

# Package ‘mobileRNA’

August 12, 2025

**Type** Package

**Title** mobileRNA: Investigate the RNA mobilome & population-scale changes

**Version** 1.5.1

**Description** Genomic analysis can be utilised to identify differences between RNA populations in two conditions, both in production and abundance. This includes the identification of RNAs produced by multiple genomes within a biological system. For example, RNA produced by pathogens within a host or mobile RNAs in plant graft systems. The mobileRNA package provides methods to pre-process, analyse and visualise the sRNA and mRNA populations based on the premise of mapping reads to all genotypes at the same time.

**License** MIT + file LICENSE

**Depends** R (>= 4.3.0)

**VignetteBuilder** knitr

**Encoding** UTF-8

**LazyData** FALSE

**Roxygen** list(markdown = TRUE)

**RoxygenNote** 7.3.1

**Suggests** knitr, rmarkdown, BiocStyle

**Imports** dplyr, tidyr, ggplot2, BiocGenerics, DESeq2, edgeR, ggrepel, grDevices, heatmap, utils, tidyselect, progress, RColorBrewer, GenomicRanges, rtracklayer, data.table, SimDesign, scales, IRanges, stats, methods, Biostrings, reticulate, S4Vectors, Seqinfo, SummarizedExperiment, rlang, bioseq, grid

**biocViews** Visualization, RNASeq, Sequencing, SmallRNA, GenomeAssembly, Clustering, ExperimentalDesign, QualityControl, WorkflowStep, Alignment, Preprocessing

**BiocType** Software

**BugReports** <https://github.com/KJeynesCopper/mobileRNA/issues>

**SystemRequirements** GNU make, ShortStack (>= 4.0), HTSeq, HISAT2, SAMtools, Conda

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

**git\_branch** devel

**git\_last\_commit** 072fb25

**git\_last\_commit\_date** 2025-07-23  
**Repository** Bioconductor 3.22  
**Date/Publication** 2025-08-11  
**Author** Katie Jeynes-Cupper [aut, cre] (ORCID:  
    <<https://orcid.org/0009-0000-1350-1371>>),  
    Marco Catoni [aut] (ORCID: <<https://orcid.org/0000-0002-3258-2522>>)  
**Maintainer** Katie Jeynes-Cupper <kej031@student.bham.ac.uk>

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|        |                                                                                                                   |
|--------|-------------------------------------------------------------------------------------------------------------------|
| mapRNA | <i>mobileRNA pre-processing method for sRNAseq &amp; mRNAseq (align-<br/>ment, raw count or cluster analysis)</i> |
|--------|-------------------------------------------------------------------------------------------------------------------|

---

Description

The mobileRNA workflow includes specific pre-processing guidelines. For sRNAseq, this undertakes alignment with Bowtie and sRNA cluster analysis with ShortStack. For mRNAseq, this undertakes alignment with HISAT2 and HTSeq. All OS software should be installed within a Conda environment.

**Usage**

```
mapRNA(
  input = c("mRNA", "sRNA"),
  sampleData = NULL,
  tidy = TRUE,
  input_files_dir,
  output_dir,
  genomefile,
  annotationfile = NULL,
  condaenv,
  threads = 6,
  mmap = "n",
  dicermin = 20,
  dicermax = 24,
  mincov = 0.5,
  pad = 200,
  order = "pos",
  stranded = "no",
  a = 10,
  mode = "union",
  nonunique = "none",
  type = "mRNA",
  idattr = "Name"
)
```

**Arguments**

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| input           | string; define type of Next-Generation Sequencing data set. "sRNA" for sRNAseq data and "mRNA" for mRNAseq data.                                                                                                                                                                                                                                                                                                          |
| sampleData      | dataframe; stores mRNA sample data where rows represent each sample in the analysis. Column one stores the sample names, while column two stores the the name(s) of the fastq file(s) for mate 1 (e.g. flyA_1.fq, flyB_1.fq) and column three stores the the name(s) of the fastq file(s) for mate 2 (e.g. flyA_2.fq, flyB_2.fq). If data is single ended, column three will not hold any values. Only for mRNA analysis. |
| tidy            | logical; removes unnecessary extra output files when set to TRUE.                                                                                                                                                                                                                                                                                                                                                         |
| input_files_dir | path; directory containing only the FASTQ samples for analysis. Note that all samples in this directory will be used by this function.                                                                                                                                                                                                                                                                                    |
| output_dir      | path; directory to store output.                                                                                                                                                                                                                                                                                                                                                                                          |
| genomefile      | path; path to a FASTA genome reference file.                                                                                                                                                                                                                                                                                                                                                                              |
| annotationfile  | path; path to a GFF file. For mRNA analysis only.                                                                                                                                                                                                                                                                                                                                                                         |
| condaenv        | character; name or directory of the Conda environment to use where OS dependencies are stored.                                                                                                                                                                                                                                                                                                                            |
| threads         | numeric; set the number of threads to use where more threads means a faster completion time. Default is 6.                                                                                                                                                                                                                                                                                                                |
| mmap            | character; define how to handle multi-mapped reads. Choose from "u", "f", "r" or "n". For core sRNA analysis, use either "u", "f" or "r" options. Where "u" means only uniquely-aligned reads are used as weights for placement of multi-mapped reads. Where "f" means fractional weighting scheme for placement of                                                                                                       |

|           |                                                                                                                                                                                                                                                                                                                                                                   |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|           | multi-mapped reads and "r" mean multi-mapped read placement is random. For core mRNA analysis, to include multimapped reads, use any parameter, other than "n". While for mobile sRNA or mRNA, it is important to use "n", to not consider multi-mapped reads, only unique reads as we cannot distinguish which genome the reads mapped to multiple locations in. |
| dicermin  | integer; the minimum size in nucleotides of a valid small RNA. This option sets the bounds to discriminate dicer-derived small RNA loci from other loci. Default is 20. For sRNA analysis only.                                                                                                                                                                   |
| dicermax  | integer; the maximum size in nucleotides of a valid small RNA. This option sets the bounds to discriminate dicer-derived small RNA loci from other loci. Default is 24. For sRNA analysis only.                                                                                                                                                                   |
| mincov    | numeric; minimum alignment depth, in units of reads per million, required to nucleate a small RNA cluster during de novo cluster search. Must be a number > 0. Default is 2. For sRNA analysis only.                                                                                                                                                              |
| pad       | integer; initial peaks are merged if they are this distance or less from each other. Must >= 1, default is 75. For sRNA analysis only.                                                                                                                                                                                                                            |
| order     | character; either "name" or "pos" to indicate how the input data has been sorted. For paired-end data only, this sorts the data either by read name or by alignment position. Default is "pos", to sort by position. For mRNA analysis only.                                                                                                                      |
| stranded  | whether the data is from a strand-specific assay, either "yes"/"no"/"reverse". Default is "no". For mRNA analysis only.                                                                                                                                                                                                                                           |
| a         | numeric; skip all reads with alignment quality lower than the given minimum value (default: 10). For mRNA analysis only.                                                                                                                                                                                                                                          |
| mode      | character; states mode to handle reads overlapping more than one feature. Either "union", "intersection-strict" and "intersection-nonempty". Default is "union". For mRNA analysis only.                                                                                                                                                                          |
| nonunique | character; states the mode to handle reads that align to or are assigned to more than one feature in the overlap. Either "none" and "all". Default is "none". For mobile mRNA, ensure the default is utilized to exclude multimapped reads. For mRNA analysis only.                                                                                               |
| type      | character; feature type (3rd column in GFF file) to be used, all features of other type are ignored. Default is "mRNA". For mRNA analysis only.                                                                                                                                                                                                                   |
| idattr    | character; GFF attribute to be used as feature ID. Several GFF lines with the same feature ID will be considered as parts of the same feature. The feature ID is used to identity the counts in the output table. Default is "Name". For mRNA analysis only.                                                                                                      |

## Details

Please ensure all OS software is installed within a Conda environment. See appendix of vignette for manual pipeline. Alignment statistics are reported for each analysis within log plain text files (log.txt).

In order to align reads, the function will check whether a genome reference index has already been generated and, if not, will generate one. The method varies between sRNA and mRNA analysis depending on the alignment tool. This is generated in the same location as the reference file.

NOTE: This function utilises the `reticulate` R package to connect to the conda environment. Hence, restart R if you wish to change the employed Conda environment during a session.

**For sRNA analysis** The function invokes a number of OS commands, and is dependent on the installation of ShortStack ( $\geq 4.0$ ) with Conda. Please note that ShortStack is only compatible with Linux and Mac operating systems.

The pipeline undertakes de novo detection of sRNA-producing loci and alignment, where the output of each are stored in their respective folders in the users desired location. The de novo detection of sRNA-producing loci analyses each sample to identify de novo sRNA-producing loci (ie. sRNA clusters), and joins these results into a single file called "locifile.txt". The alignment step aligns and clusters each sample to the genome reference along with the file containing the de novo sRNA clusters. The final reports are imported into R using `RNAimport()`.

### For mRNA analysis

The function invokes a number of OS commands, and is dependent on the installation of HISAT2, HTSeq and SAMtools with Conda. The pipeline can undertake single- or pair-end analysis, and to do so requires a data frame stating the sample information where each row represents a sample. The reads are mapped using HISAT and then the raw counts are estimated by HTSeq. The output alignment file (BAM) and raw counts file for each sample are stored within the samples own folder within the desired directory.

### Value

**\*\* For sRNA analysis\*\*** The OS commands generate output into the users desired location, generating two folders:

- 1\_de\_novo\_detection: Stores output from the detection of de novo sRNA-producing loci
- 2\_sRNA\_results: Stores results

The first folder stores the alignment (BAM) and the de novo sRNA-producing loci for each sample (.txt) within the samples respective folder. The analyses joins the de novo sRNA clusters across the experimental design which is stored in "locifile.txt". The second folder stores the final clustering results for each sample, and as before the results of each sample are stored within it's respective folder. These results (.txt) are imported into R for downstream analysis by utilizing the `RNAimport()` function.

The function generates a number of extra files for each sample and are not required for the downstream analysis. These are generated by ShortStack, see documentation for more information (<https://github.com/MikeAxtell/ShortStack>). As default these files are deleted. This is determined by the tidy argument.

**\*\* For mRNA analysis\*\*** For mRNA analysis, generate a new folder which stores the results in the users desired output location, known as "1\_mRNA\_preprocessing". Within this folder, there will contain one folder per sample storing it's sorted alignment file (BAM) and raw counts file ("Result.txt"). Note, that the function excludes multi-mapped mRNAs.

### References

ShortStack <https://github.com/MikeAxtell/ShortStack>, HISAT2 <https://anaconda.org/bioconda/hisat2>, HTSeq <https://htseq.readthedocs.io/en/master/install.html>, SAMtools <https://anaconda.org/bioconda/samtools>

### Examples

```
## Not run:

## EXAMPLE 1 - sRNAseq
samples <- file.path(system.file("extdata/sRNAseq", package="mobileRNA"))
```

```

GenomeRef <- system.file("extdata","reduced_chr12_Eggplant.fa.gz", package="mobileRNA")
output_location <- tempdir()

mapRNA(input = "sRNA",
input_files_dir = samples,
output_dir = output_location,
genomefile = GenomeRef,
condaenv = "ShortStack4",
mmap = "n")

## EXAMPLE 2 - mRNAseq

# create sample data including name, and file mates:
sampleData <- data.frame(sample = c("selfgraft_1", "selfgraft_2",
                                   "heterograft_1", "heterograft_2"),
                        mate1 = c("selfgraft_mRNAdemo_1.fq.gz", "selfgraft_mRNAdemo_2.fq.gz",
                                "heterograft_mRNAdemo_1.fq.gz", "heterograft_mRNAdemo_2.fq.gz"))

# location of samples:
samples <- system.file("extdata/mRNAseq", package="mobileRNA")

# location to store output
output_location <- tempdir()

# run alignment
mapRNA(input = "mRNA",
      input_files_dir = samples,
      output_dir = output_location,
      genomefile = output_assembly_file,
      annotationfile = output_annotation_file,
      sampleData = sampleData,
      condaenv = "/Users/user-name/miniconda3")

## End(Not run)

```

mobileRNA

*mobileRNA: Explore RNA mobilome & population-scale changes*

## Description

Uses small RNA or messenger RNA sequencing data in two conditions and identifies changes in the RNA population. *mobileRNA* was primarily designed for the identification of a putative RNA mobilome in a chimeric system. For example, in plant graft systems. As input, *mobileRNA* takes sRNAseq or mRNAseq fastq files. Output consists of a data frame with putative differences between two conditions along with a number of plots.

## Details

The most important functions in the **mobileRNA** are:

[RNAmergeGenomes](#) Merge two genome assembly files (FASTA).

[RNAmergeAnnotations](#) Merge two genome annotation files (GFF).

[mapRNA](#) Pre-processing of sRNAseq and mRNAseq (alignment, raw count, cluster analysis).

**RNAimport** Reads the pre-processing report files into a dataframe for all conditions

**RNAadicercall** Calculates the consensus sRNA dicercall class.

**RNAsubset** Subsets the data set based on the sRNA class.

**RNAifferentialAnalysis** Undertakes differential analysis with either the edgeR or DESeq2 method.

**RNAmobile** Identify putative RNA molecules produced by the non-tissue sample genome

**RNApopulation** Identify gained/lost RNA populations between treatment and control conditions.

**RNAsummary** Summarise the differential abundance of RNAs.

**RNAreorder** Reorder the data frame for differential analysis, ensuring control verse treatment comparison.

**RNAsequences** Extract RNA sequence from sRNA clusters.

**RNAattributes** Overlap the genomic features related to the sRNA clusters.

**RNAdistribution** Plot the distribution of sRNA classes based on nucleotide length.

**plotHeatmap** Heatmap of log-transformed normalization data.

**plotSampleDistance** Plots a sample distance heatmap for quality control.

**plotSamplePCA** Plots a PCA plot, customize ratio, colours and shapes.

**RNAfeatures** Summarise the distribution of sRNA clusters across genomic features.

**RNAdf2se** Convert a mobileRNA dataframe to a SummarizedExperiment object.

### Author(s)

Katie Jeynes-Cupper <kej031@student.bham.ac.uk>, Marco Catoni <m.catoni@bham.ac.uk>  
 Maintainer: Katie Jeynes-Cupper <kej031@student.bham.ac.uk>

### See Also

See vignette("mobileRNA", package = "mobileRNA") for an overview of the package.

---

mRNA\_data

*mRNA\_data: simulated messenger RNA data for biological replicates*

---

### Description

Simulated mRNAseq dataset

### Usage

```
data(mRNA_data)
```

### Details

Simulates data is taken from eggplant and tomato mRNAseq samples and created to simulate to movement of mRNA molecules from an Tomato rootstock to an Eggplant Scion. Two Eggplant replicates were spiked with the same 150 tomato mRNA clusters, and named "heterograft\_" 1 to 2. The analysis compares these heterografts to two Eggplant self-grafts which are the original unspiked Eggplant replicates, called "selfgraft\_" 1 to 2.

This data was imported and organised by the [RNAimport\(\)](#) function.

**Value**

Dataframe in global environment

**Examples**

```
data("mRNA_data")
```

---

plotHeatmap

*Heatmap of log-transformed normalization data*

---

**Description**

Undertakes normalisation of RPM/FPKM using a pseudocount and transforms the data using log-scale, to enable visualization of the differences and patterns in expression across samples using a heatmap.

**Usage**

```
plotHeatmap(
  data,
  value = "RPM",
  pseudocount = 1e-06,
  colours = (grDevices::colorRampPalette(RColorBrewer::brewer.pal(9, "GnBu")))(100),
  cluster = TRUE,
  scale = "none",
  clustering_method = "complete",
  row.names = FALSE,
  border.color = NA,
  column.angle = 45,
  title = NA
)
```

**Arguments**

|                   |                                                                                                                                                                                                                            |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data              | data.frame; originally generated by <code>RNAimport()</code>                                                                                                                                                               |
| value             | character; state the values to plot, either FPKM or RPM.                                                                                                                                                                   |
| pseudocount       | numeric; pseudo count, default is 1e-6                                                                                                                                                                                     |
| colours           | character; colors. Default is <code>grDevices::colorRampPalette(RColorBrewer::brewer.pal(9, "GnBu"))(100)</code>                                                                                                           |
| cluster           | logical; include hierarchical clustering when default <code>cluster= TRUE</code>                                                                                                                                           |
| scale             | character; indicating whether the values should be centered & scaled in either the row direction or the column direction, or none. Respective options are "row", "column" & "none". Default is <code>scale="none"</code> . |
| clustering_method | character; clustering method used. Accepts the same values as <code>hclust</code> . Default <code>clustering_method= "complete"</code>                                                                                     |
| row.names         | logical; indicated whether to include rownames from column 1 of data frame. Default <code>row.names=FALSE</code>                                                                                                           |
| border.color      | character; the border colour. Default is no border (NA).                                                                                                                                                                   |
| column.angle      | numeric; angle of the column labels, choose from 0, 45, 90, 270 or 315.                                                                                                                                                    |
| title             | character; states plot title, placed at the top center                                                                                                                                                                     |

## Details

Undertakes FPKM/RPM normalisation using a pseudocount and then transforms the normalised-RPM data using log-scale.

This function expects to receive a data frame containing FPKM/RPM data. This function employs the use of a pseudo count during normalisation as the function is expected to be used when identifying mobile sRNAs in a chimeric system. In such system, it is expected that control replicates will contain zero values for the candidate mobile sRNA clusters.

## Value

Produces a list objects storing the heatmap plot and the data.

## Examples

```
data("sRNA_data")

# vector of control names
controls <- c("selfgraft_1", "selfgraft_2" , "selfgraft_3")

# Locate potentially mobile sRNA clusters associated to tomato, no
# statistical analysis
sRNA_data_mobile <- RNAmobile(input = "sRNA", data = sRNA_data,
controls = controls, genome.ID = "B_", task = "keep", statistical = FALSE)

# plot heatmap of potential mobile sRNAs
p1 <- plotHeatmap(sRNA_data_mobile)
```

---

|                 |                                                                                                           |
|-----------------|-----------------------------------------------------------------------------------------------------------|
| plotRNAfeatures | <i>Plots the distribution of genomic features in the genome and those that overlap with sRNA clusters</i> |
|-----------------|-----------------------------------------------------------------------------------------------------------|

---

## Description

Using the RNAfeatures() function, this function plots the percentage distribution of genomic features in the provided genome annotation and percentage the distribution of genomic features which overlap sRNA clusters. This is illustrated as a stacked bar plot.

## Usage

```
plotRNAfeatures(
  data,
  annotation,
  repeats = NULL,
  promoterRegions = 1000,
  repeat.type = NULL,
  brewerPalette = "Spectral",
  x.axis.text = c("Genome", "Dataset"),
  legend.position = "bottom"
)
```

**Arguments**

|                              |                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>data</code>            | data.frame; generated by <a href="#">RNAimport()</a>                                                                                                                                                                                                                                                                                                   |
| <code>annotation</code>      | path; URL or connection to a GFFFile object. A genome reference annotation file (.gff/.gff1/.gff2/.gff3). Can be in compressed format (gzip).                                                                                                                                                                                                          |
| <code>repeats</code>         | path; URL or connection to a GFFFile object. A genome reference annotation file, which only contains information on repeat sequences in the genome (.gff/.gff1/.gff2/.gff3). By default, this is not required, however if there is a specific repeats annotation file for the genome it is suggested to supply it. Can be in compressed format (gzip). |
| <code>promoterRegions</code> | numeric; defines the upstream promoter region of genes. Default is 1000, which refers to promoters set at 1Kb upstream of genes                                                                                                                                                                                                                        |
| <code>repeat.type</code>     | character; features type in annotation file to represent repeats or transposable elements when repeats not supplied. Default is <code>c("transposable_element", transposable_element)</code> which represent the transposable element features in the TAIR10 genome annotation.                                                                        |
| <code>brewerPalette</code>   | vector; colour scales from ColorBrewer to support the <code>ggplot2::scale_fill_brewer</code> function. Default is "Spectral".                                                                                                                                                                                                                         |
| <code>x.axis.text</code>     | vector; labs to represent the genome and the dataset bars in the plot. Default is <code>x.axis.text=c("Genome", "Dataset")</code> .                                                                                                                                                                                                                    |
| <code>legend.position</code> | character; position of legend. Either "none", "left", "right", "bottom", "top", "inside".                                                                                                                                                                                                                                                              |

**Details**

RNAfeatures calculates the number or percentage of sRNA clusters which overlap with genomic features based on their genomic coordinates.

**Value**

Returns a table containing the number or percentage of overlaps in the supplied sRNA data set with specific regions in the genome annotation such as genes, repeats, introns, exons.

**See Also**

[RNAmergeAnnotations\(\)](#) to merge 2 GFF files into 1.

**Examples**

```
data("sRNA_data")
features_plot <- plotRNAfeatures(data = sRNA_data,
                                annotation = system.file("extdata",
                                                          "reduced_chr2_Tomato.gff.gz", package="mobileRNA"))
```

---

|                    |                               |
|--------------------|-------------------------------|
| plotSampleDistance | <i>Sample distance matrix</i> |
|--------------------|-------------------------------|

---

## Description

Draws a simple hierarchical clustered heatmap to observe sample distance.

## Usage

```
plotSampleDistance(
  data,
  colours = (grDevices::colorRampPalette(rev(RColorBrewer::brewer.pal(9, "GnBu"))))(255),
  vst = FALSE,
  cellheight = 40,
  cellwidth = 40
)
```

## Arguments

|            |                                                                                                                                                                                                  |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data       | data.frame; originally generated by <a href="#">RNAimport()</a>                                                                                                                                  |
| colours    | character; the colour palette. Default is <code>grDevices::colorRampPalette(RColorBrewer::brewer.pal(9, "GnBu"))(100)</code>                                                                     |
| vst        | logical; to undertake variance stabilizing transformation. By default, the function uses a regularized log transformation on the data set, however, this will not suit all experimental designs. |
| cellheight | numeric; individual cell height in points. Default is 40.                                                                                                                                        |
| cellwidth  | numeric; individual cell width in points. Default is 40.                                                                                                                                         |

## Details

In special conditions, regularized log transformation will not suit the experimental design. For example, an experimental design without replicates. In this instance, it is preferable to change the default setting and switch to a variance stabilizing transformation method (`vst=TRUE`).

## Value

A blue/green scale heatmap illustrating the sample distance.

## Examples

```
data("sRNA_data")
p1 <- plotSampleDistance(sRNA_data)
```

---

|               |                                |
|---------------|--------------------------------|
| plotSamplePCA | <i>PCA plot of PC1 and PC2</i> |
|---------------|--------------------------------|

---

### Description

Draws a principal component analysis (PCA) plot of PC1 and PC2. The function undertakes rlog transformation of the data in an unbiased manner (blind=TRUE).

### Usage

```
plotSamplePCA(
  data,
  group,
  vst = FALSE,
  labels = TRUE,
  boxed = TRUE,
  legend.title = "Conditions",
  size.ratio = 2,
  colours = NULL,
  point.shape = TRUE,
  ggplot.theme = NULL,
  label.box.padding = 1,
  title = "PCA plot",
  legend.position = "top",
  legend.direction = "horizontal"
)
```

### Arguments

|                   |                                                                                                                                                                                                                         |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data              | data.frame; originally generated by <a href="#">RNAimport()</a>                                                                                                                                                         |
| group             | character; contains experimental conditions for each replicate.<br><i>IMPORTANT:</i> Ensure this is in the same order as the replicates are found in the data frame supplied to the data argument (from left to right). |
| vst               | logical; variance stabilizing transformation. By default, the function uses a regularized log transformation on the data set, however, this will not suit all experimental designs.                                     |
| labels            | logical; include sample name labels on PCA. Default labels=TRUE                                                                                                                                                         |
| boxed             | logical; add a box around each sample name label. Default boxed=TRUE                                                                                                                                                    |
| legend.title      | character; title for legend key. Default legend.title = "Conditions"                                                                                                                                                    |
| size.ratio        | numeric; set plot ratio, broadens axis dimensions by ratio. Default size.ratio=2, double the plot dimension.                                                                                                            |
| colours           | character; vector of HEX colour codes. Must match the number of conditions.                                                                                                                                             |
| point.shape       | logical; set whether the point shapes should be different for each condition.                                                                                                                                           |
| ggplot.theme      | character; state the ggplot2 theme (without () brackets). For example, ggplot.theme=ggplot2::theme_minimal()                                                                                                            |
| label.box.padding | numeric; Amount of padding around bounding box, as a unit or number. Defaults to 1.                                                                                                                                     |
| title             | character; title for plot.                                                                                                                                                                                              |

`legend.position`  
 character; the position of legends ("none", "left", "right", "bottom", "top", or two-element numeric vector)

`legend.direction`  
 character; layout of items in legends ("horizontal" or "vertical")

## Details

This function uses the DESeq2 package to organise and plot the data. It organises the data into a DESeqDataSet which undergoes log-transformation where the results are used to undertake the PCA analysis. The results are plotted against the principal components 1 and 2.

In special conditions, regularized log transformation will not suit the experimental design. For example, an experimental design without replicates. In this instance, it is preferable to change the default setting and switch to a variance stabilizing transformation method (``vst=TRUE``).

## Value

A PCA plot to show sample distance.

## Examples

```
data("sRNA_data")

groups <- c("Heterograft", "Heterograft", "Heterograft",
           "Selfgraft", "Selfgraft", "Selfgraft")

p <- plotSamplePCA(data = sRNA_data, group = groups)

plot(p)
```

---

RNAattributes

*Overlap the genomic features related to the sRNA clusters*

---

## Description

Overlap the genomic features related to the sRNA clusters

## Usage

```
RNAattributes(
  data,
  annotation,
  match = c("within", "genes"),
  bufferRegion = 1000
)
```

**Arguments**

|              |                                                                                                                                                                                                                               |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data         | data.frame; originally generated by <code>RNAimport()</code> or containing chr, start and end columns.                                                                                                                        |
| annotation   | path; URL, connection or GFFFile object. A genome reference annotation file (.gff/.gff1/.gff2/.gff3).                                                                                                                         |
| match        | character; must be either "within" or "genes". Where "within" will return matches where the clusters can be found within any annotation, while "genes" will return matches where the clusters can be found within only genes. |
| bufferRegion | numeric; a buffer region in base-pairs to extend the start and end coordinates upstream and downstream respectively.                                                                                                          |

**Details**

Based on genomic coordinates, assign sRNA clusters with matching annotation information. This function can be used to find the genomic features from which the sRNA clusters originate from. This includes genes or repetitive regions. An additional buffer region at the start/end of the gene is added to improve hits, and align with the assumptions about promoter regions.

It is important that any alteration which were made to the genome reference (FASTA) used for alignment/clustering, such as alterations to the chromosome name, must be carried forth to the genome annotation file. See `RNAmergeGenomes()` and `RNAmergeAnnotations()` for more information.

**Value**

Appends the attribute columns from the GFF file to the supplied data based on overlapping genomic regions.

**Examples**

```
# load data
data("sRNA_data")

attributes_df <- RNAattributes(data = sRNA_data,
                              annotation = system.file("extdata",
                                                         "prefix_reduced_chr2_Tomato.gff.gz", package="mobileRNA"),
                              match = "genes")
```

---

 RNAdf2se

---

*Convert a mobileRNA dataframe to a SummarizedExperiment object*


---

**Description**

Convert any mobileRNA output dataframe into a SummarizedExperiment object.

**Usage**

```
RNAdf2se(input = c("sRNA", "mRNA"), data)
```

**Arguments**

|       |                                                      |
|-------|------------------------------------------------------|
| input | character; must be either "sRNA" or "mRNA"           |
| data  | data.frame produced by the <b>mobileRNA</b> package. |

## Details

The function relies on the naming structure of columns created by functions in the **mobileRNA** package. It is able to extract the sample names based on these additions, and organise the data appropriately.

## Value

A SummarizedExperiment object containing information from working data frame.

### # For sRNAseq data

- The rownames contain the locus name and the cluster name.
- The assays represent the additional information including DicerCall, Count, RPM, Major-RNA.
- The rowData includes the Cluster ID, the DicerCounts & the DicerConsensus.
- The colnames represents the sample replicate names.

### For mRNAseq data

- The rownames contain the gene names.
- The assays represent the additional information including Count & FPKM.
- The rowData includes the gene & the SampleCounts.
- The colnames represents the sample replicate names.

## Examples

```
# load data.frame
data("sRNA_data")

se <- RNAdf2se(input = "sRNA", data = sRNA_data)
```

---

RNAdicercall

*Define the consensus dicercall for each sRNA cluster*

---

## Description

The sRNA dicercall represents the length in nucleotides of the most abundant sRNA sequence within a cluster. The function calculates the consensus dicercall classification.

## Usage

```
RNAdicercall(
  data,
  conditions = NULL,
  ties.method = NULL,
  tidy = FALSE,
  chimeric = FALSE,
  controls = NULL,
  genome.ID = NULL
)
```

## Arguments

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>data</code>        | data.frame; originally generated by <code>RNAimport()</code> .                                                                                                                                                                                                                                                                                                                                                                                                        |
| <code>conditions</code>  | character; vector containing sample replicate names. When supplied, the data from the named replicates will be the only ones used to calculate the dicercall consensus for each sRNA cluster. Each string should represent a sample name present in the dataframe supplied to the <code>data</code> argument.                                                                                                                                                         |
| <code>ties.method</code> | character; string specifying how ties are handled, choose either "exclude" or "random". When using random, if there is a tie one of the classes will be chosen at random. While, when using exclude if there is a tie the class is set to undefined, however, if there is a tie between a undefined and a known class, the known class takes president (eg 3x24-nt and 3xN-nt, then it will be classed as 24nt). Default setting <code>ties.method="exclude"</code> . |
| <code>tidy</code>        | logical; tidy-up data by removing sRNA clusters with an unknown or unclassified result. Default setting <code>tidy=FALSE</code> , removes excess background noise.                                                                                                                                                                                                                                                                                                    |
| <code>chimeric</code>    | logical; state whether the system is chimeric and contains multiple genomes/genotypes.                                                                                                                                                                                                                                                                                                                                                                                |
| <code>controls</code>    | character; vector of control condition sample names.                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <code>genome.ID</code>   | character; chromosome identifier of the genome representing either the origin of mobile molecules or the other genome in the chimeric system.                                                                                                                                                                                                                                                                                                                         |

## Details

For each sample, the alignment/clustering step predicted the sRNA dicercall for each cluster. This value is stored in the columns starting with "DicerCall\_". This value represents the length of nucleotides of the most abundant sRNA within the cluster. For some clusters, there is no particular sRNA which is more abundant than another, hence, it is stated as "NA" or "N", which is referred to as unclassified. The `RNAdicercall()` function calculate the consensus dicercall for each sRNA cluster based on the values across replicates. There are several parameters which will alter the output, including the handling of ties and the method to draw the consensus from.

When `ties.method = "random"`, as per default, ties are broken at random. In this case, the determination of a tie assumes that the entries are probabilities: there is a relative tolerance of  $1e-5$ , relative to the largest (in magnitude, omitting infinity) entry in the row.

When `ties.method = "exclude"`, ties between sRNA classification are ruled as unclassified ("N"). However, when there is a tie between the choice of a class or unclassified result the exclude option will always select the class choice over the unclassified result.

If users are working with a chimeric system, utilise the `chimeric=TRUE` parameter and state `genome.ID` and `controls` parameter variables. This will remove any potential mapping errors which could introduce false interpretation.

To remove excess data noise, `tidy=TRUE` can be used to removed unclassified ("N") sRNA clusters, resulting in a reduced data set size.

## Value

The original input data with two additional columns appended known as `DicerCounts` and `DicerConsensus`. The `DicerCounts` column stores the number of replicates that contributed to defining the consensus dicer-derived sRNA class. Note that when utilising the exclude ties methods, the `DicerCounts` will be represented as 0 when a tie is identified. While, the `DicerConsensus` stores the consensus dicercall.

**Examples**

```
# load data
data("sRNA_data")

# define consensus sRNA classes.
conditions <- c("heterograft_1", "heterograft_2", "heterograft_3")

# Run function to define sRNA class for each cluster.
sRNA_data_dicercall <- RNAdicercall(data = sRNA_data,
                                   conditions = conditions,
                                   tidy=TRUE)
```

---

 RNA<sup>differential</sup>Analysis

*Differential Analysis using DESeq2 or edgeR*


---

**Description**

RNA<sup>differential</sup>Analysis function computes the differential analysis with DESeq2 or edgeR of sRNA or mRNA data produced by the mobileRNA package pipeline.

**Usage**

```
RNAdifferentialAnalysis(
  data,
  group,
  method = c("edgeR", "DESeq2"),
  dispersionValue = NULL
)
```

**Arguments**

|                 |                                                                                                                                                                                                                    |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data            | data.frame; originally generated by <a href="#">RNAimport()</a> .                                                                                                                                                  |
| group           | character; the condition of each sample in the experimental design, formatted in the order of samples shown in the data object from left to right.                                                                 |
| method          | character; method to undertaken differential analysis, choose from methods of either <a href="#">DESeq2::DESeq</a> or <a href="#">edgeR::edgeR</a> . Must be stated as either "DESeq2" or "edgeR" in the function. |
| dispersionValue | numeric; value to represent the dispersion value for the <a href="#">edgeR::edgeR</a> method. Recommended for analysis in experiments without biological replicates.                                               |

**Details**

The user has the flexibility to choose the method that best suits their data. In this function, the DESeq2 method, calculates the differentials based on the normalized count data based on the size factors. Whereas the edgeR method, calculates normalization factors estimates dispersion, and returns the common dispersion. After normalization, the mean expression levels across samples are calculated, and differential expression analysis is performed using the exact test within groups, and the adjusted p-values are calculated using the Benjamini-Hochberg method. Note that this function

is only capable of handling one replicate per condition with the edgeR method. This requires setting a suitable dispersion value. The dispersion value is other wise known as the common Biological squared coefficient of variation. See the User's Guide for the edgeR package for more details, [edgeR::edgeR](#).

### Value

Undertakes differential analysis, based on a specified method, and appends the results to the supplied data frame. This includes:

- Count mean
- Log fold change
- p-value
- Adjusted p-value
- Comparison order

### Examples

```
# load data
data("sRNA_data")

# sample conditions.
groups <- c("Selfgraft", "Selfgraft", "Selfgraft", "Heterograft", "Heterograft", "Heterograft")

## Differential analysis: DEseq2 method
sRNA_DESeq2 <- RNAdifferentialAnalysis(data = sRNA_data,
                                     group = groups,
                                     method = "DESeq2" )

## Differential analysis: edgeR method
sRNA_edgeR <- RNAdifferentialAnalysis(data = sRNA_data,
                                     group = groups,
                                     method = "edgeR" )
```

---

RNAdistribution

*Plot the distribution of sRNA classes based on nucleotide length*

---

### Description

RNAdistribution plots the distribution of dicer-derived sRNA classes across samples or the sRNA consensus determined by the [RNAAdicercall\(\)](#) function. This can be displayed as a line or bar plot.

### Usage

```
RNAdistribution(
  data,
  samples = NULL,
  style,
  data.type = "samples",
```

```

facet = TRUE,
facet.arrange = 3,
colour = "#0868AC",
outline = "black",
wrap.scales = "fixed",
overlap = TRUE,
relative = FALSE
)

```

## Arguments

|               |                                                                                                                                                                                                                                                                                                                                     |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data          | data.frame; generated originally by <a href="#">RNAimport()</a>                                                                                                                                                                                                                                                                     |
| samples       | character; states a subset of samples to plot. This argument is based on the sample names within the data.                                                                                                                                                                                                                          |
| style         | character; style="line" or style="bar". Instructs how to plot the data. Where style="line" plots a line graph and style="bar" plots a bar graph.                                                                                                                                                                                    |
| data.type     | character; either plotting "samples" or the "consensus" stored in the 'DicerConsensus' column.                                                                                                                                                                                                                                      |
| facet         | logical; forms a matrix of panels defined by row and column faceting variables. It plots the results for each sample as a bar chart and contains it within a single plot. The number of rows in the facet can be changed using the argument facet.arrange. Default facet = TRUE , plots each sample separately when facet = FALSE . |
| facet.arrange | numeric; value supplied to define the number of columns to include in the facet. This argument is piped into the ncol argument in <a href="#">ggplot2::facet_wrap()</a> to define the number of columns. By default, this is set to 3.                                                                                              |
| colour        | character; fill colour, Default is "#0868AC".                                                                                                                                                                                                                                                                                       |
| outline       | character; states the outline colour for a box plot. Default is "black".                                                                                                                                                                                                                                                            |
| wrap.scales   | character; scales be fixed ("fixed", the default), free ("free"), or free in one dimension ("free_x", "free_y")                                                                                                                                                                                                                     |
| overlap       | logical; generates a single line graph, containing all sample replicate information. Default overlap=TRUE.                                                                                                                                                                                                                          |
| relative      | logical; used in conjunction with data.type="consensus". Instructs plotting of the relative frequency of all sRNA classes across the data defined by the consensus dicer-derived sRNA column (see <a href="#">RNAdicercall()</a> function for more information).                                                                    |

## Details

The function can be used to plot a variety of different comparisons and plots. It can be used to plot the distribution of sRNA classes within each sample replicate, which can be represented as a bar chart style="bar" or a line graph style="line". These plots can be represented individually or in a single facet plot when facet="TRUE".

Additionally, there is the option to plot the distribution of sRNA classes within individual samples or to plot the distribution of the consensus dicer-derived sRNA classes determined by the [RNAdicercall\(\)](#) function and stored in the column DicerConsensus when data.type="consensus". When plotting samples individually, there is the option to overlap the results onto a single line graph when overlap=TRUE. This is not an option for bar plots.

**Value**

The function returns a list containing the results: a data frame and the plot(s). To access an element, simply use the "\$" symbol, and the elements "data" and "plot" will appear.

**Examples**

```
# load data
data('sRNA_data')

p1 <- RNAdistribution(data = sRNA_data, style = "line")

p2 <- RNAdistribution(data = sRNA_data, style = "line", overlap = FALSE)

p3 <- RNAdistribution(data = sRNA_data, style = "bar")

p3.2 <- RNAdistribution(data = sRNA_data, style = "bar",
                      samples = c("heterograft_1", "heterograft_2",
                                   "heterograft_3"))

p4 <- RNAdistribution(data = sRNA_data, style = "bar", facet = FALSE)

p5 <- RNAdistribution(data = sRNA_data, style = "bar",
                      facet = TRUE, facet.arrange = 2 )

# Run function to define sRNA class for each cluster.
sRNA_data_dicercall <- mobileRNA::RNAdicercall(data = sRNA_data, tidy=TRUE)

p6 <- RNAdistribution(data = sRNA_data_dicercall, style = "bar", data.type = "consensus")
```

---

RNAfeatures

---

*Summarise the distribution of sRNA clusters across genomic features*


---

**Description**

Calculates the number of genomic features within the supplied annotations and calculates the number of sRNA clusters which overlap with these genomic features. Features include promoter regions, repeat regions, exons, introns, and untranslated regions. This can be summarised as the absolute or relative values.

**Usage**

```
RNAfeatures(
  data,
  annotation,
  repeats = NULL,
  promoterRegions = 1000,
  percentage = TRUE,
  repeat.type = NULL
)
```

**Arguments**

|                              |                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>data</code>            | data.frame; generated by <code>RNAimport()</code>                                                                                                                                                                                                                                                                                                      |
| <code>annotation</code>      | path; URL or connection to a GFFFile object. A genome reference annotation file (.gff/.gff1/.gff2/.gff3). Can be in compressed format (gzip).                                                                                                                                                                                                          |
| <code>repeats</code>         | path; URL or connection to a GFFFile object. A genome reference annotation file, which only contains information on repeat sequences in the genome (.gff/.gff1/.gff2/.gff3). By default, this is not required, however if there is a specific repeats annotation file for the genome it is suggested to supply it. Can be in compressed format (gzip). |
| <code>promoterRegions</code> | numeric; defines the upstream promoter region of genes. Default is 1000, which refers to promoters set at 1Kb upstream of genes                                                                                                                                                                                                                        |
| <code>percentage</code>      | logical; define whether to return the results as a percentage of the total or returned as a count value representing the number of sRNA clusters that overlap with a given genomic feature. Default is TRUE.                                                                                                                                           |
| <code>repeat.type</code>     | character; features type in annotation file to represent repeats or transposable elements when repeats not supplied. Default is <code>c("transposable_element", transposable_element)</code> which represent the transposable element features in the TAIR10 genome annotation.                                                                        |

**Details**

RNAfeatures calculates the number or percentage of sRNA clusters which overlap with genomic features based on their genomic coordinates.

**Value**

Returns a table containing the number or percentage of overlaps in the supplied sRNA data set with specific regions in the genome annotation such as genes, repeats, introns, exons.

**See Also**

`RNAmergeAnnotations()` to merge 2 GFF files into 1.

**Examples**

```
data("sRNA_data")
features <- RNAfeatures(data = sRNA_data,
                        annotation = system.file("extdata",
                                                "reduced_chr2_Tomato.gff.gz", package="mobileRNA"))
```

**Description**

Load and organise either sRNAseq or mRNAseq pre-processing results into a single dataframe containing all experimental replicates specified where rows represent either a sRNA cluster (ie. sRNA producing-locus) or gene, respectively. Based on using the mobileRNA pre-processing method (See `mapRNA()`).

## Usage

```
RNAimport(
  input = c("sRNA", "mRNA"),
  directory,
  samples,
  analysisType = "mobile",
  annotation,
  idattr = "Name",
  FPKM = FALSE,
  featuretype = "mRNA"
)
```

## Arguments

|              |                                                                                                                                                                                                                                                                                |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| input        | string; define type of dataset. "sRNA" for sRNAseq data and "mRNA" for mRNAseq data.                                                                                                                                                                                           |
| directory    | path; directory containing of sample folders generated by ShortStack                                                                                                                                                                                                           |
| samples      | character; vector naming samples correlating to outputted folders within the directory path.                                                                                                                                                                                   |
| analysisType | character; either "core" or "mobile" to represent the sRNA analysis workflow. Where the "core" sRNA analysis imports all reads (unique & multi-map), while "mobile" sRNA analysis imports only uniquely aligned read counts. Only for sRNA data, default is "mobile".          |
| annotation   | path; directory to genome annotation (GFF) file used for pre-processing. Only for mRNA data.                                                                                                                                                                                   |
| idattr       | character; GFF attribute to be used as feature ID containing mRNA names. Several GFF lines with the same feature ID will be considered as parts of the same feature. The feature ID is used to identity the counts in the output table. Default is "Name". Only for mRNA data. |
| FPKM         | logical; calculate the FPKM for each sample. Default is FALSE.                                                                                                                                                                                                                 |
| featuretype  | character; type of feature. Default is "mRNA", only for mRNA data.                                                                                                                                                                                                             |

## Details

The `RNAimport()` function requires the user to supply a directory path and a character vector. The path must be to the pre-processing output.

Following the `mobileRNA` method, for sRNA analysis, the path will be to the `2_alignment_results` folder. While for mRNA analysis, the path will be to the `2_raw_counts` folder. Both folders are generated by the `mapRNA()` function. The vector should contain strings that represent and mirror the names of the sample replicate folders in the above directory.

Together this information allows the function to extract the information stored in "Result.txt" files of each sample.

## Value

**For sRNAseq:** A dataframe where rows represent sRNA clusters and columns represent replicate information extracted from the ShortStack output. Replicate information includes Dicer-call, Counts, and MajorRNA sequence. Each replicate information is distinguishable as the replicate name is joined as a suffix to each column name. For example, for a sample called "Sample1", the columns will include `DicerCall_Sample1`, `Count_Sample1`, `MajorRNA_Sample1` and `RPM_Sample1`.

The breakdown of each column:

- Locus : sRNA cluster locus
- chr : Chromosome
- start : start coordinate of cluster
- end : end coordinate of cluster
- Cluster : name of cluster
- DicerCall\_ : the size in nucleotides of most abundant sRNA in the cluster
- Count\_ : number of uniquely aligned sRNA-seq reads that overlap the locus
- MajorRNA\_ : RNA sequence of the most abundant sRNA in the cluster
- RPM\_ : reads per million
- FPKM\_ : Fragments Per Kilobase of transcript per Million mapped reads (only if option activated)

**For mRNAseq:** A dataframe where rows represent genes and columns represent replicate information extracted from HTseq result. Replicate information includes Counts and FPKM. For example, for a sample called "Sample1", the columns will include Count\_Sample1, and FPKM\_Sample1.

The breakdown of each column:

- mRNA : Name of mRNA
- Locus: Genomic loci of mRNA
- chr : Chromosome
- start : start coordinate
- end : end coordinate
- width: width in nucleotides of regions
- Count\_ : number of uniquely aligned mRNA-seq reads that overlap the locus
- FPKM\_ : Fragments Per Kilobase of transcript per Million mapped reads

## References

ShortStack <https://github.com/MikeAxtell/ShortStack>, HISAT2 <https://anaconda.org/bioconda/hisat2>, HTSeq <https://htseq.readthedocs.io/en/master/install.html>, SAMtools <https://anaconda.org/bioconda/samtools>

## Examples

```
## Not run:
# import sRNAseq data
df_sRNA <- RNAimport(input = "sRNA",
                     directory = "./analysis/sRNA_mapping_results",
                     samples = c("heterograft_1", "heterograft_2",
                                "heterograft_3", "selfgraft_1", "selfgraft_2",
                                "selfgraft_3"))

# The output of this function can be explored in the data object sRNA_data
data("sRNA_data")
head(sRNA_data)
```

```
# import sRNAseq data
df_mRNA <- RNAimport(input = "mRNA",
                      directory = "./analysis/mRNA_mapping_results",
                      samples = c("heterograft_1", "heterograft_2",
                                "heterograft_3", "selfgraft_1", "selfgraft_2",
                                "selfgraft_3"),
                      annotation = "./merged_annotation.gff3")

## End(Not run)
```

---

RNAmergeAnnotations      *Merge two genome annotation files (GFF Format)*

---

## Description

Merges two genomes annotation files (GFF) into one single GFF format file saved to the desired directory. This function adds a unique prefix to the chromosome names in each genome annotation to ensure each is distinguishable within the merged file.

## Usage

```
RNAmergeAnnotations(
  annotationA,
  annotationB,
  output_file,
  AnnoA.ID = "A",
  AnnoB.ID = "B",
  format = "gff3"
)
```

## Arguments

|             |                                                                                                                                     |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------|
| annotationA | path; path to a genome annotation assembly file in GFF format.                                                                      |
| annotationB | path; path to a genome annotation assembly file in GFF format.                                                                      |
| output_file | path; a character string or a base::connections() open for writing. Including file output name, and must have a GFF file extension. |
| AnnoA.ID    | character; string to represent prefix added to existing chromosome names in annotationA. Default set as "A".                        |
| AnnoB.ID    | character; string to represent prefix added to existing chromosome names in annotationB. Default set as "B".                        |
| format      | format of GFF output, either "gff", "gff1", "gff2", "gff3." Default is "gff3".                                                      |

## Details

As default, the function removes periods and adds a prefix to the existing chromosome names. The prefix is separated from the original chromosome name by an underscore. For example, based on the default settings, it will add the prefix "A\_" to the chromosome names in annotationA, for instance, A\_0, A\_1, A\_2 etc.

The merged genome is saved to the specified output directory, and requires the user to set the name with a GFF format.

**IMPORTANT:** The genome reference and annotation of a species must have chromosomes with matching names. It is critical that if you used the `RNAmergeGenomes()` function to create a merged reference genome, that you treat the input annotations in the same way.

### Value

A GFF format file containing the annotations of two genomes distinguishable by the appended prefixes.

### Examples

```
anno1 <- system.file("extdata", "reduced_chr12_Eggplant.gff.gz",
  package="mobileRNA")

anno2 <- system.file("extdata", "reduced_chr2_Tomato.gff.gz",
  package="mobileRNA")

output_file <- tempfile("merged_annotation", fileext = ".gff3")

merged_anno <- RNAmergeAnnotations(annotationA = anno1, annotationB = anno2,
  output_file = output_file)
```

---

|                 |                                                             |
|-----------------|-------------------------------------------------------------|
| RNAmergeGenomes | <i>Merge two genome reference assemblies (FASTA format)</i> |
|-----------------|-------------------------------------------------------------|

---

### Description

Merges two reference genomes (FASTA) into one single reference with modified chromosome names.

Typically, use genomeA as the origin tissue genome assembly, and genomeB as the genome from which mobile RNAs are produced by.

### Usage

```
RNAmergeGenomes(
  genomeA,
  genomeB,
  output_file,
  GenomeA.ID = "A",
  GenomeB.ID = "B",
  compress.output = FALSE
)
```

### Arguments

|             |                                                                                                                                      |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------|
| genomeA     | path; path to a genome reference assembly file in FASTA format.                                                                      |
| genomeB     | path; path to a genome reference assembly file in FASTA format.                                                                      |
| output_file | path; a character string or a base::connections() open for writing. Including file output name, and file extension of .fa or .fasta. |

|                 |                                                                                                          |
|-----------------|----------------------------------------------------------------------------------------------------------|
| GenomeA.ID      | character; string to represent prefix added to existing chromosome names in genomeA. Default set as "A"  |
| GenomeB.ID      | character; string to represent prefix added to existing chromosome names in genomeB. Default set as "B". |
| compress.output | logical; state whether the output file should be in a compressed format (gzip)                           |

### Details

The function merges two FASTA files, however, when merging genomic files it is critical that the two genomes are distinguishable by the chromosome names. As a default setting, the function extracts the chromosome names for the given FASTA files and alters adds a unique prefix while retaining the identifying number. Plus, removes any periods.

As default, the function will rename the chromosome names in genome\_A to "A" and separates the prefix and the existing chromosome names with an underscore ("\_"). For example, A\_0, A\_1, A\_2 etc.

Please note that the underscore is added automatically, hence, when setting a custom prefix just includes character values.

**IMPORTANT:** The genome reference and annotation of the same species/accession/variety must have chromosomes with matching names. It is critical that if you use the [RNAmergeAnnotations\(\)](#) function to create a merged genome annotation, that you treat the input references in the same way.

### Value

Returns a single FASTA format file containing both genome assemblies with edited chromosome names (prefixes, and removal of periods) to the given directory.

### Examples

```
fasta_1 <- system.file("extdata", "reduced_chr12_Eggplant.fa.gz",
  package="mobileRNA")

fasta_2 <-system.file("extdata", "reduced_chr2_Tomato.fa.gz",
  package="mobileRNA")

output_file <- file.path(tempfile("merged_annotation", fileext = ".fa"))

merged_ref <- RNAmergeGenomes(genomeA = fasta_1,
  genomeB = fasta_2,
  output_file = output_file)
```

---

RNAmobile

*Identify putative RNA molecules produced by the non-tissue sample genome*

---

### Description

A function to identify the putative sRNA or mRNA molecules produced by the non-tissue sample genome. Includes putative RNA mobilome or RNAs not expected to be found within the tissue of origin.

**Usage**

```

RNAmobile(
  input = c("sRNA", "mRNA"),
  data,
  controls,
  genome.ID,
  task = NULL,
  statistical = FALSE,
  alpha = 0.1,
  threshold = NULL
)

```

**Arguments**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>input</code>       | character; must be either "sRNA" or "mRNA" to represent the type of data.                                                                                                                                                                                                                                                                                                                             |
| <code>data</code>        | data.frame; generated through the <b>mobileRNA</b> method.                                                                                                                                                                                                                                                                                                                                            |
| <code>controls</code>    | character vector; containing names of control samples.                                                                                                                                                                                                                                                                                                                                                |
| <code>genome.ID</code>   | character; string or chromosome identifier related to the chromosomes in a given genome. A distinguishing feature of the genome of interest or non-interest in the chromosome name (chr column).                                                                                                                                                                                                      |
| <code>task</code>        | character; string to set the method to keep or remove the chromosomes containing the identifying string. To keep the chromosomes with the ID, set <code>task=keep</code> . To remove, set <code>task="remove"</code> . As default, task is set to keep.                                                                                                                                               |
| <code>statistical</code> | If TRUE, will undertake statistical filtering based on the a p-value or adjusted p-value threshold stated by <code>alpha</code> . Default set at FALSE. Requires presence of columns containing statistical data. In order to filter by the adjusted p-value, a column named <code>padjusted</code> must be present. See <a href="#">RNA Differential Analysis()</a> to calculate statistical values. |
| <code>alpha</code>       | numeric; adjusted p-value cutoff as the target FDR for independent filtering. Default is 0.1. Only mobile molecules with adjusted p-values equal or lower than specified are returned.                                                                                                                                                                                                                |
| <code>threshold</code>   | numeric; set a threshold level. For sRNA analysis, this represents filtering by the minimum number of replicates that defined the consensus dicercall which is stored in the <code>DicerCounts</code> column. While, for mRNA analysis this represents the number of replicates which contained reads for the mRNA molecule which is stored in the <code>SampleCounts</code> column.                  |

**Details**

The function identifies candidate sRNAs or mRNAs produced by a specific genome/genotype. It does so by either keeping or removing those mapped to a given genome. To do so, it requires a common pre-fix across chromosomes of the given genome. See [RNA Merge Genomes\(\)](#) for more information. In addition, it removes RNAs which were likely to be falsely mapped. These are those which were mapped to the non-tissue genotype in the control samples.

**For sRNAseq:** A greater confidence in the sRNA candidates can be achieved by setting a threshold that considers the number of replicates which contributed to defining the consensus dicercall (ie. consensus sRNA classification). This parameter filters based on the `DicerCounts` column introduced by the [RNA dicercall\(\)](#) function.

**For mRNAseq:** A greater confidence in the mRNA candidates can be achieved by setting a threshold that considers the number of replicates which contained reads for the mRNA molecule. This parameter filters based on the SampleCounts column introduced by the `RNAimport()` function.

**Statistical Analysis** The function also allows for filtering using statistical inference generated from the differential analysis of the total data set using the function `RNA Differential Analysis()`. When `statistical=TRUE`, the feature is enabled and selects molecules that meet the adjusted p-value cutoff defined by alpha.

### Value

A data frame containing candidate mobile sRNAs or mRNAs, which could have been further filtered based on statistical significance and the ability to by-pass the thresholds which determine the number of replicates that defined the consensus dicercall (sRNA) or contributed to reads counts (mRNA).

### Examples

```
data("sRNA_data")

# vector of control names
controls <- c("selfgraft_1", "selfgraft_2" , "selfgraft_3")

# Locate potentially mobile sRNA clusters associated to tomato, no
# statistical analysis
mobile_df1 <- RNAmobile(input = "sRNA", data = sRNA_data,
  controls = controls, genome.ID = "B_", task = "keep", statistical = FALSE)
```

---

|               |                                                                                      |
|---------------|--------------------------------------------------------------------------------------|
| RNApopulation | <i>Identify gained/lost RNA populations between treatment and control conditions</i> |
|---------------|--------------------------------------------------------------------------------------|

---

### Description

Identify unique sRNA or mRNA populations within a set of samples, typically within the same condition, compared to the other samples in the analysis. This can be known as lost or gained populations due to a treatment.

### Usage

```
RNApopulation(
  data,
  conditions,
  statistical = FALSE,
  alpha = 0.05,
  chimeric = FALSE,
  controls = NULL,
  genome.ID = NULL,
  dual = TRUE
)
```



---

|            |                                                                                                      |
|------------|------------------------------------------------------------------------------------------------------|
| RNAreorder | <i>Reorder the data frame for differential analysis, ensuring control verse treatment comparison</i> |
|------------|------------------------------------------------------------------------------------------------------|

---

### Description

Re-organise the working data frame, placing control samples before treatment samples. This ensures differential analysis comparison between controls and treatment are in the correct arrangement.

### Usage

```
RNAreorder(data, controls)
```

### Arguments

|          |                                                      |
|----------|------------------------------------------------------|
| data     | data.frame; generated by <a href="#">RNAimport()</a> |
| controls | character; vector of control condition sample names. |

### Value

A re-ordered/re-organised working data frame with control samples after the 5 cluster information columns, and treatment sample columns after the control sample columns.

### Examples

```
# load data
data("sRNA_data")

controlReps <- c("selfgraft_1", "selfgraft_2", "selfgraft_3")

reorder_df <- RNAreorder(data = sRNA_data, controls = controlReps)
```

---

|              |                                                |
|--------------|------------------------------------------------|
| RNAsequences | <i>Extract RNA sequence from sRNA clusters</i> |
|--------------|------------------------------------------------|

---

### Description

RNAsequences extrapolates the RNA sequence for sRNA clusters through two different methods utilising the RNA sequence of the most abundant transcript identified within each replicate. This can either be determined by extracting the consensus sequence across replicates or by comparing the sequences across replicates and selecting the most abundant. In this second method ties between sequences can be seen, hence, the user must decide whether a sequence is then chosen at random from the most abundant or will exclude any sequence determination.

The function also calculates the RNA & DNA complementary sequences, as well as stating the length/width of the sequence.

**Usage**

```
RNAsequences(
  data,
  original = FALSE,
  method = c("consensus", "set"),
  match.threshold = 1,
  duplicates = "random",
  tidy = FALSE
)
```

**Arguments**

|                              |                                                                                                                                                                                                                                                                                                                          |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>data</code>            | data.frame; generated by <a href="#">RNAimport()</a>                                                                                                                                                                                                                                                                     |
| <code>original</code>        | logical; output results to working date as additional columns ( <code>original=TRUE</code> ), or output as new data frame ( <code>original=FALSE</code> ). by default, <code>FALSE</code>                                                                                                                                |
| <code>method</code>          | character; string to define method. Either "consensus" or "set". The "consensus" method identifies the consensus sequences across replicated based on the <code>bioseq</code> package method. Whereas the "set" is based on the fixed sequences calculated for each replicate and whether they are exact matches or not. |
| <code>match.threshold</code> | numeric; the minimum number of replicates required to share the sRNA sequence to count as a match. Default is 1. Only applicable to the "set" method.                                                                                                                                                                    |
| <code>duplicates</code>      | character; string to define how to deal with a tie, "random" as default. Options include "random" and "exclude". Only applicable to the "set" method.                                                                                                                                                                    |
| <code>tidy</code>            | logical; tidy-up data set by removing sRNA clusters with a unknown or unclassified consensus sRNA sequence result. By default, <code>tidy=FALSE</code> , while <code>tidy=TRUE</code> removes sRNA clusters with an undetermined consensus RNA sequence.                                                                 |

**Details**

The set method checks whether each sample in the data set shares the same major sRNA sequence for a given sRNA cluster. If at least two replicates share the same sRNA sequence, the sequence is pulled and the complementary DNA and RNA sequences are calculated. Using the `match.threshold` parameter, we can alter the minimum number of replicates required to share the RNA sequence to count as a match. For example, if set as `match.threshold=3`, at least 3 replicates must contain the same sequence. As a general rule, if only one replicate has determined a sRNA sequence it is noted that there is no match, but the sequence is pulled and the complementary sequences calculated.

The match column can either return "Yes", "No" or "Duplicate". If a match between replicates is found, "Yes" is supplied, if not, "No". While if there is a tie between sequences "Duplicate" is supplied. For examples, if an equal number of replicates have sequence "x" and sequence "y".

In the situation where duplicates are identified, as default, at random a consensus sRNA sequence is selected. This parameter can be changed to "exclude", and under this parameter no consensus sequence is pulled.

Whereas with the consensus method, the consensus sequence is pulled from all replicates.

**Value**

The results can be added as additional columns to the working data frame supplied to the function or stored as a new data frame containing only the results from the function. The results includes:

- Match: whether the RNA sequence is consistent across replicates
- Sequence: character; sequence of the most abundant sRNA within a cluster
- Complementary\_RNA: character; complementary RNA nucleotide sequence
- Complementary\_DNA: character; complementary DNA nucleotide sequence
- Width: numeric; length of nucleotide sequence

### Examples

```
data("sRNA_data")

# vector of control names
controls <- c("selfgraft_1", "selfgraft_2", "selfgraft_3")

# Locate potentially mobile sRNA clusters associated to tomato, no
# statistical analysis
sRNA_data_mobile <- RNAmobile(input = "sRNA", data = sRNA_data,
  controls = controls, genome.ID = "B_", task = "keep", statistical = FALSE)

mobile_sequences <- RNAsequences(sRNA_data_mobile, method = "consensus")
```

---

RNAsubset

*Subset sRNA data based on dicercall size*

---

### Description

Subset the existing dataframe to contain only the desired sRNA class(s) based on the consensus dicercall determination and statistical significance.

### Usage

```
RNAsubset(data, class, statistical = FALSE, alpha = 0.05)
```

### Arguments

|             |                                                                                                                                                                                                                      |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data        | data.frame; generated by <a href="#">RNAimport()</a> , containing the additional information generated by <a href="#">RNAdicercall()</a> which defines the consensus sRNA class for each sRNA dicer-derived clusters |
| class       | numeric; sRNA dicercall class(es) to select. Based on size in nucleotides.                                                                                                                                           |
| statistical | logical; filter and select statistically significant sRNA. If statistical=TRUE, sRNA clusters are selected based on p-adjusted alpha threshold.                                                                      |
| alpha       | numeric; user-defined numeric value to represent the adjusted p-value threshold to define statistical significance. Defaults setting alpha=0.05.                                                                     |

### Details

See [RNAdicercall\(\)](#) for information on defining the consensus sRNA dicercall class for each cluster. The function allows the choice to filtered the data by statistical significance based on differential expression analysis, see [RNAdifferentialAnalysis\(\)](#). Set statistical=TRUE to filtered by statistical significance (p-adjusted).

It is important to consider what point in your analysis the data is subset as it will drastically reduce your sample size, altering the output of statistical analyse.

**Value**

A data frame containing only sRNA clusters defined with a specific sRNA dicer-derived consensus size.

**Examples**

```
# load data
data("sRNA_data")

# define consensus sRNA classes.
conditions <- c("heterograft_1", "heterograft_2", "heterograft_3")

# Run function to define sRNA class for each cluster.
sRNA_data_dicercall <- RNAdicercall(data = sRNA_data,
                                   conditions = conditions,
                                   tidy=TRUE)

# Subset data for 24-nt sRNAs
sRNA_24 <- RNAsubset(sRNA_data_dicercall, class = 24)

# Subset data for 21/22-nt sRNAs
sRNA_2122 <- RNAsubset(sRNA_data_dicercall, class = c(21, 22))
```

RNAsummary

*Summarise differential analysis results***Description**

Print a summary of the statistical analysis of sRNA clusters (sRNAseq) or mRNAs (mRNAseq) from a mobileRNA analysis

**Usage**

```
RNAsummary(
  data,
  alpha = 0.1,
  chimeric = FALSE,
  controls = NULL,
  genome.ID = NULL
)
```

**Arguments**

|           |                                                                                                                                                 |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| data      | data.frame; generated by <a href="#">RNAdifferentialAnalysis()</a>                                                                              |
| alpha     | numeric; user-defined numeric value to represent the adjusted p-value threshold to define statistical significance. Defaults setting alpha=0.1. |
| chimeric  | logical; state whether system is chimeric: contains multiple genomes/genotypes.                                                                 |
| controls  | character; vector of control condition sample names.                                                                                            |
| genome.ID | character; chromosome identifier of the genome representing either the origin of mobile molecules or the other genome in the chimeric system.   |

**Details**

To look only at the differential abundance from RNAs in the mobilome, use the `chimeric=TRUE` parameter and supply the chromosome identifier of the genome from which mobile molecules originate from to the `genome.ID` parameter & the control condition samples names to the `controls` parameter.

**Value**

Prints a summary of the RNAs which align with the adjusted p-value cutoff and states the number which has a positive and negative log-fold change. Where a positive log-fold change represents an increase in abundance and a negative value represents a decrease in abundance between the conditions.

**Examples**

```
# load data
data("sRNA_data")

# sample conditions.
groups <- c("Selfgraft", "Selfgraft", "Selfgraft", "Heterograft", "Heterograft", "Heterograft")

## Differential analysis: DEseq2 method
sRNA_DESeq2 <- RNADESeq2(data = sRNA_data,
                          group = groups,
                          method = "DESeq2" )

res <- RNASummary(sRNA_DESeq2)
```

---

sRNA\_data

*sRNA\_data: simulated data for biological replicates*


---

**Description**

Simulated sRNAseq dataset

**Usage**

```
data(sRNA_data)
```

**Details**

Simulated data is taken from eggplant and tomato sRNAseq samples and created to simulate to movement of sRNA molecules from an Tomato rootstock to an Eggplant Scion. Three Eggplant replicates were spiked with the same 150 tomato sRNA clusters, and named "heterograft\_" 1 to 3. The analysis compares these heterografts to three Eggplant self-grafts which are the original un-spiked Eggplant replicates, called "selfgraft\_" 1 to 3.

This data was imported and organised by the `RNAimport()` function.

**Value**

Dataframe in global environment

**Examples**

```
data("sRNA_data")
```

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