

# Package ‘zellkonverter’

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**Title** Conversion Between scRNA-seq Objects

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**Description** Provides methods to convert between Python AnnData objects and SingleCellExperiment objects. These are primarily intended for use by downstream Bioconductor packages that wrap Python methods for single-cell data analysis. It also includes functions to read and write H5AD files used for saving AnnData objects to disk.

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zellkonverter-package *zellkonverter: Conversion Between scRNA-seq Objects*

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## Description

Provides methods to convert between Python AnnData objects and SingleCellExperiment objects. These are primarily intended for use by downstream Bioconductor packages that wrap Python methods for single-cell data analysis. It also includes functions to read and write H5AD files used for saving AnnData objects to disk.

## Author(s)

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- Aaron Lun <infinite.monkeys.with.keyboards@gmail.com> ([ORCID](#))

## See Also

Useful links:

- <https://github.com/theislab/zellkonverter>
- Report bugs at <https://github.com/theislab/zellkonverter/issues>

## Description

Conversion between Python AnnData objects and [SingleCellExperiment](#) objects.

## Usage

```
AnnData2SCE(  
    adata,  
    X_name = NULL,  
    layers = TRUE,  
    uns = TRUE,  
    var = TRUE,  
    obs = TRUE,  
    varm = TRUE,  
    obsm = TRUE,  
    varp = TRUE,  
    obsp = TRUE,  
    raw = FALSE,  
    skip_assays = FALSE,  
    hdf5_backed = TRUE,  
    verbose = NULL  
)
```

```
SCE2AnnData(  
    sce,  
    X_name = NULL,  
    assays = TRUE,  
    colData = TRUE,  
    rowData = TRUE,  
    varm = TRUE,  
    reducedDims = TRUE,  
    metadata = TRUE,  
    colPairs = TRUE,  
    rowPairs = TRUE,  
    skip_assays = FALSE,  
    verbose = NULL  
)
```

## Arguments

adata	A <b>reticulate</b> reference to a Python AnnData object.
X_name	For SCE2AnnData() name of the assay to use as the primary matrix (X) of the AnnData object. If NULL, the first assay of sce will be used by default. For

AnnData2SCE() name used when saving X as an assay. If NULL looks for an X\_name value in uns, otherwise uses "X".

layers, uns, var, obs, varm, obsm, varp, obsp, raw  
Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.

skip\_assays Logical scalar indicating whether to skip conversion of any assays in sce or adata, replacing them with empty sparse matrices instead.

hdf5\_backed Logical scalar indicating whether HDF5-backed matrices in adata should be represented as HDF5Array objects. This assumes that adata is created with backed="r".

verbose Logical scalar indicating whether to print progress messages. If NULL uses getOption("zellkonverter.verbose").

sce A [SingleCellExperiment](#) object.

assays, colData, rowData, reducedDims, metadata, colPairs, rowPairs  
Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.

## Details

These functions assume that an appropriate Python environment has already been loaded. As such, they are largely intended for developer use, most typically inside a **basilisk** context.

The conversion is not entirely lossless. The current mapping is shown below (also at <https://tinyurl.com/AnnData2SCE>):

SingleCellExperiment				AnnData		
R object used by Bioconductor packages				Python object used by Scanpy and related packages		
Rows contain features and columns contain cells				Rows contain observations (cells) and columns contain variables (features)		
	Each element is a matrix of expression values with the same dimensions	SimpleList of matrices	assays	↔	X	Numpy array Primary matrix of expression data
	Any unstructured data	list	metadata	↔	layers	Dictionary of arrays Dictionary-like object where each element is an array of expression values with the same dimensions as X
	Names of rows (cells)	vector	colnames	↔	uns	OrderedDict Unstructured annotation
	Columns describe annotations of the columns (cells)	DataFrame	colData	↔	obs_names	Pandas index Names of observations (cells)
IMPLEMENTED	Each element is a matrix where the number of rows is equal to the number of cells and each column is a dimension	List of matrices	reducedDims	↔	obs	Pandas DataFrame One-dimensional annotations of the observations (cells)
	Relationships between columns (cells)	List of SelfHits	colPairs	↔	obsm	Dictionary of arrays Dictionary-like object where each element is an array where the number of rows is equal to the number of observations (cells)
	Names of rows (features)	vector	rownames	↔	obsp	Dictionary of arrays Dictionary-like object where each element is a square array containing annotations between observations (cells)
	Columns describe annotations of the rows (features)	DataFrame	rowData	↔	var_names	Pandas index Names of variables (features)
	Relationships between rows (features)	List of SelfHits	rowPairs	↔	vars	Pandas DataFrame One-dimensional annotations of the variables (features)
NOT IMPLEMENTED	Nested SingleCellExperiments with information about alternative feature sets	List of SingleCellExperiments	altExp	↔	varm	Dictionary of arrays Dictionary-like object where each element is an array where the number of rows is equal to the number of variables (features)
	Internal unstructured data that is not meant to be modified by users	list	int_metadata	↔	varp	Dictionary of arrays Dictionary-like object where each element is a square array containing annotations between variables (features)
	Internal annotation for columns (cells) that is not meant to be modified by users	DataFrame	int_colData	↔	raw	AnnData Raw version of X and var prior to any filtering. Is not indexed as part of the object.
	Internal annotation for rows (features) that is not meant to be modified by users	DataFrame	int_elementMetadata			

In SCE2AnnData(), matrices are converted to a **numpy**-friendly format. Sparse matrices are converted to [dgCMatrix](#) objects while all other matrices are converted into ordinary matrices. If skip\_assays = TRUE, empty sparse matrices are created instead and the user is expected to fill in the assays on the Python side.

For `AnnData2SCE()`, a warning is raised if there is no corresponding R format for a matrix in the `AnnData` object, and an empty sparse matrix is created instead as a placeholder. If `skip_assays = NA`, no warning is emitted but variables are created in the `int_metadata()` of the output to specify which assays were skipped.

If `skip_assays = TRUE`, empty sparse matrices are created for all assays, regardless of whether they might be convertible to an R format or not. In both cases, the user is expected to fill in the assays on the R side, see `readH5AD()` for an example.

We attempt to convert between items in the `SingleCellExperiment metadata()` slot and the `AnnData uns` slot. If an item cannot be converted a warning will be raised.

Values stored in the `varm` slot of an `AnnData` object are stored in a column of `rowData()` in a `SingleCellExperiment` as a `DataFrame` of matrices. If this column is present an attempt is made to transfer this information when converting from `SingleCellExperiment` to `AnnData`.

### Value

`AnnData2SCE()` will return a `SingleCellExperiment` containing the equivalent data from `adata`.

`SCE2AnnData()` will return a **reticulate** reference to an `AnnData` object containing the content of `sce`.

### Author(s)

Luke Zappia

Aaron Lun

### See Also

`writeH5AD()` and `readH5AD()` for dealing directly with H5AD files.

### Examples

```
if (requireNamespace("scRNAseq", quietly = TRUE)) {
  library(basilisk)
  library(scRNAseq)
  seger <- SegerstolpePancreasData()

  # These functions are designed to be run inside
  # a specified Python environment
  roundtrip <- basiliskRun(fun = function(sce) {
    # Convert SCE to AnnData:
    adata <- zellkonverter::SCE2AnnData(sce)

    # Maybe do some work in Python on 'adata':
    # BLAH BLAH BLAH

    # Convert back to an SCE:
    zellkonverter::AnnData2SCE(adata)
  }, env = zellkonverterAnnDataEnv, sce = seger)
}
```

---

AnnData-Environment     *AnnData environment*

---

### Description

The Python environment used by **zellkonverter** for interfacing with the **anndata** Python library (and H5AD files) is described by the dependencies in `.AnnDataDependencies`. The `zellkonverterAnnDataEnv` variable is the `basilisk::BasiliskEnvironment()` used by **zellkonverter**.

### Usage

```
.AnnDataDependencies  
  
zellkonverterAnnDataEnv
```

### Format

A character vector containing the pinned versions of all Python packages in `zellkonverterAnnDataEnv`.  
A `basilisk::BasiliskEnvironment()` containing **zellkonverter**'s AnnData Python environment.

### Details

The `.AnnDataDependencies` variable is exposed for use by other package developers who want an easy way to define the dependencies required for creating a Python environment to work with AnnData objects, most typically within a **basilisk** context. For example, we can simply combine this vector with additional dependencies to create a **basilisk** environment with Python package versions that are consistent with those in **zellkonverter**.

If you want to run code in the exact environment used by **zellkonverter** this can be done using `zellkonverterAnnDataEnv` in combination with `basilisk::basiliskStart()` and/or `basilisk::basiliskRun()`. Please refer to the **basilisk** documentation for more information on using these environments.

### Author(s)

Luke Zappia  
Aaron Lun

### Examples

```
.AnnDataDependencies  
  
cl <- basilisk::basiliskStart(zellkonverterAnnDataEnv)  
anndata <- reticulate::import("anndata")  
basilisk::basiliskStop(cl)
```

---

expectSCE	<i>Expect SCE</i>
-----------	-------------------

---

**Description**

Test that a `SingleCellExperiment` matches an expected object. Designed to be used inside `testthat::test_that()` during package testing.

**Usage**

```
expectSCE(sce, expected)
```

**Arguments**

sce	A <a href="#">SingleCellExperiment</a> object.
expected	A template <a href="#">SingleCellExperiment</a> object to compare to.

**Value**

TRUE invisibly if checks pass

**Author(s)**

Luke Zappia

---

readH5AD	<i>Read H5AD</i>
----------	------------------

---

**Description**

Reads a H5AD file and returns a [SingleCellExperiment](#) object.

**Usage**

```
readH5AD(  
  file,  
  X_name = NULL,  
  use_hdf5 = FALSE,  
  reader = c("python", "R"),  
  verbose = NULL,  
  ...  
)
```

## Arguments

file	String containing a path to a .h5ad file.
X_name	Name used when saving X as an assay. If NULL looks for an X_name value in uns, otherwise uses "X".
use_hdf5	Logical scalar indicating whether assays should be loaded as HDF5-based matrices from the <b>HDF5Array</b> package.
reader	Which HDF5 reader to use. Either "python" for reading with the <b>anndata</b> Python package via <b>reticulate</b> or "R" for <b>zellkonverter</b> 's native R reader.
verbose	Logical scalar indicating whether to print progress messages. If NULL uses <code>getOption("zellkonverter.verbose")</code> .
...	Arguments passed on to <a href="#">AnnData2SCE</a>
layers	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
uns	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
var	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
obs	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
varm	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
obsm	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
varp	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
obsp	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
raw	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
skip_assays	Logical scalar indicating whether to skip conversion of any assays in sce or adata, replacing them with empty sparse matrices instead.

## Details

Setting `use_hdf5 = TRUE` allows for very large datasets to be efficiently represented on machines with little memory. However, this comes at the cost of access speed as data needs to be fetched from the HDF5 file upon request.



When first run, this function will instantiate a conda environment containing all of the necessary dependencies. This will not be performed on any subsequent run or if any other **zellkonverter** function has been run prior to this one.

Setting `reader = "R"` will use an experimental native R reader instead of reading the file into Python and converting the result. This avoids the need for a Python environment and some of the issues with conversion but is still under development and is likely to return slightly different output.

### Value

A [SingleCellExperiment](#) object is returned.

### Author(s)

Luke Zappia  
Aaron Lun

### See Also

[writeH5AD\(\)](#), to write a [SingleCellExperiment](#) object to a H5AD file.

[AnnData2SCE\(\)](#), for developers to convert existing AnnData instances to a [SingleCellExperiment](#).

### Examples

```
library(SummarizedExperiment)

file <- system.file("extdata", "krumsiek11.h5ad", package = "zellkonverter")
sce <- readH5AD(file)
class(assay(sce))

sce2 <- readH5AD(file, use_hdf5 = TRUE)
class(assay(sce2))

sce3 <- readH5AD(file, reader = "R")
```

---

setZellkonverterVerbose

*Set zellkonverter verbose*

---

### Description

Set the zellkonverter verbosity option

### Usage

```
setZellkonverterVerbose(verbose = TRUE)
```

### Arguments

`verbose` Logical value for the verbosity option.

**Details**

Running `setZellkonverterVerbose(TRUE)` will turn on **zellkonverter** progress messages by default without having to set `verbose = TRUE` in each function call. This is done by setting the `"zellkonverter.verbose"` option. Running `setZellkonverterVerbose(FALSE)` will turn default verbosity off.

**Value**

The value of `getOption("zellkonverter.verbose")` invisibly

**Examples**

```
current <- getOption("zellkonverter.verbose")
setZellkonverterVerbose(TRUE)
getOption("zellkonverter.verbose")
setZellkonverterVerbose(FALSE)
getOption("zellkonverter.verbose")
setZellkonverterVerbose(current)
getOption("zellkonverter.verbose")
```

---

 validateH5ADSCE

*Validate H5AD SCE*


---

**Description**

Validate a `SingleCellExperiment` created by `readH5AD()`. Designed to be used inside `testthat::test_that()` during package testing.

**Usage**

```
validateH5ADSCE(sce, names, missing)
```

**Arguments**

<code>sce</code>	A <a href="#">SingleCellExperiment</a> object.
<code>names</code>	Named list of expected names. Names are slots and values are vectors of names that are expected to exist in that slot.
<code>missing</code>	Named list of known missing names. Names are slots and values are vectors of names that are expected to not exist in that slot.

**Details**

This function checks that a `SingleCellExperiment` contains the expected items in each slot. The main reason for this function is avoid repeating code when testing multiple `.h5ad` files. The following items in `names` and `missing` are recognised:

- `assays` - Assay names

- colData - colData column names
- rowData - rowData column names
- metadata - metadata names
- redDim - Reduced dimension names
- varm - Column names of the varm rowData column (from the AnnData varm slot)
- colPairs - Column pair names
- rowPairs - rowData pair names
- raw\_rowData - rowData columns names in the raw altExp
- raw\_varm - Column names of the raw varm rowData column (from the AnnData varm slot)

If an item in names or missing is NULL then it won't be checked. The items in missing are checked that they explicitly do not exist. This is mostly for record keeping when something is known to not be converted but can also be useful when the corresponding names item is NULL.

### Value

If checks are successful TRUE invisibly, if not other output depending on the context

### Author(s)

Luke Zappia

---

writeH5AD

*Write H5AD*

---

### Description

Write a H5AD file from a [SingleCellExperiment](#) object.

### Usage

```
writeH5AD(  
  sce,  
  file,  
  X_name = NULL,  
  skip_assays = FALSE,  
  compression = c("none", "gzip", "lzf"),  
  verbose = NULL,  
  ...  
)
```

**Arguments**

sce	A <a href="#">SingleCellExperiment</a> object.
file	String containing a path to write the new .h5ad file.
X_name	Name of the assay to use as the primary matrix (X) of the AnnData object. If NULL, the first assay of sce will be used by default.
skip_assays	Logical scalar indicating whether assay matrices should be ignored when writing to file.
compression	Type of compression when writing the new .h5ad file.
verbose	Logical scalar indicating whether to print progress messages. If NULL uses <code>getOption("zellkonverter.verbose")</code> .
...	Arguments passed on to <a href="#">SCE2AnnData</a>
varm	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
assays	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
colData	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
rowData	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
reducedDims	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
metadata	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
colPairs	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.
rowPairs	Arguments specifying how these slots are converted. If TRUE everything in that slot is converted, if FALSE nothing is converted and if a character vector only those items or columns are converted.

**Details****Environment:**

When first run, this function will instantiate a conda environment containing all of the necessary dependencies. This will not be performed on any subsequent run or if any other **zellkonverter** function has been run prior to this one.

**Skipping assays:**

Setting `skip_assays = TRUE` can occasionally be useful if the matrices in `sce` are stored in a format that is not amenable for efficient conversion to a **numpy**-compatible format. In such cases, it can be better to create an empty placeholder dataset in `file` and fill it in R afterwards.

**DelayedArray assays:**

If `sce` contains any **DelayedArray** matrices as assays `writeH5AD()` will write them to disk using the **rhd5** package directly rather than via Python to avoid instantiating them in memory. However there is currently an issue which prevents this being done for sparse **DelayedArray** matrices.

**Known conversion issues:**

*Coercion to factors:*

The **anndata** package automatically converts some character vectors to factors when saving `.h5ad` files. This can effect columns of `rowData(sce)` and `colData(sce)` which may change type when the `.h5ad` file is read back into R.

**Value**

A NULL is invisibly returned.

**Author(s)**

Luke Zappia

Aaron Lun

**See Also**

[readH5AD\(\)](#), to read a [SingleCellExperiment](#) file from a H5AD file.

[SCE2AnnData\(\)](#), for developers to create an `AnnData` object from a [SingleCellExperiment](#).

**Examples**

```
# Using the Zeisel brain dataset
if (requireNamespace("scRNAseq", quietly = TRUE)) {
  library(scRNAseq)
  sce <- ZeiselBrainData()

  # Writing to a H5AD file
  temp <- tempfile(fileext = ".h5ad")
  writeH5AD(sce, temp)
}
```

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