

# Package ‘struct’

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**Type** Package

**Title** Statistics in R Using Class-based Templates

**Version** 1.23.2

**Description** Defines and includes a set of class-based templates for developing and implementing data processing and analysis workflows, with a strong emphasis on statistics and machine learning. The templates can be used and where needed extended to 'wrap' tools and methods from other packages into a common standardised structure to allow for effective and fast integration. Model objects can be combined into sequences, and sequences nested in iterators using overloaded operators to simplify and improve readability of the code. Ontology lookup has been integrated and implemented to provide standardised definitions for methods, inputs and outputs wrapped using the class-based templates.

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'entity\_class.R' 'enum\_class.R' 'output\_class.R'  
'model\_class.R' 'example\_objects.R' 'model\_list\_class.R'  
'metric\_class.R' 'iterator\_class.R' 'optimiser\_class.R'  
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---

 struct-package

*struct: Statistics in R Using Class-based Templates*


---

## Description

Defines and includes a set of class-based templates for developing and implementing data processing and analysis workflows, with a strong emphasis on statistics and machine learning. The templates can be used and where needed extended to 'wrap' tools and methods from other packages into a common standardised structure to allow for effective and fast integration. Model objects can be combined into sequences, and sequences nested in iterators using overloaded operators to simplify and improve readability of the code. Ontology lookup has been integrated and implemented to provide standardised definitions for methods, inputs and outputs wrapped using the class-based templates.

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- Ralf Johannes Maria Weber <r.j.weber@bham.ac.uk>

---

`.DollarNames.struct_class`  
*autocompletion*

---

### **Description**

This function returns slotnames for autocompletion when using \$ syntax

### **Usage**

```
## S3 method for class 'struct_class'
.DollarNames(x, pattern = "")

## S4 method for signature 'struct_class'
.DollarNames(x, pattern = "")

## S3 method for class 'chart'
.DollarNames(x, pattern = "")

## S4 method for signature 'chart'
.DollarNames(x, pattern = "")

## S3 method for class 'DatasetExperiment'
.DollarNames(x, pattern = "")

## S4 method for signature 'DatasetExperiment'
.DollarNames(x, pattern = "")

## S3 method for class 'model'
.DollarNames(x, pattern = "")

## S4 method for signature 'model'
.DollarNames(x, pattern = "")

## S3 method for class 'metric'
.DollarNames(x, pattern = "")

## S4 method for signature 'metric'
.DollarNames(x, pattern = "")

## S3 method for class 'iterator'
.DollarNames(x, pattern = "")

## S4 method for signature 'iterator'
.DollarNames(x, pattern = "")

## S3 method for class 'optimiser'
.DollarNames(x, pattern = "")

## S4 method for signature 'optimiser'
.DollarNames(x, pattern = "")
```

```
## S3 method for class 'preprocess'  
.DollarNames(x, pattern = "")  
  
## S4 method for signature 'preprocess'  
.DollarNames(x, pattern = "")  
  
## S3 method for class 'resampler'  
.DollarNames(x, pattern = "")  
  
## S4 method for signature 'resampler'  
.DollarNames(x, pattern = "")
```

### Arguments

x                    a struct\_class object  
pattern             the text used to compare against the slot names

### Value

A vector of slot names

---

.query\_ols\_api                    *Query the OLS API for ontology term information*

---

### Description

Internal helper function to fetch term details from the Ontology Lookup Service API.

### Usage

```
.query_ols_api(obo_id, api_url = "https://www.ebi.ac.uk/ols4/api")
```

### Arguments

obo\_id                (character) The ontology ID in format PREFIX:DIGITS (e.g., 'STATO:0000046')  
api\_url               (character) The base URL for the OLS API. Default is the current OLS4 API  
                      endpoint. Can be overridden if the API URL changes or for testing purposes.

### Value

A list with elements:

**label** The term label  
**description** The term description  
**iri** The Internationalized Resource Identifier  
  
Returns NULL if the query fails.

---

`as.code`*Convert to code*

---

### Description

Prints a block of code that can be used to replicate the input object.

### Usage

```
as.code(M, start = "M = ", mode = "compact", quiet = FALSE)

## S4 method for signature 'struct_class'
as.code(M, start = "M = ", mode = "compact", quiet = FALSE)

## S4 method for signature 'model_seq'
as.code(M, start = "M = ", mode = "compact", quiet = FALSE)

## S4 method for signature 'iterator'
as.code(M, start = "M = ", mode = "compact", quiet = FALSE)
```

### Arguments

<code>M</code>	a struct model, model_seq or iterator object
<code>start</code>	text prepended to the code. Default is "M = "
<code>mode</code>	"compact" will use the least amount of lines, "expanded" will put each object and input on a new line. "neat" will produce an output somewhere between "compact" and "expanded".
<code>quiet</code>	TRUE or FALSE to print code to console

### Value

A string of code to reproduce the input object.  
a string of code to reproduce the model  
a string of code to reproduce the model sequence  
a string of code to reproduce the iterator

### Examples

```
M = example_model(value_1 = 10)
as.code(M)
M = example_model()
as.code(M)
M = example_model()
as.code(M)
M = example_model()
as.code(M)
```

---

as.DatasetExperiment    *Convert a SummarizedExperiment to DatasetExperiment*

---

**Description**

Converts a SummarizedExperiment to DatasetExperiment. The assay data is transposed, and colData and rowData switched to match. struct specific slots such as "name" and "description" are extracted from the metaData.

**Usage**

```
as.DatasetExperiment(obj)
```

**Arguments**

obj                    a SummarizedExperiment object

**Value**

a DatasetExperiment object

---

as.DatasetExperiment, SummarizedExperiment-method  
*Convert a SummarizedExperiment to DatasetExperiment*

---

**Description**

The assay data is transposed, and colData and rowData switched to match. struct specific slots such as "name" and "description" are extracted from the metaData if available. NB Any additional metadata will be lost during this conversion.

**Usage**

```
## S4 method for signature 'SummarizedExperiment'  
as.DatasetExperiment(obj)
```

**Arguments**

obj                    a SummarizedExperiment object

**Value**

a DatasetExperiment object

as.SummarizedExperiment

*Convert a DatasetExperiment to a SummarizedExperiment*

---

### Description

Converts a DatasetExperiment to SummarizedExperiment. The assay data is transposed, and colData and rowData switched to match. struct specific slots such as "name" and "description" are stored in the metaData.

### Usage

```
as.SummarizedExperiment(obj)
```

### Arguments

obj                    a DatasetExperiment object

### Value

a SummarizedExperiment object

---

as.SummarizedExperiment, DatasetExperiment-method

*Convert a DatasetExperiment to SummarizedExperiment*

---

### Description

Converts a DatasetExperiment to SummarizedExperiment. The assay data is transposed, and colData and rowData switched to match. struct specific slots such as "name" and "description" are stored in the metaData.

### Usage

```
## S4 method for signature 'DatasetExperiment'  
as.SummarizedExperiment(obj)
```

### Arguments

obj                    a DatasetExperiment object

### Value

a SummarizedExperiment object

---

as_data_frame	<i>convert to data.frame</i>
---------------	------------------------------

---

**Description**

Most often used with univariate statistics to gather all the different outputs in a consistent format.

**Usage**

```
as_data_frame(M, ...)
```

**Arguments**

M	a struct object
...	other inputs passed through this function

**Value**

a data.frame containing outputs from an object

---

calculate	<i>Calculate metric</i>
-----------	-------------------------

---

**Description**

A class for metrics to assess performance of e.g. models, iterators. Not intended to be called directly, this class should be inherited to provide functionality for method-specific classes.

**Usage**

```
calculate(obj, ...)

value(obj)

value(obj) <- value

max_length(obj) <- value

metric(...)

## S4 method for signature 'metric'
calculate(obj, Y, Yhat)

## S4 method for signature 'metric'
value(obj)

## S4 replacement method for signature 'metric'
value(obj) <- value
```

**Arguments**

obj	a metric object
...	named slots and their values.
value	value
Y	the true class labels
Yhat	the predicted class labels

**Value**

value the calculated value of a metric  
a metric object

**Examples**

```
MET = metric()
calculate(MET)
MET = metric()
M = metric()
calculate(M,Y,Yhat)
MET = metric()
value(MET)
MET = metric()
value(MET) = 10
```

---

chart

---

*Constructor for struct chart objects*


---

**Description**

A base class in the **struct** package. Should not be called directly.

**Usage**

```
chart(...)
```

**Arguments**

... named slots and their values that get passed to struct\_class

**Details**

The `chart` class provides a template for figures, charts and plots associated with other objects. For example, a `DatasetExperiment` object could have a histogram plotted for a specified column.

Charts can have parameters but not outputs (other than the figure itself), as chart objects are not intended to be used for calculations. The `chart_plot` method can be used to display a chart for an object, and `chart_names` can be used to list all chart objects associated with an object.

Classes that inherit the `stato` class have STATO integration enabled, allowing `stato_id` to be set and formal names and descriptions pulled from the STATO ontology database.

**Value**

a chart object  
 a struct\_class object

**Examples**

```
C = example_chart()
```

---

chart_names	<i>chart names</i>
-------------	--------------------

---

**Description**

Returns a list of valid charts for a struct object

**Usage**

```
chart_names(obj, ret = "char")

## S4 method for signature 'struct_class'
chart_names(obj, ret = "char")
```

**Arguments**

obj	An object derived from the struct_class object
ret	A string indicating whether a list of objects ('obj') or a list of chart names ('char') is returned. 'char' is default.

**Details**

The chart\_names method searches for chart objects associated with the unput object.

**Value**

list of chart names, or a list of chart objects

**Examples**

```
M = example_model()
chart_names(M) # 'example_chart'
chart_names(M, 'char') # as above
chart_names(M, 'obj') # returns a list of chart objects
```

---

 chart\_plot

*chart\_plot*


---

### Description

Plots a chart object

### Usage

```
chart_plot(obj, dobj, ...)
```

```
## S4 method for signature 'chart,ANY'
chart_plot(obj, dobj)
```

### Arguments

obj	A chart object
dobj	An object derived from struct_class
...	optional inputs

### Details

The optional optional inputs depend on the input object/chart, but might include an additional dataset object or a second model object, for example.

### Value

a plot object

### Methods (by class)

- `chart_plot(obj = chart, dobj = ANY):`

### Examples

```
C = example_chart()
chart_plot(C, iris_DatasetExperiment())
```

---

 citations

*Citations for an object*


---

### Description

All struct objects have a "citations" slot, which is a list of references in bibtex format. The `citations` method gathers citations from an object and all struct objects that it inherits to generate a complete list.



## Details

The `DatasetExperiment` object is an extension of the `SummarizedExperiment` object from the `SummarizedExperiment` package (found on Bioconductor). It incorporates the basic functionality of struct objects, containing fields such as `Description`, `Name` and `Type` with features of `SummarizedExperiment` such as subsetting.

There are some important differences between `DatasetExperiment` and `SummarizedExperiment`:

- In `DatasetExperiment` data is stored as Samples (rows) x Features (columns)
- `DatasetExperiment` currently only supports a single assay
- `length(DatasetExperiment)` returns the number of samples

## Value

`DatasetExperiment`

## Slots

`name` Name of the dataset  
`description` Brief description of the dataset  
`type` The type of dataset e.g. `single_block`

---

enum

*Enum objects*

---

## Description

A base class in the **struct** package. Not normally called directly.

## Usage

```
enum(
  name,
  description = character(0),
  type = "character",
  value = character(0),
  max_length = 1,
  allowed,
  ...
)

## S4 replacement method for signature 'enum'
value(obj) <- value
```

## Arguments

`name` the name of the object  
`description` a description of the object  
`type` the type of the struct object  
`value` value of the enum

max_length	Maximum length of value vector (default 1)
allowed	A list of allowed values
...	additional inputs to the struct_class object
obj	an enum object

### Details

An enum object is a special type of entity object that ensures the value must be one from a list of allowed values.

Enum objects are usually defined in the prototype of another object, but can be extracted using `param_obj` and `output_obj`.

### Value

an enum object

### Examples

```
# Create a new enum object
E = enum(
  name = 'example',
  description = 'this is an example',
  type = 'character',
  value = 'hello',
  allowed = c('hello','world')
)

# Get/set the value of the entity object
value(E)
value(E) = 'world'
```

---

example_chart	<i>example chart object</i>
---------------	-----------------------------

---

### Description

an example of a chart object for documentation purposes

### Usage

```
example_chart(...)

## S4 method for signature 'example_chart,example_model'
chart_plot(obj, dobj)
```

### Arguments

...	named slots and their values.
obj	a chart object
dobj	a <code>example_model</code> object

**Value**

a chart object

**Examples**

```
C = example_chart()
chart_plot(C, example_model())
```

---

example\_iterator-class

*Example iterator*

---

**Description**

An example iterator for testing  
runs the example iterator, which just returns a value of 3.142

**Usage**

```
## S4 method for signature 'example_iterator, DatasetExperiment, metric'  
run(I, D, MET)
```

**Arguments**

I	example_iterator object
D	dataset object
MET	metric object

**Value**

test iterator object  
dataset object

**Examples**

```
I = example_iterator()

I = example_iterator()
D = iris_DatasetExperiment()
MET = metric()
I = run(I, D, MET)
```

---

example_model	<i>Example model</i>
---------------	----------------------

---

### Description

An example model for testing. Training this model adds value\_1 to a data set, and prediction using this model adds value\_2.

trains the example model, which adds value\_1 to the raw data of a dataset

predicts using the example model, which adds value\_2 to the raw data of a dataset

### Usage

```
example_model(value_0 = 0, value_1 = 10, value_2 = 20, ...)
```

```
## S4 method for signature 'example_model,DatasetExperiment'
model_train(M, D)
```

```
## S4 method for signature 'example_model,DatasetExperiment'
model_predict(M, D)
```

### Arguments

value_0	a numeric value
value_1	a numeric value
value_2	a numeric value
...	named slots and their values.
M	A struct model object
D	A DatasetExperiment object

### Value

modified example\_model object

dataset object

dataset object

### Examples

```
M = example_model()
M = example_model(value_1 = 10, value_2 = 20)
D = iris_DatasetExperiment()
M = example_model(value_1 = 10, value_2 = 20)
M = model_train(M,D)
D = iris_DatasetExperiment()
M = example_model(value_1 = 10, value_2 = 20)
M = model_predict(M,D)
```

---

export_xlsx	<i>write a dataset object to file</i>
-------------	---------------------------------------

---

**Description**

Exports a dataset object to an excel file with sheets for data, sample\_meta and variable\_meta

**Usage**

```
export_xlsx(object, outfile, transpose = TRUE)

## S4 method for signature 'DatasetExperiment'
export_xlsx(object, outfile, transpose = TRUE)
```

**Arguments**

object	a dataset object
outfile	the filename (including path) to write the data to
transpose	TRUE (default) or FALSE to transpose the output data

**Value**

an excel file with sheets for data and meta data

**Examples**

```
## Not run:
D = iris_DatasetExperiment() # example dataset
export_xlsx(D, 'iris_DatasetExperiment.xlsx')

## End(Not run)
```

---

get_description	<i>Get struct object help description</i>
-----------------	---

---

**Description**

This function is to help developers including struct objects in their own R packages, and isnt intended for general use. Use with roxygen 2 '@eval' tags this function generates a detailed description of a struct object generated by extracting names, descriptions etc from slots in a suitable format.

**Usage**

```
get_description(id)
```

**Arguments**

id	(character) the name of a struct object to generate documentation for
----	---

**Value**

a character string of roxygen formatted documentation for the object

**Examples**

```
get_description('example_model')
```

---

```
iris_DatasetExperiment
      Fisher's Iris data
```

---

**Description**

Fisher's Iris data as a DatasetExperiment object

**Usage**

```
iris_DatasetExperiment()
```

**Value**

DatasetExperiment object

**Examples**

```
D = iris_DatasetExperiment()
```

---

```
is_output          Verify output
```

---

**Description**

Verify that the name of a output is valid for an object

**Usage**

```
is_output(obj, name)

## S4 method for signature 'struct_class'
is_output(obj, name)
```

**Arguments**

obj            A model or iterator object derived from the *\*struct\** class  
name           Name of output

**Value**

TRUE if output name is valid, FALSE if not

**Examples**

```
M = example_model()
is_output(M, 'result_1') # TRUE
is_output(M, 'result_0') # FALSE
```

---

is_param	<i>Verify parameter</i>
----------	-------------------------

---

**Description**

Verify that the input name is a valid input parameter for an object

**Usage**

```
is_param(obj, name)

## S4 method for signature 'struct_class'
is_param(obj, name)
```

**Arguments**

obj	An object derived from struct_class
name	Name of parameter

**Value**

TRUE if parameter name is valid, FALSE if not

**Examples**

```
M = example_model()
is_param(M, 'value_1') # TRUE
is_param(M, 'alpha') # FALSE
```

---

libraries	<i>Libraries for an object</i>
-----------	--------------------------------

---

**Description**

All struct objects have a "libraries" slot, which is a character array of libraries required to use the object. The `libraries` method gathers libraries from an object and all struct objects that it inherits to generate a complete list.

**Usage**

```
libraries(obj)

## S4 method for signature 'struct_class'
libraries(obj)
```

**Arguments**

obj                    a struct object

**Value**

a character array of R packages needed by the object

**Examples**

```
M = example_model()
libraries(M)
```

---

max_length	<i>get the max value vector length for an entity</i>
------------	--

---

**Description**

A base class in the **struct** package. Not normally called directly. An entity object is used to store information about a parameter or output. The standard 'name', 'description' and 'type' slots are included, along with 'value' for storing the value of the parameter and 'max\_length' for restricting the length of 'value' if needed.

**Usage**

```
max_length(obj)

entity(
  name,
  description = character(0),
  type = "character",
  value = NULL,
  max_length = Inf,
  ...
)

## S4 method for signature 'entity'
value(obj)

## S4 replacement method for signature 'entity'
value(obj) <- value

## S4 method for signature 'entity'
max_length(obj)

## S4 replacement method for signature 'entity'
max_length(obj) <- value
```

**Arguments**

obj	An entity object
name	the name of the object
description	a description of the object
type	the type of the struct object
value	The value of the parameter/outputs
max_length	Maximum length of value vector (default 1)
...	additional inputs to the struct_class object

**Details**

Entity objects are usually defined in the prototype of another object, but can be extracted using `param_obj` and `output_obj`.

**Value**

max value vector length for an entity  
An entity object

**Examples**

```
# Create a new entity object
E = entity(
  name = 'example',
  description = 'this is an example',
  type = 'numeric',
  value = 1
)

# Get/set the value of the entity object
value(E)
value(E) = 10
```

---

model

*model class*


---

**Description**

A class for models that can be trained/applied to datasets e.g. PCA, PLS etc. Also used for preprocessing steps that require application to test sets. not intended to be called directly, this class should be inherited to provide functionality for method-specific classes.

**Usage**

```
model(
  predicted = character(0),
  seq_in = "data",
  seq_fcn = function(x) {
    return(x)
  },
)
```

```

    ...
  )

  ## S4 method for signature 'model,DataSetExperiment'
  model_train(M, D)

  ## S4 method for signature 'model,DataSetExperiment'
  model_predict(M, D)

  ## S4 method for signature 'model,DataSetExperiment'
  model_apply(M, D)

  ## S4 method for signature 'model,DataSetExperiment'
  model_reverse(M, D)

  ## S4 method for signature 'model'
  predicted(M)

  ## S4 method for signature 'model'
  seq_in(M)

  ## S4 replacement method for signature 'model,character'
  seq_in(M) <- value

  ## S4 method for signature 'model'
  predicted_name(M)

  ## S4 replacement method for signature 'model,character'
  predicted_name(M) <- value

```

### Arguments

predicted	The name of an output slot to return when using predicted() (see details)
seq_in	the name of an output slot to connect with the "predicted" output of another model (see details)
seq_fcn	a function to apply to seq_in before inputting into the next model. Typically used to extract a single column, or convert from factor to char etc.
...	named slots and their values.
M	A struct model object
D	A DataSetExperiment object
value	The value to assign

### Value

trained model object  
 model object with test set results  
 trained model object  
 dataset dataset object with the reverse model applied  
 the predicted output, as specified by predicted\_name

the id of the input parameter to be replaced by the predicted output of the previous model in a model sequence. Reserved keyword 'data' means that the input data used by `model_train`, `model_apply` etc is used. `seq_in = 'data'` is the default setting.

the modified model object

the id of the output returned by `predicted()`

the modified model object

### predicted slot

The "predicted" slot is a slots for use by users to control the flow of model sequences. The `predicted()` function is used to return a default output and from a model. Typically it is a `DatasetExperiment` object that is passed directly into the next model in a sequence as the data for that model.

### seq\_in slot

In a sequence of models (see `model_seq`) the "predicted" slot is connected to the `DatasetExperiment` input of the next model. `seq_in` can be used to control flow and connect the "predicted" output to the input parameter of the next model. Default is the keyword 'data', and can otherwise be replaced by any input slot from the model. The slot `seq_fcn` can be used to apply a transformation to the output before it is used as an input. This allows you to e.g. convert between types, extract a single column from a `data.frame` etc.

### Examples

```
M = model()
D = DatasetExperiment()
M = model()
M = model_train(M,D)
D = DatasetExperiment()
M = model()
M = model_train(M,D)
M = model_predict(M,D)
D = DatasetExperiment()
M = model()
M = model_apply(M,D)
D = DatasetExperiment()
M = model()
M = model_train(M,D)
M = model_predict(M,D)
M = model_reverse(M,D)
D = DatasetExperiment()
M = example_model()
M = model_train(M,D)
M = model_predict(M,D)
p = predicted(M)
D = DatasetExperiment()
M = example_model()
seq_in(M) = 'data'
M = example_model()
seq_in(M) = 'value_1'
M = example_model()
predicted_name(M)
M = example_model()
predicted_name(M) = 'result_2'
```

---

models	<i>Get/set models of a model_seq</i>
--------	--------------------------------------

---

**Description**

Returns the list of models in a model\_seq object

**Usage**

```
models(ML)
```

```
models(ML) <- value
```

**Arguments**

ML                    a model\_seq object

value                a list containing only model objects

**Value**

models(ML) returns a list of models in the model sequence

models(ML)<- sets the list of models in the model sequence

**Examples**

```
# Create a model sequence
ML = model_seq()
models(ML) = list(example_model(), example_model())
models(ML)
```

---

model_apply	<i>Apply a model</i>
-------------	----------------------

---

**Description**

Applies a method to the input dataset

**Usage**

```
model_apply(M, D, ...)
```

**Arguments**

M                    a 'method' object

D                    another object used by the first

...                  other optional inputs

**Value**

Returns a modified method object

**Examples**

```
M = example_model()
M = model_apply(M, iris_DatasetExperiment())
```

---

model_predict	<i>Model prediction</i>
---------------	-------------------------

---

**Description**

Apply a model using the input dataset. Assumes the model is trained first.

**Usage**

```
model_predict(M, D, ...)
```

**Arguments**

M	a model object
D	a dataset object
...	other optional inputs

**Value**

Returns a modified model object

**Examples**

```
M = example_model()
M = model_predict(M, iris_DatasetExperiment())
```

---

model_reverse	<i>Reverse preprocessing</i>
---------------	------------------------------

---

**Description**

Reverse the effect of a preprocessing step on a dataset\_

**Usage**

```
model_reverse(M, D, ...)
```

**Arguments**

M	a model object
D	a dataset object
...	other optional inputs

**Value**

Returns a modified dataset object

**Examples**

```
M = example_model()
D = model_reverse(M, iris_DatasetExperiment())
```

---

model_seq	<i>model_seq class</i>
-----------	------------------------

---

**Description**

A class for (ordered) lists of models

**Usage**

```
model_seq(...)

## S4 method for signature 'model_seq,DatasetExperiment'
model_train(M, D)

## S4 method for signature 'model_seq,DatasetExperiment'
model_predict(M, D)

## S4 method for signature 'model_seq,ANY,ANY,ANY'
x[i]

## S4 replacement method for signature 'model_seq,ANY,ANY,ANY'
x[i] <- value

## S4 method for signature 'model_seq'
models(ML)

## S4 replacement method for signature 'model_seq,list'
models(ML) <- value

## S4 method for signature 'model_seq'
length(x)

## S4 method for signature 'model,model_seq'
e1 + e2

## S4 method for signature 'model_seq,model'
e1 + e2

## S4 method for signature 'model,model'
e1 + e2

## S4 method for signature 'model_seq'
predicted(M)

## S4 method for signature 'model_seq,DatasetExperiment'
model_apply(M, D)
```

**Arguments**

...	named slots and their values.
M	a model object
D	a dataset object
x	a model_seq object
i	index
value	value
ML	a model_seq object
e1	a model or model_seq object
e2	a model or model_seq object

**Value**

model sequence  
 model sequence  
 model at the given index in the sequence  
 model sequence with the model at index i replaced  
 a list of models in the sequence  
 a model sequence containing the input models  
 the number of models in the sequence  
 a model sequence with the additional model appended to the front of the sequence  
 a model sequence with the additional model appended to the end of the sequence  
 a model sequence  
 the predicted output of the last model in the sequence

**Examples**

```

MS = model_seq()
MS = model() + model()
MS = example_model() + example_model()
MS = model_train(MS, DatasetExperiment())
D = DatasetExperiment()
MS = example_model() + example_model()
MS = model_train(MS, D)
MS = model_predict(MS, D)
MS = model() + model()
MS[2]

MS = model() + model()
MS[3] = model()

MS = model() + model()
L = models(MS)

MS = model_seq()
L = list(model(), model())
models(MS) = L

```

```
MS = model() + model()
length(MS) # 2

MS = model() + model()
M = model()
MS = M + MS

MS = model() + model()
M = model()
MS = MS + M

MS = model() + model()

D = DatasetExperiment()
M = example_model()
M = model_train(M,D)
M = model_predict(M,D)
p = predicted(M)
D = DatasetExperiment()
MS = example_model() + example_model()
MS = model_apply(MS,D)
```

---

model_train	<i>Train a model</i>
-------------	----------------------

---

## Description

Trains a model using the input dataset

## Usage

```
model_train(M, D, ...)
```

## Arguments

M	a model object
D	a dataset object
...	other optional inputs

## Value

Returns a modified model object

## Examples

```
M = example_model()
M = model_train(M,iris_DatasetExperiment())
```

---

new_struct	<i>Generate a <b>struct</b> object from a Class</i>
------------	---

---

### Description

This function creates a newly allocated object from the class identified by the first argument. It works almost identically to `new` but is specific to objects from the **struct** package and ensures that entity slots have their values assigned correctly. This function is usually called by class constructors and not used directly.

### Usage

```
new_struct(class, ...)
```

### Arguments

<code>class</code>	The class of struct object to create
<code>...</code>	named slots and values to assign

### Value

An object derived from `struct_class`

### Examples

```
S = new_struct('struct_class')
```

---

ontology	<i>Ontology for an object</i>
----------	-------------------------------

---

### Description

All **struct** objects have an "ontology" slot, which is a list of ontology items for the object. The `ontology` method gathers ontology items from an object and all **struct** objects that it inherits to generate a complete list.

A base class in the **struct** package. Stores ontology information e.g. term, description, id etc for **struct** objects and provides methods for populating these fields using the 'rols' package.

A base class in the **struct** package. Stores multiple 'ontology\_term' objects.

### Usage

```
ontology(obj, ...)
```

```
ontology_term(id)
```

```
ontology_list(...)
```

```
## S4 method for signature 'ontology_list,ANY,ANY,ANY'
x[i]
```

```

## S4 method for signature 'ontology_list,ANY,ANY'
x[[i]]

## S4 replacement method for signature 'ontology_list,ANY,ANY,ANY'
x[i] <- value

## S4 method for signature 'ontology_list'
length(x)

## S4 method for signature 'struct_class'
ontology(obj, ...)

## S4 method for signature 'model_seq'
ontology(obj, ...)

```

### Arguments

obj	a struct object
...	character ontology IDs (e.g. STATO:0000046) or NULL for an empty list
id	(character) The ontology term id e.g. 'STATO:0000046'
x	the list
i	The list item index
value	an ontology_term() object

### Value

x[i] returns a subset of list x  
x[[i]] returns the ontology\_term at index i.  
x[i] <- replaces the list item at index i  
length(x) returns the number of items in the list.

### Examples

```

M = example_model()
ontology(M)
## Not run:
OT = ontology_term(id='STATO:0000046')

## End(Not run)
## Not run:
OT = ontology_list(terms=list(
  ontology_term(id = 'OBI:0200051'),
  ontology_term(id = 'STATO:0000046')
))

## End(Not run)
## Not run:
OL = ontology_list('STATO:0000046')
OL[1] # an ontology list

## End(Not run)

```

```

## Not run:
OL = ontology_list('STAT0:0000046')
OL[[1]] # an ontology_item

## End(Not run)

## Not run:
OL = ontology_list('STAT0:0000046')
OL[1] = ontology_term('STAT0:0000302')

## End(Not run)

## Not run:
OL = ontology_list()
length(OL) # 0

## End(Not run)

```

---

ontology_online	<i>Enable or disable Ontology Lookup Service (OLS) requests</i>
-----------------	---

---

## Description

Sets the package option `struct.ontology.online`. When `FALSE`, `ontology_term`, `ontology_list`, and `ontology` do not perform HTTP requests to OLS; ontology IDs are still stored, but label, description, and IRI are left empty (the same outcome as a failed lookup).

## Usage

```
ontology_online(online = TRUE)
```

## Arguments

<code>online</code>	Logical scalar. If <code>TRUE</code> (default when the option is unset), OLS is queried for term metadata. If <code>FALSE</code> , lookups are skipped and no network access is attempted.
---------------------	--

## Details

The setting is `options(struct.ontology.online = online)`. If the option has never been set, behaviour matches `online = TRUE`. Typical uses include vignette builds, unit tests, and offline sessions.

## Value

`online`, invisibly.

## See Also

[ontology\\_term](#), [ontology\\_list](#), [ontology](#)

**Examples**

```
ontology_online(FALSE)
ontology_online(TRUE)
```

---

 optimiser

*optimiser class*


---

**Description**

A special class of iterator for selecting optimal parameter values not intended to be called directly, this class should be inherited to provide functionality for method-specific classes.

**Usage**

```
optimiser(...)
```

**Arguments**

...                    named slots and their values.

**Value**

an optimiser object

**Examples**

```
OPT = optimiser()
```

---

 output\_ids

*Output identifiers*


---

**Description**

return a list of valid output ids for an object

**Usage**

```
output_ids(obj)
```

```
## S4 method for signature 'struct_class'
output_ids(obj)
```

**Arguments**

obj                    A model or iterator object derived from the \*struct\* class

**Value**

list of output ids

**Examples**

```
M = example_model()
output_ids(M)
```

---

output_list	<i>output list</i>
-------------	--------------------

---

**Description**

get/set a named list of outputs and their current value for an object

**Usage**

```
output_list(obj)

output_list(obj) <- value

## S4 method for signature 'struct_class'
output_list(obj)

## S4 replacement method for signature 'struct_class,list'
output_list(obj) <- value
```

**Arguments**

obj	An object derived from struct_class
value	A named list of outputs and corresponding values

**Value**

A named list of outputs and corresponding values  
struct object

**Examples**

```
M = example_model()
L = output_list(M)
M = example_model()
output_list(M) = list('result_1' = DatasetExperiment(), 'result_2' = DatasetExperiment())
```

---

output_name	<i>output name</i>
-------------	--------------------

---

**Description**

return a the name for a output, if available

**Usage**

```
output_name(obj, name)
```

```
## S4 method for signature 'struct_class,character'
output_name(obj, name)
```

**Arguments**

obj	A model or iterator object derived from the *struct* class
name	Name of output

**Value**

name of output

**Examples**

```
M = example_model()
output_name(M, 'result_1')
```

---

output_obj	<i>Output objects</i>
------------	-----------------------

---

**Description**

Gets or sets the object of an output e.g. to an entity() object.

**Usage**

```
output_obj(obj, name)
```

```
output_obj(obj, name) <- value
```

```
## S4 method for signature 'struct_class,character'
output_obj(obj, name)
```

```
## S4 replacement method for signature 'struct_class,character'
output_obj(obj, name) <- value
```

**Arguments**

obj            A model or iterator object derived from the *\*struct\** class  
 name          Name of output  
 value         A valid value for the output being set

**Value**

output\_obj(M, name) returns the named output as an object  
 output\_obj(M, name)<- sets the named output of an object  
 the modified object

**Examples**

```
# get the output as an object
M = example_model()
obj = output_obj(M, 'result_1')

# set a output as an object
output_obj(M, 'result_1') = entity(value = 15, type = 'numeric', name = 'result_1')
```

---

output_value	<i>output values</i>
--------------	----------------------

---

**Description**

get/set the values for an output\_

**Usage**

```
output_value(obj, name)

output_value(obj, name) <- value

## S4 method for signature 'struct_class,character'
output_value(obj, name)

## S4 replacement method for signature 'struct_class,character'
output_value(obj, name) <- value
```

**Arguments**

obj            A model or iterator object derived from the *\*struct\** class  
 name          Name of output  
 value         A valid value for the output being set

**Value**

Value of output  
 struct object

**Examples**

```
M = example_model()
output_value(M, 'result_1')
M = example_model()
output_value(M, 'result_1') = DatasetExperiment()
```

---

param_ids	<i>Parameter identifiers</i>
-----------	------------------------------

---

**Description**

return a list of valid parameter ids for an object

**Usage**

```
param_ids(obj)

## S4 method for signature 'struct_class'
param_ids(obj)
```

**Arguments**

obj                    An object derived from struct\_class

**Value**

list of parameter ids

**Examples**

```
M = example_model()
param_ids(M)
```

---

param_list	<i>Parameter list</i>
------------	-----------------------

---

**Description**

get/set a named list of parameters and their current value for an object

**Usage**

```
param_list(obj)

param_list(obj) <- value

## S4 method for signature 'struct_class'
param_list(obj)

## S4 replacement method for signature 'struct_class,list'
param_list(obj) <- value
```

**Arguments**

obj            An object derived from struct\_class  
 value         A named list of parameters and corresponding values

**Value**

A named list of parameters names and corresponding values

**Examples**

```
M = example_model()
L = param_list(M)

M = example_model()
param_list(M) = list('value_1' = 15, 'value_2' = 20)
```

---

param_name	<i>Parameter name</i>
------------	-----------------------

---

**Description**

Returns the name for a parameter, if available

**Usage**

```
param_name(obj, name)

## S4 method for signature 'struct_class,character'
param_name(obj, name)
```

**Arguments**

obj            An object derived from struct\_class  
 name          Name of parameter

**Value**

name of parameter

**Examples**

```
M = example_model()
param_name(M, 'value_1')
```

---

 param\_obj

*Parameter objects*


---

**Description**

Gets or sets the object of a parameter e.g. to an entity() object.

**Usage**

```
param_obj(obj, name)
```

```
param_obj(obj, name) <- value
```

```
## S4 replacement method for signature 'struct_class,character'
param_obj(obj, name) <- value
```

```
## S4 method for signature 'struct_class,character'
param_obj(obj, name)
```

**Arguments**

obj	An object derived from struct_class
name	Name of parameter
value	A valid value for the parameter being set

**Value**

param\_obj(M, name) Returns the named parameter as an object

param\_obj(M, name)<- Sets the named parameter of an object

**Examples**

```
# get the parameter as an object
M = example_model()
obj = param_obj(M, 'value_0')

# set a parameter as an object
param_obj(M, 'value_0') = entity(value = 15, type = 'numeric', name='value_0')
```

---

 param\_value

*Parameter values*


---

**Description**

get/set the values for a parameter.

**Usage**

```

param_value(obj, name)

param_value(obj, name) <- value

## S4 method for signature 'struct_class,character'
param_value(obj, name)

## S4 replacement method for signature 'struct_class,character'
param_value(obj, name) <- value

```

**Arguments**

obj	A model or iterator object derived from structclass
name	Name of parameter
value	A valid value for the parameter being set

**Value**

Value of parameter

**Examples**

```

M = example_model()
param_value(M, 'value_1')

M = example_model()
param_value(M, 'value_1') = 0.95

```

---

predicted

*Prediction output*

---

**Description**

returns the prediction output for a model\_ This is supplied as input to the next model when used in a model\_seq

**Usage**

```
predicted(M)
```

**Arguments**

M	a model object
---	----------------

**Value**

The value returned varies depending on the output\_

**Examples**

```
M = example_model()
M = model_train(M, iris_DatasetExperiment())
M = model_predict(M, iris_DatasetExperiment())
predicted(M)
```

---

predicted_name	<i>Predicted output name</i>
----------------	------------------------------

---

**Description**

get/set the prediction output for a model\_ This determines which outputs from this model are supplied as inputs to the next model when used in a model\_seq

**Usage**

```
predicted_name(M)

predicted_name(M) <- value
```

**Arguments**

M	a model object
value	name of an output for this model

**Value**

predicted\_name returns the name of the predicted output  
 predicted\_name<- sets the name of the predicted output

**Examples**

```
M = example_model()
predicted_name(M)
predicted_name(M) = 'result_2'
```

---

preprocess	<i>preprocessing class</i>
------------	----------------------------

---

**Description**

A class used for preprocessing steps that require application to test sets. not intended to be called directly, this class should be inherited to provide functionality for method-specific classes.

**Usage**

```
preprocess(...)
```

## S4 method for signature 'preprocess, DatasetExperiment'  
 model\_reverse(M, D)

**Arguments**

...            named slots and their values.  
M              a model object  
D              a dataset object

**Value**

dataset object

**Examples**

```
M = preprocess()  
D = DatasetExperiment()  
M = model()  
D2 = model_reverse(M,D)
```

---

resampler

*resampler class*

---

**Description**

A class for resampling methods such as cross-validation. not intended to be called directly.

**Usage**

```
resampler(...)
```

**Arguments**

...            named slots and their values.

**Value**

a resampler object

**Examples**

```
R = resampler()
```

---

result	<i>Iterator result</i>
--------	------------------------

---

**Description**

Returns the results of an iterator. This is used to control model flow in a similar way to predict for model and model\_seq objects.

**Usage**

```
result(M)
```

**Arguments**

M                    an iterator object

**Value**

the returned output varies with the algorithm implemented

**Examples**

```
D = iris_DatasetExperiment() # get some data
MET = metric() # use a metric
I = example_iterator() # initialise iterator
models(I) = example_model() # set the model
I = run(I,D,MET) # run
result(I)
```

---

result_name	<i>get/set output name as prediction output for a model</i>
-------------	---

---

**Description**

get/set the prediction output for a model\_ This determines which outputs from this model are supplied as inputs to the next model when used in a model\_seq

**Usage**

```
result_name(M)
```

```
result_name(I) <- value
```

**Arguments**

M                    an iterator object  
 I                    an iterator object  
 value                name of an output for iterator M

**Value**

result\_name(M) returns the name of the output for this iterator (equivalent to predicted for model objects)

result\_name(I)<- sets the default output for an iterator

**Examples**

```
I = example_iterator() # initialise iterator
result_name(I)
result_name(I) = 'result_1'
```

---

run	<i>Run iterator</i>
-----	---------------------

---

**Description**

Runs an iterator, applying the chosen model multiple times.

Evaluates an iterator by e.g. averaging over all iterations. May be deprecated in a future release as evaluate is applied by run anyway.

A class for iterative approaches that involve the training/prediction of a model multiple times. Not intended to be called directly, this class should be inherited to provide functionality for method-specific classes.

**Usage**

```
run(I, D, MET)

evaluate(I, MET)

iterator(...)

## S4 method for signature 'iterator,DatasetExperiment,metric'
run(I, D, MET = NULL)

## S4 method for signature 'iterator,metric'
evaluate(I, MET)

## S4 method for signature 'iterator'
models(ML)

## S4 replacement method for signature 'iterator,model_OR_iterator'
models(ML) <- value

## S4 replacement method for signature 'iterator,character'
result_name(I) <- value

## S4 method for signature 'iterator'
result(M)

## S4 method for signature 'iterator'
```

```

result_name(M)

## S4 method for signature 'iterator,model_OR_iterator'
e1 * e2

## S4 method for signature 'iterator,ANY,ANY,ANY'
x[i]

## S4 replacement method for signature 'iterator,ANY,ANY,ANY'
x[i] <- value

```

### Arguments

I	an iterator object
D	a dataset object
MET	a metric object
...	named slots and their values.
ML	a model sequence object
value	value
M	a model object
e1	an iterator object
e2	an iterator or a model object
x	a sequence object
i	index into sequence

### Details

Running an iterator will apply the iterator a number of times to a dataset\_ For example, in cross-validation the same model is applied multiple times to the same data, splitting it into training and test sets. The input metric object can be calculated and collected for each iteration as an output\_

### Value

Modified iterator object  
 Modified iterator object  
 the modified model object  
 model at the given index in the sequence  
 iterator with the model at index i replaced

### Examples

```

D = iris_DatasetExperiment() # get some data
MET = metric() # use a metric
I = example_iterator() # initialise iterator
models(I) = example_model() # set the model
I = run(I,D,MET) # run
D = iris_DatasetExperiment() # get some data
MET = metric() # use a metric
I = example_iterator() # initialise iterator
models(I) = example_model() # set the model

```

```

I = run(I,D,MET) # run
I = evaluate(I,MET) # evaluate
I = iterator()
I = iterator() * model()
D = DatasetExperiment()
MET = metric()
I = iterator() * model()
I = run(I,D,MET)

I = iterator()
result_name(I) = 'example'
MS = model() + model()
I = iterator() * MS
I[2] # returns the second model() object

MS = model() + model()
I = iterator() * MS
I[2] = model() # sets the second model to model()

```

---

seq\_in

*Sequence input*


---

### Description

get/set the input parameter replaced by the output of the previous model in a model sequence. Default is "data" which passes the output as the data input for methods such as `model_train` and `model_apply`.

### Usage

```
seq_in(M)
```

```
seq_in(M) <- value
```

### Arguments

M	a model object
value	name of an output for this model

### Value

`seq_in` returns the name of the input parameter replaced when used in a model sequence

`seq_in<-` sets the name of the input parameter replaced when used in a model sequence

### Examples

```

M = example_model()
seq_in(M)
seq_in(M) = 'value_1'

```

---

set_obj_method	<i>update method for a struct object</i>
----------------	--

---

### Description

a helper function to update methods for a struct object

### Usage

```
set_obj_method(
  class_name,
  method_name,
  definition,
  where = toplev(parent.frame()),
  signature = c(class_name, "DatasetExperiment")
)
```

### Arguments

class_name	the name of the to update the method for
method_name	the name of the method to update. Must be an existing method for the object.
definition	the function to replace the method with. This function will be used when the method is called on the object.
where	the environment to create the object in. default where = toplev(parent.frame())
signature	a list of classes that this object requires as inputs. Default is c(class_name,'DatasetExperiment')

### Value

a method is created in the specified environment

### Examples

```
set_struct_obj(
  class_name = 'add_two_inputs',
  struct_obj = 'model',
  params = c(input_1 = 'numeric', input_2 = 'numeric'),
  outputs = c(result = 'numeric'),
  prototype = list(
    input_1 = 0,
    input_2 = 0,
    name = 'Add two inputs',
    description = 'example class that adds two values together')
)
```

---

set_obj_show	<i>a helper function to update the show method for a struct object</i>
--------------	--

---

### Description

a helper function to update the show method for a struct object

### Usage

```
set_obj_show(class_name, extra_string, where = topenv(parent.frame()))
```

### Arguments

class_name	the name of the to update the method for
extra_string	a function that returns an extra string using the input object as an input e.g. function(object){return = 'extra_string'}
where	the environment to create the object in. default where = topenv(parent.frame())

### Value

a method is created in the specified environment

### Examples

```
# create an example object first
set_struct_obj(
  class_name = 'add_two_inputs',
  struct_obj = 'model',
  params = c(input_1 = 'numeric', input_2 = 'numeric'),
  outputs = c(result = 'numeric'),
  prototype = list(
    input_1 = 0,
    input_2 = 0,
    name = 'Add two inputs',
    description = 'example class that adds two values together')
)

# now update the method
set_obj_show(
  class_name = 'add_two_inputs',
  extra_string = function(object) {return('The extra text')}
)
```

---

set_struct_obj	<i>define a new struct object</i>
----------------	-----------------------------------

---

**Description**

a helper function to create new struct objects

**Usage**

```
set_struct_obj(
  class_name,
  struct_obj,
  params = character(0),
  outputs = character(0),
  private = character(0),
  prototype = list()
)
```

**Arguments**

class_name	the name of the new class to create
struct_obj	the struct obj to inherit e.g. 'model', 'metric' etc
params	a named character vector of input parameters where each element specifies the type of value that will be in the slot e.g. c(example = 'character')
outputs	a named character vector of outputs where each element specifies the type of value that will be in the slot e.g. c(example = 'character')
private	a named character vector of private slots where each element specifies the type of value that will be in the slot e.g. c(example = 'character'). These are intended for internal use by the object and generally not available to the user.
prototype	a named list with initial values for slots.

**Value**

a new class definition. to create a new object from this class use `X = new_class_name()`

---

struct_class	<i>Constructor for struct_class objects</i>
--------------	---

---

**Description**

Creates a new `struct_class` object and populates the slots. Not intended for direct use.

**Usage**

```
struct_class(
  name = character(0),
  description = character(0),
  type = character(0),
  citations = list(),
  ontology = character(0)
)
```

**Arguments**

name	the name of the object
description	a description of the object
type	the type of the struct object
citations	a list of citations for the object in "bibentry" format
ontology	a list of ontology ids for the object

**Value**

a struct\_class object

---

struct\_class-class      struct\_class *object definition*

---

**Description**

Defines the struct class base template. This class is inherited by other objects and not intended for direct use. It defines slots and methods common to all **struct** objects.

**Value**

Returns a **struct** object

**Public slots**

Public slots can be accessed using shorthand \$ notation and are intended for users building workflows.

name character() A short descriptive name of the struct object  
description character() A longer description of the struct object and what it does  
type character() A keyword that describes the type of struct object  
libraries character() A (read only) list of R packages used by this struct object  
citations list of bibentry A (read only) list of citations relevant to this struct object, in Bibtex format.

**Private slots**

Private slots are not readily accessible to users and are intended for developers creating their own struct objects. Any slot not listed within `‘.params’` or `‘.outputs’` is considered a private slot.

`.params` character() A list of additional slot names that can be get/set by the user for a specific struct object. These are used as input parameters for different methods.  
`.outputs` character() a list of additional slot names that can be get by the user. These are used to store the results of a method.

**Examples**

```
S = struct_class(name = 'Example',description = 'An example object')
```

---

struct_template	<i>StRUCT templates</i>
-----------------	-------------------------

---

**Description**

Create a struct template

**Usage**

```
struct_template(  
  template = "model",  
  output,  
  in_editor = TRUE,  
  overwrite = FALSE  
)
```

**Arguments**

template	the type of object you want a template for e.g. 'model'
output	the name/path of the output file
in_editor	TRUE/FALSE to open the created file in the default editor
overwrite	= TRUE/FALSE to overwrite file if exists already

**Value**

A template is created at the output location specified

**Examples**

```
## Not run:  
struct_template('model', 'example.R', FALSE)  
  
## End(Not run)
```

---

test_metric-class	<i>Example metric</i>
-------------------	-----------------------

---

**Description**

An example metric for testing  
calculates a metric, which just returns a value of 3.142

**Usage**

```
## S4 method for signature 'test_metric'  
calculate(obj)
```

**Arguments**

obj                    metric object

**Value**

test metric object  
dataset object

**Examples**

```
MET = test_metric()  
  
MET = test_metric()  
MET = calculate(MET)
```

---

\$,ontology\_list-method

*Get/set ontology\_list slots*

---

**Description**

Dollar syntax can be used to as a shortcut for getting values for ontology\_list objects.

**Usage**

```
## S4 method for signature 'ontology_list'  
x$name
```

**Arguments**

x                    An ontology\_term object  
name                The name of the slot to access

**Value**

Slot value

**Examples**

```
## Not run:  
OL = ontology_list('STATO:0000046')  
OL$terms  
  
## End(Not run)
```

---

\$,ontology\_term-method  
*Get/set ontology term slots*

---

### Description

Dollar syntax can be used to as a shortcut for getting values for ontology\_term objects.

### Usage

```
## S4 method for signature 'ontology_term'  
x$name
```

### Arguments

x	An ontology_term object
name	The name of the slot to access

### Value

Slot value

### Examples

```
## Not run:  
OT = ontology_term(id='STAT0:0000046')  
OT$ontology # returns "STAT0"  
  
## End(Not run)
```

---

\$,struct\_class-method *Get/set parameter or output values*

---

### Description

Dollar syntax can be used to as a shortcut for getting/setting input parameter and output values for struct objects.

### Usage

```
## S4 method for signature 'struct_class'  
x$name
```

### Arguments

x	An object derived from struct_class
name	The name of the slot to access

### Value

Parameter/output value

**Examples**

```
M = example_model()
M$value_1 = 10
M$value_1 # 10
```

---

`$<-`,struct\_class-method*Get/set parameter or output values*

---

**Description**

Dollar syntax can be used to as a shortcut for getting/setting input parameter and output values for struct objects.

**Usage**

```
## S4 replacement method for signature 'struct_class'
x$name <- value
```

**Arguments**

<code>x</code>	An object derived from struct_class
<code>name</code>	The name of the slot to access
<code>value</code>	The value to assign

**Value**

Parameter/output value

**Examples**

```
M = example_model()
M$value_1 = 10
M$value_1 # 10
```

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