Package 'GEOquery'

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Title Get data from NCBI Gene Expression Omnibus (GEO)

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Description The NCBI Gene Expression Omnibus (GEO) is a public repository of microarray data. Given the rich and varied nature of this resource, it is only natural to want to apply BioConductor tools to these data. GEOquery is the bridge between GEO and BioConductor.

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Author Sean Davis [aut, cre] (ORCID: <https://orcid.org/0000-0002-8991-6458>)

Maintainer Sean Davis <seandavi@gmail.com>

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browseGEOAccession *Open the GEO page for a given accession*

Description

Sometimes, you just need to see the GEO website page for a GEO accession. This function opens the GEO page for a given accession number in the default browser.

Usage

```
browseGEOAccession(geo)
```

Arguments

geo	A GEO accession number

See Also

urlForAccession

Examples

```
## Not run:
browseGEOAccession("GSE262484")

## End(Not run)
```

browseWebsiteRNASeqSearch *Browse GEO search website for RNA-seq datasets*

Description

This function opens a browser window to the NCBI GEO website with a search for RNA-seq datasets. It is included as a convenience function to remind users of how to search for RNA-seq datasets using the NCBI GEO website and an "rnaseq counts" filter.

Usage

```
browseWebsiteRNASeqSearch()
```

Examples

```
## Not run:
browseWebsiteRNASeqSearch()

## End(Not run)
```

coercion *Convert a GDS data structure to a BioConductor data structure*

Description

Functions to take a GDS data structure from getGEO and coerce it to limma MALists or ExpressionSets.

Arguments

GDS	The GDS datastructure returned by getGEO
do.log2	Boolean, should the data in the GDS be log2 transformed before inserting into the new data structure
GPL	Either a GPL data structure (from a call to getGEO) or NULL. If NULL, this will cause a call to getGEO to produce a GPL. The gene information from the GPL is then used to construct the genes slot of the resulting limma MAList object or the featureData slot of the ExpressionSet instance.
AnnotGPL	In general, the annotation GPL files will be available for GDS records, so the default is to use these files over the user-submitted GPL files
getGPL	A boolean defaulting to TRUE as to whether or not to download and include GPL information when converting to ExpressionSet or MAList. You may want to set this to FALSE if you know that you are going to annotate your featureData using Bioconductor tools rather than relying on information provided through NCBI GEO. Download times can also be greatly reduced by specifying FALSE.

Details

This function just rearranges one data structure into another. For GDS, it also deals appropriately with making the 'targets' list item for the limma data structure and the phenoData slot of ExpressionSets.

Value

GDS2MA	A limma MAList
GDS2eSet	An ExpressionSet object

Author(s)

Sean Davis

References

See the limma and ExpressionSet help in the appropriate packages

Examples

```
## Not run: gds505 <- getGEO('GDS505')
## Not run: MA <- GDS2MA(gds505)
## Not run: eset <- GDS2eSet(gds505)
```

`extractFilenameFromDownloadURL` *Extract filename from a GEO download URL*

Description

This function extracts the filename from a GEO download URL. The filename is expected to be a query parameter called "file". If the query parameter is not found, the function returns NULL.

Usage

```
extractFilenameFromDownloadURL(url)
```

Arguments

`url`	A GEO download URL

Details

The idea is to use this function to extract filenames that contain important metadata from the GEO RNA-seq quantification.

In particular, the filename is expected to contain the genome build and species information that we can attach to the SummarizedExperiment.

Value

A character vector with the filename

GDS-class *Class 'GDS'*

Description

A class describing a GEO GDS entity

Objects from the Class

Objects can be created by calls of the form `new('GDS', ...)`

Author(s)

Sean Davis

See Also

GEOData-class

GEOData-accessors *Generic functions for GEOquery*

Description

The main documentation is in the Class documentation

Author(s)

Sean Davis

See Also

GEOData-class

GEOData-class *Class 'GEOData'*

Description

A virtual class for holding GEO samples, platforms, and datasets

Objects from the Class

Objects can be created by calls of the form `new('GEOData', ...)`.

Author(s)

Sean Davis

See Also

GDS-class, GPL-class, GSM-class, GEODataTable-class,

GEODataTable-class *Class 'GEODataTable'*

Description

Contains the column descriptions and data for the datatable part of a GEO object

Objects from the Class

Objects can be created by calls of the form `new('GEODataTable', ...)`.

Author(s)

Sean Davis

getDirListing *get a directory listing from NCBI GEO*

Description

This one makes some assumptions about the structure of the HTML response returned.

Usage

```
getDirListing(url)
```

Arguments

`url`	A URL, assumed to return an NCBI-formatted index page

getGEO *Get a GEO object from NCBI or file*

Description

This function is the main user-level function in the GEOquery package. It directs the download (if no filename is specified) and parsing of a GEO SOFT format file into an R data structure specifically designed to make access to each of the important parts of the GEO SOFT format easily accessible.

Usage

```
getGEO(
  GEO = NULL,
  filename = NULL,
  destdir = tempdir(),
  GSElimits = NULL,
  GSEMatrix = TRUE,
  AnnotGPL = FALSE,
  getGPL = TRUE,
  parseCharacteristics = TRUE
)
```

Arguments

GEO	A character string representing a GEO object for download and parsing. (eg., 'GDS505','GSE2','GSM2','GPL96')
filename	The filename of a previously downloaded GEO SOFT format file or its gzipped representation (in which case the filename must end in .gz). Either one of GEO or filename may be specified, not both. GEO series matrix files are also handled. Note that since a single file is being parsed, the return value is not a list of esets, but a single eset when GSE matrix files are parsed.
destdir	The destination directory for any downloads. Defaults to the architecture-dependent tempdir. You may want to specify a different directory if you want to save the file for later use. Doing so is a good idea if you have a slow connection, as some of the GEO files are HUGE!
GSElimits	This argument can be used to load only a contiguous subset of the GSMs from a GSE. It should be specified as a vector of length 2 specifying the start and end (inclusive) GSMs to load. This could be useful for splitting up large GSEs into more manageable parts, for example.
GSEMatrix	A boolean telling GEOquery whether or not to use GSE Series Matrix files from GEO. The parsing of these files can be many orders-of-magnitude faster than parsing the GSE SOFT format files. Defaults to TRUE, meaning that the SOFT format parsing will not occur; set to FALSE if you for some reason need other columns from the GSE records.

`AnnotGPL` A boolean defaulting to FALSE as to whether or not to use the Annotation GPL information. These files are nice to use because they contain up-to-date information remapped from Entrez Gene on a regular basis. However, they do not exist for all GPLs; in general, they are only available for GPLs referenced by a GDS

`getGPL` A boolean defaulting to TRUE as to whether or not to download and include GPL information when getting a GSEMatrix file. You may want to set this to FALSE if you know that you are going to annotate your featureData using Bioconductor tools rather than relying on information provided through NCBI GEO. Download times can also be greatly reduced by specifying FALSE.

`parseCharacteristics` A boolean defaulting to TRUE as to whether or not to parse the characteristics information (if available) for a GSE Matrix file. Set this to FALSE if you experience trouble while parsing the characteristics.

Details

getGEO functions to download and parse information available from NCBI GEO (http://www.ncbi.nlm.nih.gov/geo). Here are some details about what is avaible from GEO. All entity types are handled by getGEO and essentially any information in the GEO SOFT format is reflected in the resulting data structure.

From the GEO website:

The Gene Expression Omnibus (GEO) from NCBI serves as a public repository for a wide range of high-throughput experimental data. These data include single and dual channel microarray-based experiments measuring mRNA, genomic DNA, and protein abundance, as well as non-array techniques such as serial analysis of gene expression (SAGE), and mass spectrometry proteomic data. At the most basic level of organization of GEO, there are three entity types that may be supplied by users: Platforms, Samples, and Series. Additionally, there is a curated entity called a GEO dataset.

A Platform record describes the list of elements on the array (e.g., cDNAs, oligonucleotide probesets, ORFs, antibodies) or the list of elements that may be detected and quantified in that experiment (e.g., SAGE tags, peptides). Each Platform record is assigned a unique and stable GEO accession number (GPLxxx). A Platform may reference many Samples that have been submitted by multiple submitters.

A Sample record describes the conditions under which an individual Sample was handled, the manipulations it underwent, and the abundance measurement of each element derived from it. Each Sample record is assigned a unique and stable GEO accession number (GSMxxx). A Sample entity must reference only one Platform and may be included in multiple Series.

A Series record defines a set of related Samples considered to be part of a group, how the Samples are related, and if and how they are ordered. A Series provides a focal point and description of the experiment as a whole. Series records may also contain tables describing extracted data, summary conclusions, or analyses. Each Series record is assigned a unique and stable GEO accession number (GSExxx).

GEO DataSets (GDSxxx) are curated sets of GEO Sample data. A GDS record represents a collection of biologically and statistically comparable GEO Samples and forms the basis of GEO's suite of data display and analysis tools. Samples within a GDS refer to the same Platform, that is,

they share a common set of probe elements. Value measurements for each Sample within a GDS are assumed to be calculated in an equivalent manner, that is, considerations such as background processing and normalization are consistent across the dataset. Information reflecting experimental design is provided through GDS subsets.

Value

An object of the appropriate class (GDS, GPL, GSM, or GSE) is returned. If the GSEMatrix option is used, then a list of ExpressionSet objects is returned, one for each SeriesMatrix file associated with the GSE accesion. If the filename argument is used in combination with a GSEMatrix file, then the return value is a single ExpressionSet.

Warning

Some of the files that are downloaded, particularly those associated with GSE entries from GEO are absolutely ENORMOUS and parsing them can take quite some time and memory. So, particularly when working with large GSE entries, expect that you may need a good chunk of memory and that coffee may be involved when parsing....

Author(s)

Sean Davis

See Also

getGEOfile

Examples

```
gds <- getGEO('GDS10')
gds

gse <- getGEO('GSE10')
# Returns a list, so look at first item

gse[[1]]
```

---

getGEOfile *Download a file from GEO soft file to the local machine*

Description

This function simply downloads a SOFT format file associated with the GEO accession number given.

Usage

```
getGEOfile(
  GEO,
  destdir = tempdir(),
  AnnotGPL = FALSE,
  amount = c("full", "brief", "quick", "data")
)
```

Arguments

GEO	Character string, the GEO accession for download (eg., GDS84, GPL96, GSE2553, or GSM10)
destdir	Directory in which to store the resulting downloaded file. Defaults to tempdir()
AnnotGPL	A boolean defaulting to FALSE as to whether or not to use the Annotation GPL information. These files are nice to use because they contain up-to-date information remapped from Entrez Gene on a regular basis. However, they do not exist for all GPLs; in general, they are only available for GPLs referenced by a GDS
amount	Amount of information to pull from GEO. Only applies to GSE, GPL, or GSM. See details...

Details

This function downloads GEO SOFT files based on accession number. It does not do any parsing. The first two arguments should be fairly self-explanatory, but the last is based on the input to the acc.cgi url at the geo website. In the default 'full' mode, the entire SOFT format file is downloaded. Both 'brief' and 'quick' offer shortened versions of the files, good for 'peeking' at the file before a big download on a slow connection. Finally, 'data' downloads only the data table part of the SOFT file and is good for downloading a simple EXCEL-like file for use with other programs (a convenience).

Value

Invisibly returns the full path of the downloaded file.

Author(s)

Sean Davis

References

http://www.ncbi.nlm.nih.gov/geo/query/acc.cgi

See Also

getGEO

Examples

```
# myfile <- getGEOfile('GDS10')
```

`getGEOSeriesFileListing` *GSE Supplemental file listing*

Description

The GEO Series records often have one or more supplemental files. In most cases, those files are archived as '.tar' files, the contents of which are only available in a file listing file not present on the website for download.

Usage

```
getGEOSeriesFileListing(GSE)
```

Arguments

`GSE`	character(1) the GSE accession

Details

This function reads that file listing file and returns the results as a data.frame.

Value

A data.frame with 5 columns. See example.

Examples

```
getGEOSeriesFileListing('GSE288770')
```

getGEOSuppFiles *Get Supplemental Files from GEO*

Description

NCBI GEO allows supplemental files to be attached to GEO Series (GSE), GEO platforms (GPL), and GEO samples (GSM). This function 'knows' how to get these files based on the GEO accession. No parsing of the downloaded files is attempted, since the file format is not generally knowable by the computer.

Usage

```
getGEOSuppFiles(
  GEO,
  makeDirectory = TRUE,
  baseDir = getwd(),
  fetch_files = TRUE,
  filter_regex = NULL
)
```

Arguments

GEO	A GEO accession number such as GPL1073 or GSM1137
makeDirectory	Should a 'subdirectory' for the downloaded files be created? Default is TRUE. If FALSE, the files will be downloaded directly into the baseDir.
baseDir	The base directory for the downloads. Default is the current working directory.
fetch_files	logical(1). If TRUE, then actually download the files. If FALSE, just return the filenames that would have been downloaded. Useful for testing and getting a list of files without actual download.
filter_regex	A character(1) regular expression that will be used to filter the filenames from GEO to limit those files that will be downloaded. This is useful to limit to, for example, bed files only.

Details

Again, just a note that the files are simply downloaded.

Value

If fetch_files=TRUE, a data frame is returned invisibly with rownames representing the full path of the resulting downloaded files and the records in the data.frame the output of file.info for each downloaded file. If fetch_files=FALSE, a data.frame of URLs and filenames is returned.

Author(s)

Sean Davis sdavis2@mail.nih.gov

Examples

```
a <- getGEOSuppFiles('GSM1137', fetch_files = FALSE)
a

# with a set of single-cell RNA-seq data
a <- getGEOSuppFiles('GSE161228', fetch_files = FALSE)
a
```

`getGEOSuppFileURL` *Get GEO supplemental file URL for a given GEO accession*

Description

Get GEO supplemental file URL for a given GEO accession

Usage

```
getGEOSuppFileURL(GEO)
```

Arguments

`GEO`

Examples

```
# an example of a GEO supplemental file URL
# with a set of single-cell RNA-seq data
url = getGEOSuppFileURL("GSE161228")
url

## Not run:
  browseURL(url)

## End(Not run)
```

`getGSEDataTables` *Get GSE data tables from GEO into R data structures.*

Description

In some cases, instead of individual sample records (GSM) containing information regarding sample phenotypes, the GEO Series contains that information in an attached data table. And example is given by GSE3494 where there are two data tables with important information contained within them. Using getGEO with the standard parameters downloads the GSEMatrix file which, unfortunately, does not contain the information in the data tables. This function simply downloads the "header" information from the GSE record and parses out the data tables into R data.frames.

Usage

```
getGSEDataTables(GSE)
```

Arguments

GSE	The GSE identifier, such as "GSE3494".

Value

A list of data.frames.

Author(s)

Sean Davis sdavis2@mail.nih.gov

See Also

getGEO

Examples

```
dfl = getGSEDataTables('GSE3494')
lapply(dfl,head)
```

---

getGSEDownloadPageURLs

get all download links from a GEO accession

Description

This function gets all download links from a GEO accession number.

Usage

```
getGSEDownloadPageURLs(gse)
```

Arguments

gse	GEO accession number

Value

A character vector with all download links

`getRNAQuantAnnotationURL` *Get the RNA-seq quantification annotation link*

Description

This function extracts the link to the RNA-seq quantification annotation file from a geoDownloadLinks object.

Usage

```
getRNAQuantAnnotationURL(links)
```

Arguments

`links`	A geoDownloadLinks object

Value

A character vector with the link to the annotation file

`getRNAQuantRawCountsURL` *Get the link to the raw counts file from GEO*

Description

This function extracts the link to the raw counts file from a geoDownloadLinks object.

Usage

```
getRNAQuantRawCountsURL(links)
```

Arguments

`links`	A geoDownloadLinks object

Value

A character vector with the link to the raw counts file

`getRNASeqData` *Get GEO RNA-seq quantifications as a SummarizedExperiment object*

Description

For human and mouse GEO datasets, NCBI GEO attempts to process the raw data and provide quantifications in the form of raw counts and an annotation file. This function downloads the raw counts and annotation files from GEO and merges that with the metadata from the GEO object to create a SummarizedExperiment.

Usage

```
getRNASeqData(accession)
```

Arguments

`accession`	GEO accession number

Details

A major barrier to fully exploiting and reanalyzing the massive volumes of public RNA-seq data archived by SRA is the cost and effort required to consistently process raw RNA-seq reads into concise formats that summarize the expression results. To help address this need, the NCBI SRA and GEO teams have built a pipeline that precomputes RNA-seq gene expression counts and delivers them as count matrices that may be incorporated into commonly used differential expression analysis and visualization software.

The pipeline processes RNA-seq data from SRA using the HISAT2 aligner and and then generates gene expression counts using the featureCounts program.

See the GEO documentation for more details.

Value

A SummarizedExperiment object with the raw counts as the counts assay, the annotation as the rowData, and the metadata from GEO as the colData.

Examples

```
se <- getRNASeqData("GSE164073")
se
```

getRNASeqQuantGenomeInfo *Extract genome build and species for GEO RNA-seq quantification*

Description

This function extracts the genome build and species information for a GEO RNA-seq quantification.

Usage

```
getRNASeqQuantGenomeInfo(gse)
```

Arguments

gse	GEO accession number

Value

A character vector with the genome build and species information

Examples

```
getRNASeqQuantGenomeInfo("GSE164073")
```

getRNASeqQuantResults *Get RNA-seq quantification and annotation from GEO*

Description

This function downloads the raw counts and annotation files from GEO for a given GEO accession number.

Usage

```
getRNASeqQuantResults(gse)
```

Arguments

gse	GEO accession number

Value

A list with two elements: quants (a matrix of raw counts) and annotation (a data frame of annotation information).

GPL-class *Class 'GPL'*

Description

Contains a full GEO Platform entity

Objects from the Class

Objects can be created by calls of the form `new('GPL', ...)`.

Author(s)

Sean Davis

See Also

GEOData-class

GSE-class *Class 'GSE'*

Description

Contains a GEO Series entity

Objects from the Class

Objects can be created by calls of the form `new('GSE', ...)`.

Author(s)

Sean Davis

See Also

GPL-class,GSM-class

GSM-class *Class 'GSM'*

Description

A class containing a GEO Sample entity

Objects from the Class

Objects can be created by calls of the form `new('GSM', ...)`.

Author(s)

Sean Davis

See Also

GEOData-class

hasRNASeqQuantifications *Does a GEO accession have RNA-seq quantifications?*

Description

This function checks if a GEO accession number has RNA-seq quantifications available. It does this by checking if the GEO accession number has a "RNA-Seq raw counts" link available on the GEO download page.

Usage

```
hasRNASeqQuantifications(accession)
```

Arguments

accession	GEO accession number

Value

TRUE if the GEO accession number has RNA-seq quantifications available, FALSE otherwise.

Examples

```
hasRNASeqQuantifications("GSE164073")
```

parseGEO *Parse GEO text*

Description

Workhorse GEO parsers.

Usage

```
parseGEO(
  fname,
  GSElimits,
  destdir = tempdir(),
  AnnotGPL = FALSE,
  getGPL = TRUE
)
```

Arguments

fname	The filename of a SOFT format file. If the filename ends in .gz, a gzfile() connection is used to read the file directly.
GSElimits	Used to limit the number of GSMs parsed into the GSE object; useful for memory management for large GSEs.
destdir	The destination directory into which files will be saved (to be used for caching)
AnnotGPL	Fetch the annotation GPL if available
getGPL	Fetch the GPL associated with a GSEMatrix entity (should remain TRUE for all normal use cases)

Details

These are probably not useful to the end-user. Use getGEO to access these functions. parseGEO simply delegates to the appropriate specific parser. There should be no reason to use the parseGPL, parseGDS, parseGSE, or parseGSM functions directly.

Value

parseGEO returns an object of the associated type. For example, if it is passed the text from a GDS entry, a GDS object is returned.

Author(s)

Sean Davis

See Also

getGEO

parseGSEMatrix *Parse a GSE mstrix file*

Description

Not meant for user calling, but parses a single GSEMatrix file.

Usage

```
parseGSEMatrix(
  fname,
  AnnotGPL = FALSE,
  destdir = tempdir(),
  getGPL = TRUE,
  parseCharacteristics = TRUE
)
```

Arguments

fname	filename
AnnotGPL	set to TRUE to get the annotation GPL version
destdir	the destdination directory for download
getGPL	whether or not to get the GPL associated
parseCharacteristics	Whether or not to do full 'characteristic' parsing

readRNAQuantAnnotation *Read RNA-seq quantification annotation from GEO*

Description

This function reads the annotation file from a GEO link. The annotation file is expected to be a tab-separated file with the first column containing the gene IDs and the remaining columns containing the annotation information.

Usage

```
readRNAQuantAnnotation(link)
```

Arguments

link	A link to the annotation file

Value

A data frame of annotation information with gene IDs as row names

readRNAQuantRawCounts *Read raw counts from GEO*

Description

This function reads the raw counts from a GEO link. The raw counts are expected to be in a tab-separated file with the first column containing the gene IDs and the remaining columns containing the raw counts.

Usage

```
readRNAQuantRawCounts(link)
```

Arguments

link	A link to the raw counts file

Details

This function reads the raw counts and returns a matrix with the gene IDs as the row names, ready for use in creating a SummarizedExperiment.

Value

A matrix of raw counts with gene IDs as row names

searchFieldsGEO *Provide a list of possible search fields for GEO search*

Description

Provide a list of possible search fields for GEO search

Usage

```
searchFieldsGEO()
```

Value

a data.frame with names of possible search fields for GEO search as well as descriptions, data types, etc. for each field. Fields are in rows and their properties are in columns.

See Also

searchGEO

Examples

```
searchFieldsGEO()
```

`searchGEO` *Search GEO database*

Description

This function searches the GDS database, and return a data.frame for all the search results.

Usage

```
searchGEO(query, step = 500L)
```

Arguments

`query`	character, the search term. The NCBI uses a search term syntax which can be associated with a specific search field with square brackets. So, for instance "Homo sapiens[ORGN]" denotes a search for `Homo sapiens` in the "Organism" field. Details see https://www.ncbi.nlm.nih.gov/geo/info/qqtutorial.html. The names and definitions of these fields can be identified using searchFieldsGEO.
`step`	the number of records to fetch from the database each time. You may choose a smaller value if failed.

Details

The NCBI allows users to access more records (10 per second) if they register for and use an API key. set_entrez_key function allows users to set this key for all calls to rentrez functions during a particular R session. You can also set an environment variable `ENTREZ_KEY` by Sys.setenv. Once this value is set to your key rentrez will use it for all requests to the NCBI. Details see https://docs.ropensci.org/rentrez/articles/rentrez_tutorial.html#rate-limiting-and-api-keys

Value

a data.frame contains the search results

See Also

searchFieldsGEO

Examples

```
## Not run:
searchGEO("diabetes[ALL] AND Homo sapiens[ORGN] AND GSE[ETYP]")

## End(Not run)
```

urlExtractRNASeqQuantGenomeInfo *Extract genome build and species from a GEO download URL*

Description

This function extracts the genome build and species information from a GEO download URL. The genome build and species information is expected to be in the filename of the download URL.

Usage

```
urlExtractRNASeqQuantGenomeInfo(url)
```

Arguments

url	A GEO annotation file download URL

Value

A character vector with the genome build and species information

urlForAccession *The URL for a GEO accession*

Description

Sometimes, you just need the URL for a GEO accession. This function returns the URL for a given GEO accession number that can be used to access the GEO page for that accession.

Usage

```
urlForAccession(geo)
```

Arguments

geo	A GEO accession number

Value

A character vector with the URL for the GEO accession

See Also

browseGEOAccession

Examples

```
urlForAccession("GSE262484")
```

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