or genes). Must have the following columns: src_type, src, dest_type, dest, direction and type. Direction must be one of the two strings: "directed" or "undirected".
metaboliteEdges	interactions between metabolites. Can be NULL. Otherwise, it must have the same structure as proteinEdges.
mixedEdges	interactions between metabolites and proteins. Can be NULL. Otherwise, it must have the same structure as proteinEdges.
timestamp	when the pathway was annotated, by default the time buildPathway is called.

## Value

A new [Pathway](#) instance.

## Examples

```
edges <- data.frame(src_type = "ENTREZID", src="672",
                   dest_type = "ENTREZID", dest="7157",
                   direction="undirected", type="binding")
pathway <- buildPathway("#1", "example", "hsapiens", "database", edges)

# Example with metabolites:
edges <- data.frame(src_type = "ENTREZID", src="672",
                   dest_type = "ENTREZID", dest="7157",
                   direction="undirected", type="binding")
mixed <- data.frame(src_type = "CHEBI", src="77750",
                   dest_type = "ENTREZID", dest="7157",
                   direction="undirected", type="binding")
pathway <- buildPathway("#1", "example", "hsapiens", "database",
                       edges, mixedEdges = mixed)
```

---

convertIdentifiers      *Convert the node identifiers of a pathway.*

---

## Description

Converts the node identifiers of pathways.

If the option `Ncpus` is set to a value larger than 1 and the package `parallel` is installed, the conversion procedure will automatically use multiple cores.

## Usage

```
convertIdentifiers(x, to)
```

## Arguments

<code>x</code>	can be a list of pathways or a single pathway
<code>to</code>	a string describing the type of the identifier. Can assume the values "entrez", "symbol" or the name of one of the columns provided by an Annotation package (for example, "UNIPROT").

## Value

A Pathway object.

## See Also

[Pathway](#)

## Examples

```
r <- pathways("hsapiens", "reactome")
convertIdentifiers(r$mTORC1-mediated signalling`, "symbol")
```

---

cytoscapePlot	<i>Plot a pathway graph in Cytoscape</i>
---------------	--

---

### Description

Renders the topology of a pathway as a Cytoscape graph.

### Usage

```
cytoscapePlot(pathway, ..., cy.ver = 3)
```

### Arguments

pathway	a Pathway object.
...	optional arguments forwarded to <a href="#">pathwayGraph</a> .
cy.ver	select a Cytoscape version. Only version 3 is supported in this release.

### Details

Requires the RCy3 package.

### Value

An invisible list with two items:

graph	the <a href="#">graphNEL</a> object sent to Cytoscape.
suid	the RCy3 network SUID.

### See Also

[Pathway](#)  
[pathwayGraph](#)

### Examples

```
## Not run:  
r <- pathways()  
cytoscapePlot(convertIdentifiers(reactome$`Unwinding of DNA`, "symbol"))  
  
## End(Not run)
```

---

Pathway-class	<i>Class "Pathway"</i>
---------------	------------------------

---

### Description

A biological pathway.

### Variants

A Pathway instance actually stores multiple variants of the same biological data.

This is the list of included variants:

- `proteins`: includes only interactions among proteins;
- `metabolites`: includes only interactions among metabolites;
- `mixed`: includes all available interactions.

### Methods

`pathwayId(p)`: Returns the native ID of the pathway.

`pathwayTitle(p)`: Returns the title of the pathway.

`pathwayDatabase(p)`: Returns the name of the database the pathway was derived from.

`pathwaySpecies(p)`: Returns the name of the species in which the pathway was annotated.

`pathwayTimestamp(p)`: Returns the date of pathway data retrieval.

`pathwayURL(p)`: Returns the URL of the pathway in its original database, if available.

`convertIdentifiers(p, to)`: Returns a new pathway using a different type of node identifiers.

`edges(p, which = c("proteins", "metabolites", "mixed"), stringsAsFactors = TRUE)`: Returns a data.frame describing the edges of this pathway.

The option which selects the desired pathway variant (see section "Variants" above).

If `stringsAsFactors` is TRUE, strings are converted to factors.

`nodes(p, which = c("proteins", "metabolites", "mixed"))`: Returns the names of the nodes belonging to this pathway.

The option which selects the desired pathway variant (see section "Variants" above).

`plot(p)`: Shows the pathway topology in Cytoscape.

`runClipper(p, expr, classes, method, ...)`: Runs a clipper analysis over the pathway.

`runTopologyGSA(p, test, exp1, exp2, alpha, ...)`: Runs a topologyGSA analysis over the pathway.

### Author(s)

Gabriele Sales

### See Also

[pathways](#)

### Examples

```
reactome <- pathways("hsapiens", "reactome")
pathway <- reactome[[1]]

pathwayTitle(pathway)
pathwaySpecies(pathway)
nodes(pathway)
edges(pathway)
```

---

pathwayDatabases	<i>List the available pathway databases.</i>
------------------	--

---

### Description

Obtains the list of pathway databases available through graphi te.

### Usage

```
pathwayDatabases()
```

### Value

Returns a data.frame with two columns: species and database.

### Author(s)

Gabriele Sales

### See Also

[pathways](#)

### Examples

```
pathwayDatabases()
```

---

pathwayGraph	<i>Graph representing the topology of a pathway</i>
--------------	---

---

**Description**

Builds a graphNEL object representing the topology of a pathway.

**Usage**

```
pathwayGraph(pathway, which = "proteins", edge.types = NULL)
```

**Arguments**

pathway	a <a href="#">Pathway</a> object.
which	the pathway variant you want. See <a href="#">Pathway</a> documentation for a list of the supported variants.
edge.types	keep only the edges matching the type names in this vector.

**Value**

A graphNEL object.

**See Also**

[Pathway](#)  
[graphNEL](#)

**Examples**

```
r <- pathways("hsapiens", "reactome")
pathwayGraph(r$`mTORC1-mediated signalling`, edge.types="Binding")
```

---

PathwayList-class	<i>Class "PathwayList"</i>
-------------------	----------------------------

---

**Description**

A collection of pathways from a single database.

**Extends**

Class "[Pathways](#)", directly.

## Methods

`l[i]` returns a selection of the pathways contained in the pathway list.

`l[[i]]` gives access to one of the pathways contained in the pathway list.

`l$title` loads a pathways by its title.

`convertIdentifiers(l, to)` returns a new list of pathways using a different type of node identifiers.

`length(l)` returns the number of pathways contained in the list.

`names(l)` returns the titles of the pathways contained in the list.

`prepareSPIA(l, pathwaySetName, print.names=FALSE)` prepares the pathways for a SPIA analysis.

`runClipper(l, expr, classes, method, maxNodes=150, ...)` runs a clipper analysis over all the pathways in the list.

`runTopologyGSA(l, test, exp1, exp2, alpha, maxNodes=150, ...)` runs a topologyGSA analysis over all the pathways in the list.

## Author(s)

Gabriele Sales

## See Also

[pathways](#)

---

pathways

*Retrieve a list of pathways.*

---

## Description

Retrieve a list of pathways from a database for a given species.

graphite currently supports the following databases:

- [KEGG](#)
- [PANTHER](#)
- [PathBank](#)
- [PharmGKB](#)
- [Reactome](#)
- [SMPDB](#)
- [WikiPathways](#)

Call the [pathwayDatabase](#) function for more details.

## Usage

```
pathways(species, database)
```

**Arguments**

species            one of the supported species  
database           the name of the pathway database

**Value**

A PathwayList object.

**See Also**

[PathwayList](#), [pathwayDatabases](#)

**Examples**

```
pathways("hsapiens", "reactome")
```

---

Pathways-class	<i>Class "Pathways"</i>
----------------	-------------------------

---

**Description**

A virtual class acting as a common parent to all other classes representing pathway databases.

**Objects from the Class**

A virtual Class: No objects may be created from it.

**Methods**

No methods defined with class "Pathways" in the signature.

**Author(s)**

Gabriele Sales

**See Also**

[PathwayList](#)

---

prepareSPIA	<i>Prepare pathway dataset needed by runSPIA.</i>
-------------	---

---

**Description**

Prepare pathway dataset needed by runSPIA. See [runSPIA](#) and [spia](#) for more details.

**Usage**

```
prepareSPIA(db, pathwaySetName, print.names = FALSE)
```

**Arguments**

`db` a [PathwayList](#) object or a list of [Pathways](#).  
`pathwaySetName` name of the output pathway set.  
`print.names` print pathway names as the conversion advances.

**Value**

This function has no return value.

**References**

Tarca AL, Draghici S, Khatri P, Hassan SS, Mittal P, Kim JS, Kim CJ, Kusanovic JP, Romero R. A novel signaling pathway impact analysis. *Bioinformatics*. 2009 Jan 1;25(1):75-82.

Adi L. Tarca, Sorin Draghici, Purvesh Khatri, et. al, A Signaling Pathway Impact Analysis for Microarray Experiments, 2008, *Bioinformatics*, 2009, 25(1):75-82.

Draghici, S., Khatri, P., Tarca, A.L., Amin, K., Done, A., Voichita, C., Georgescu, C., Romero, R.: A systems biology approach for pathway level analysis. *Genome Research*, 17, 2007.

**See Also**

[runSPIA](#)

[spia](#)

[PathwayList](#)

---

runClipper

*Run a topological analysis on an expression dataset using clipper.*


---

## Description

clipper is a package for topological gene set analysis. It implements a two-step empirical approach based on the exploitation of graph decomposition into a junction tree to reconstruct the most relevant signal path. In the first step clipper selects significant pathways according to statistical tests on the means and the concentration matrices of the graphs derived from pathway topologies. Then, it "clips" the whole pathway identifying the signal paths having the greatest association with a specific phenotype.

If the option `Ncpus` is set to a value larger than 1 and the package `parallel` is installed, the conversion procedure will automatically use multiple cores.

## Usage

```
runClipper(x, expr, classes, method, which = "proteins", seed = NULL, ...)
```

## Arguments

<code>x</code>	a <a href="#">PathwayList</a> , a list of <a href="#">Pathways</a> or a single <a href="#">Pathway</a> object.
<code>expr</code>	a matrix (size: number <code>p</code> of genes x number <code>n</code> of samples) of gene expression.
<code>classes</code>	a vector (length: <code>n</code> ) of class assignments.
<code>method</code>	the kind of test to perform on the cliques. It could be either "mean" or "variance".
<code>which</code>	the pathway variant you want. See <a href="#">Pathway</a> documentation for a list of the supported variants.
<code>seed</code>	if not NULL, set the seed for the random number generator used by clipper.
<code>...</code>	additional options: see for details <a href="#">easyClip</a> . When invoked on a <a href="#">PathwayList</a> , you can use the named option <code>maxNodes</code> to limit the analysis to those pathways with at most a given number of nodes.

## Details

The expression data and the pathway have to be annotated in the same set of identifiers.

## Value

See the documentation of [easyClip](#).

## References

Martini P, Sales G, Massa MS, Chiogna M, Romualdi C. Along signal paths: an empirical gene set approach exploiting pathway topology. *Nucleic Acids Res.* 2013 Jan 7;41(1):e19. doi: 10.1093/nar/gks866. Epub 2012 Sep 21. PubMed PMID: 23002139; PubMed Central PMCID: PMC3592432.

**See Also**[clipper](#)**Examples**

```

if (require(clipper) & require(ALL) & require(a4Preproc)) {
  data(ALL)
  pheno <- as(phenoData(ALL), "data.frame")
  samples <- unlist(lapply(c("NEG", "BCR/ABL"), function(t) {
    which(grepl("^B\\d*", pheno$BT) & (pheno$mol.biol == t))[1:10]
  }))
  classes <- c(rep(1,10), rep(2,10))

  expr <- exprs(ALL)[,samples]
  rownames(expr) <- paste("ENTREZID", featureData(addGeneInfo(ALL))$ENTREZID,
    sep = ":")

  k <- as.list(pathways("hsapiens", "kegg"))
  selected <- k[c("Bladder cancer", "Hippo signaling pathway - multiple species")]

  runClipper(selected, expr, classes, "mean", pathThr = 0.1)
}

```

runSPIA

*Run SPIA analysis***Description**

Run a topological analysis on an expression dataset using SPIA.

**Usage**

```
runSPIA(de, all, pathwaySetName, ...)
```

**Arguments**

de	A named vector containing log <sub>2</sub> fold-changes of the differentially expressed genes. The names of this numeric vector are Entrez gene IDs.
all	A vector with the Entrez IDs in the reference set. If the data was obtained from a microarray experiment, this set will contain all genes present on the specific array used for the experiment. This vector should contain all names of the 'de' argument.
pathwaySetName	The name of a pathway set created with <a href="#">prepareSPIA</a> .
...	Additional options to pass to <a href="#">spia</a> .

**Details**

The spia option "organism" is internally used. It is an error use it in the additional options.

**Value**

The same of `spia`, without KEGG links. A data frame containing the ranked pathways and various statistics: `pSize` is the number of genes on the pathway; `NDE` is the number of DE genes per pathway; `tA` is the observed total perturbation accumulation in the pathway; `pNDE` is the probability to observe at least `NDE` genes on the pathway using a hypergeometric model; `pPERT` is the probability to observe a total accumulation more extreme than `tA` only by chance; `pG` is the p-value obtained by combining `pNDE` and `pPERT`; `pGFdr` and `pGFWER` are the False Discovery Rate and respectively Bonferroni adjusted global p-values; and the `Status` gives the direction in which the pathway is perturbed (activated or inhibited).

**References**

Tarca AL, Draghici S, Khatri P, Hassan SS, Mittal P, Kim JS, Kim CJ, Kusanovic JP, Romero R. A novel signaling pathway impact analysis. *Bioinformatics*. 2009 Jan 1;25(1):75-82.

Adi L. Tarca, Sorin Draghici, Purvesh Khatri, et. al, A Signaling Pathway Impact Analysis for Microarray Experiments, 2008, *Bioinformatics*, 2009, 25(1):75-82.

Draghici, S., Khatri, P., Tarca, A.L., Amin, K., Done, A., Voichita, C., Georgescu, C., Romero, R.: A systems biology approach for pathway level analysis. *Genome Research*, 17, 2007.

**See Also**

[spia](#)

**Examples**

```
if (require(SPIA) && require(hgu133plus2.db)) {
  data(colorectalcancer)

  top$ENTREZ <- mapIds(hgu133plus2.db, top$ID, "ENTREZID", "PROBEID", multiVals = "first")
  top <- top[!is.na(top$ENTREZ) & !duplicated(top$ENTREZ), ]
  top$ENTREZ <- paste("ENTREZID", top$ENTREZ, sep = ":")
  tg1 <- top[top$adj.P.Val < 0.05, ]

  DE_Colorectal = tg1$logFC
  names(DE_Colorectal) <- tg1$ENTREZ
  ALL_Colorectal <- top$ENTREZ

  kegg <- pathways("hsapiens", "kegg")[1:20]
  kegg <- convertIdentifiers(kegg, "ENTREZID")
  prepareSPIA(kegg, "keggEx")
  runSPIA(de = DE_Colorectal, all = ALL_Colorectal, "keggEx")

  unlink("keggExSPIA.RData")
}
```

---

runTopologyGSA	<i>Run a topological analysis on an expression dataset using topologyGSA.</i>
----------------	---

---

## Description

Use graphical models to test the pathway components highlighting those involved in its deregulation.

If the option `Ncpus` is set to a value larger than 1 and the package `parallel` is installed, the conversion procedure will automatically use multiple cores.

## Usage

```
runTopologyGSA(x, test, exp1, exp2, alpha, ...)
```

## Arguments

<code>x</code>	a <a href="#">PathwayList</a> , a list of <a href="#">Pathways</a> or a single <a href="#">Pathway</a> object.
<code>test</code>	Either "var" and "mean". Determine the type of test used by topologyGSA.
<code>exp1</code>	Experiment matrix of the first class, genes in columns.
<code>exp2</code>	Experiment matrix of the second class, genes in columns.
<code>alpha</code>	Significance level of the test.
<code>...</code>	Additional parameters forwarded to topologyGSA. When invoked on a <a href="#">PathwayList</a> , can use the named option "maxNodes" to limit the analysis to those pathways having up to this given number of nodes.

## Details

This function produces a warning and returns NULL when the number of genes in common between the expression matrices and the pathway is less than 3.

## Value

See documentation of [pathway.var.test](#) and [pathway.mean.test](#).

## References

Massa MS, Chiogna M, Romualdi C. Gene set analysis exploiting the topology of a pathway. *BMC System Biol.* 2010 Sep 1;4:121.

**Examples**

```
if (require(topologyGSA)) {  
  data(examples)  
  colnames(y1) <- paste("SYMBOL", colnames(y1), sep = ":")  
  colnames(y2) <- paste("SYMBOL", colnames(y2), sep = ":")  
  
  k <- pathways("hsapiens", "kegg")  
  p <- convertIdentifiers(k[["Fc epsilon RI signaling pathway"]], "SYMBOL")  
  runTopologyGSA(p, "var", y1, y2, 0.05)  
}
```

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