



# Building a knowledge-base

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*Documentation for the Tom.bio ID Visualisation Framework*



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## 2 Introduction

This document is a reference for building knowledge-bases for use with the Tom.bio ID Visualisation framework (referred to in this document as ‘the framework’). Most of the examples referred to are from the example ‘biscuits’ knowledge-base which is supplied with the framework (‘biscuits.xlsm’). We recommend that, before you start building your own knowledge-base, you work through this documentation using the ‘biscuits’ example. This documentation will make most sense to you if you have the biscuit knowledge base open and refer to it as you go.

## 3 Building a knowledge-base

The framework uses a spreadsheet to represent taxonomic knowledge. The example spreadsheet provided with the framework is an Excel workbook, but you can use any type of spreadsheet you like to build a knowledge-base that can be used by the framework – the only requirement is that it can save to CSV (Comma Separated Value) files – since this is what the framework actually reads.



Each knowledge-base is represented by five CSV files with the following names:

- taxa.csv
- characters.csv
- values.csv
- media.csv
- config.csv



In the example Excel biscuits workbook, there is a separate worksheet for each of these. A sixth worksheet – called ‘macros’ – has a button on it which invokes a macro to save the current workbook and export each of the five worksheets – taxa, characters, values, media and config – to the CSV files that are read by the framework. This makes it easy to generate all the CSVs required by the framework at the push of a button (but you can save each of them manually if you don’t want to use the macro).

Further sections in this document deal with each of the five CSV files (which will be referred to here as ‘worksheets’).

On all worksheets, placing a hash character (‘#’) as the first character of the first column in a row effectively ‘comments out’ the whole row – it won’t be read by the framework. This is a useful mechanism for knowledge-base authors to provide notes on their knowledge-bases or to make rows invisible to the framework without removing them from the knowledge-base.

*Note that, in general, text in the knowledge-base is treated case-sensitively by the framework, so, for example, ‘Shape’ is not the same as ‘shape’.* So be sure to have regard for case when creating knowledge-bases.



### 3.1 The taxa worksheet

The example below shows the taxa worksheet from the biscuits knowledge-base.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Taxon	Shape	BiscuitColour	Coating	Holes	Pattern	Words	SingleDouble	FillingColour	Width	Length	ChocTaste	Availability	TopTen
2	Rich Highland Shortie	Round	Pale brown	None	Yes	Yes	No	Single	n/a	57	57	none	[jan-dec]	no
3	Romany Vanilla Cream	Round	Dark brown	None	No	Yes	No	Double	White	47	47	none	[jan-dec]	no
4	Shortcake	Rectangular	Pale brown	None	Yes	Yes	No	Single	n/a	37	61	none	[jan-dec]	no
5	Custard Cream	Rectangular	Pale brown	None	Yes	Yes	Yes	Double	White	34	47	none	[jan-dec]	yes
6	Bourbon Cream	Rectangular	Dark brown	None	Yes	No	Yes	Double	Dark brown	30	62	little	[jan-dec]	yes
7	Happy Face	Round	Pale brown	None	No	Yes	No	Double	White	47	47	none	[jan-dec]	no
8	Milk Chocolate Digestive	Round	Pale brown	Chocolate	No	No	No	Single	n/a	58	58	very	[jan-dec]	no
9	Milk Chocolate Finger	Cigar	Pale brown	Chocolate	No	No	No	Single	n/a	15	78	very	[jan-dec]	yes
10	Jam Sandwich Cream	Round	Pale brown	None	No	Yes	No	Double	White and red	47	47	none	[jan-dec]	no
11	Choc Chip Cookie	Round	Pale brown	None	No	No	No	Single	n/a	57	57	moderate	[jan-dec]	no
12	#Rich's fantasy biscuit 1	Triangle	Dark brown   Pale brown	Toffee	Yes	No	No	Single	n/a	[80-90]	[90-100]	very	[jan-dec]	no
13	Rich's fantasy biscuit 2	Hexagonal	Pink   Dark brown   Pale brown	Chocolate	Yes	No	?	Double	Dark brown	[80-90]	[90-100]	[little-very]	[may-jun]	no
14	Rich's fantasy biscuit 3	Round	Pale brown	Chocolate	No	No	No	Double	n/a	50	50	very   moderate	dec	no
15	Rich's fantasy biscuit 4	Cigar	Dark brown	Chocolate	Yes	Yes	No	Single	n/a	10	70	very   [none-little]	[dec-feb]	no

#### 3.1.1 General rules for the taxa worksheet

These are the general rules to bear in mind when specifying knowledge on the taxa worksheet:

- There *must* be a column called 'Taxon'. This column holds the names of the taxa as they will appear to users of the visualisations.
- The order of the columns is unimportant (and the 'Taxon' column needn't be the first column).
- Further columns represent attributes of the taxa – e.g. morphological characters.
- No spaces are allowed in the column names.
- The column names are not what appears to users (see section on character worksheet) so you only need to use names that are meaningful to you as the knowledge-base author.
- Apart from the first row (header row), which must contain the column names, each row represents a different taxon.
- A taxon can be included in the knowledge-base but excluded from the visualisations by being 'commented out' with the hash character '#' – as is the case for 'Rich's fantasy biscuit 1' in the biscuits knowledge-base.
- The values in the cells of a morphological character column contain the character state values for each of the taxa.
- Character state values can 'commented out' by using a leading hash character ('#').
- There's no practical limit on the number of taxa (rows) or characters (columns) that can be specified.
- There are two broad types of character state values: text and numeric.

11	Choc Chip Cookie	Round
12	#Rich's fantasy biscuit 1	Triangle
13	Rich's fantasy biscuit 2	Hexagonal

#### 3.1.2 Text character state values

Text values are expressed with normal alphanumeric characters. In fact you can use most keyboard characters in text state values (but they have not all been tested exhaustively). However, one character – '|' – has a reserved meaning. It is interpreted as 'or' by the framework so you should only use this to separate multiple alternatives for a given taxon/character. An example in the biscuits knowledge-base is the value for the 'Colour' character and 'Rich's fantasy biscuit 2' taxon which is specified as 'Pink | Dark brown | Pale brown'. That means that this type of biscuit can be either pink, dark brown or light brown and would score as a match for that character if the user specified any one of those three colours with the frameworks character state input tools. (See also the section on 'special character state values'.)

BiscuitColour
Pale brown
Dark brown   Pale brown
Pink   Dark brown   Pale brown



There is no equivalent 'and' character. So you can't specify, for example, that a biscuit is both pink *and* dark brown in a way that would match a multiple selection by the user (see section on the character worksheet for an explanation of multiple state selection). Instead you would have to specify 'Pink and dark brown' as the character state – the word 'and' would have no special meaning to the framework, but this character state would be considered by the framework to be completely different from both 'Pink' and 'Dark brown' and presented to the user as a separate possible value in its own right.

Normally, when constructing a knowledge-base, if you find yourself wishing to use 'and' a lot to combine character states, it is an indication that you might be trying to specify a character which would be better disaggregated into two or more different characters.

### 3.1.3 Numeric character state values

Numeric values are expressed in any of the commonly accepted ways (except scientific notation), so any of the following examples are valid: 1000, 1, 1.0, 0.01 and 123.123. It is frequently necessary to provide a numeric range and this is accomplished using the notation '[n1-n2]' where n1 and n2 are numbers specified in a valid format. Examples from the biscuits knowledge-base include the values of the 'Width' and 'Length' characters for 'Rich's fantasy biscuit 2'. That means that the size of 'Rich's fantasy biscuit 2' is variable and will match against any number specified by a user which is within the specified range (unusual for a biscuit but common for biological organisms!).

	A	J	K
1	Taxon	Width	Length
11	Choc Chip Cookie	57	57
12	#Rich's fantasy biscuit 1	[80-90]	[90-100]
13	Rich's fantasy biscuit 2	[80-90]	[90-100]

### 3.1.4 Ordinal character state values

Ordinal characters are a bit of a hybrid of text and numeric – having some properties of each of them. They look like text values – being comprised of words rather than numbers – but the essential feature of ordinal character values is that they can be ranked – like numbers.

For example imagine a character that can take the following values:

- 'hairless'
- 'few hairs'
- 'moderately hairy'
- 'very hairy'
- 'downy'

These values are comprised of words, but they can be ordered – e.g. 'moderately hairy' is less than 'very hairy' but greater than 'few hairs'. Why is this important? If this character was a 'text' type, then a value of 'few hairs' specified by a user would not match 'downy' taxa or taxa that are 'moderately hairy'. But in reality these types of character states are hard to judge and they can often also be variable in nature; under these circumstances, you might want taxa that are 'moderately hairy' to score *something* when the user enters 'few hairs' and, furthermore, to score more than taxa that are 'downy'. In such cases, you specify characters as type 'ordinal' (which will be described in the section on the 'characters worksheet').



The way you can specify ordinal character values on the taxa worksheet has something in common with text characters and something with numeric characters. Like text characters, values are just specified by entering their text values. Alternatives can be specified by using the 'or' character – '|' – as with text characters, but because they are ranked, it is normally better to specify an ordinal range, in a similar fashion to numeric characters. For example if you wanted to specify a hairiness range for a certain taxon, you could specify it thus: '[hairless-moderately hairy]'.

An example from the biscuits knowledge-base is shown here. (Note however, that although the 'or' character has been demonstrated, there are probably few realistic examples where you'd need to use this – normally a range will suffice.)

ChocTaste
none
none
none
none
little
none
very
very
none
moderate
very
[little-very]
very   moderate
very   [none-little]

### 3.1.5 Special character state values

As well as the text and numeric state values indicated above, there are three other 'special' values that can be used in the character/taxon character state spreadsheet cells. These are:

- ""
- '?'
- 'n/a'

The first one is an empty cell, i.e. no value at all. This is allowed in a knowledge-base and is treated as a missing value. Missing values neither score for or against a taxon when matching against user input. Obviously the performance of knowledge-bases with lots of missing values is poorer than those that are well-populated, but it is imperative that visualisations can operate 'normally' on knowledge-bases with missing values so that knowledge-base authors can see progress as their knowledge-bases mature.

The second – the question mark – also denotes missing data and is treated in exactly the same way as an empty cell by the framework. However it can be used by the knowledge-base author as a marker in the knowledge-base, for instance as a reminder that some work is needed on that character state.

The final one – 'n/a' – represents 'not applicable'. This should be used for characters that are not applicable for a given taxon. For example in the biscuits knowledge-base the value 'n/a' is used for the character 'FillingColour' for those taxa that have a value of 'single' for the character 'SingleDouble', indicating that they do not have fillings. If the user specifies a value for the character 'FillingColour' then those taxa with a value of 'n/a' will score negatively for that character.

	A	I
1	<b>Taxon</b>	<b>FillingColour</b>
2	Rich Highland Shortie	n/a
3	Romany Vanilla Cream	White
4	Shortcake	n/a
5	Custard Cream	White
6	Bourbon Cream	Dark brown
7	Happy Face	White
8	Milk Chocolate Digestive	n/a

### 3.1.6 Describing taxonomy in a knowledge-base

Some visualisations make use of taxonomic (as opposed to morphological) knowledge expressed in a knowledge base (e.g. the Circle-pack key). So for example you could record, for each taxon in your knowledge base, the genus, sub-family, family and any other higher level taxonomic groupings that you like.



To do that, you add columns to the taxa worksheet in the normal way – each column representing a taxonomic rank – and populate the cells with the value of that rank for each taxon. The example below shows a section from a knowledge-base on harvestmen.

	A	B	C	D
1	Taxon	Family	SubFamily	Genus
2	Nemastoma bimaculatum	Nemastomatidae		Nemastoma
3	Mitostoma chrysomelas	Nemastomatidae		Mitostoma
4	Nemastomella bacillifera	Nemastomatidae		Nemastomella
5	Trogulus tricarinatus	Trogulidae		Trogulus
6	Anelasmacephalus cambridgei	Trogulidae		Anelasmacephalus
7	Sabacon viscayanum ramblaianum	Sabaconidae		Sabacon
8	Homalenotus quadridentatus	Sclerosomatidae	Sclerosomatinae	Homalenotus
9	Oligolophus tridens	Phalangiidae	Oligolophinae	Oligolophus
10	Oligolophus hanseni	Phalangiidae	Oligolophinae	Oligolophus
11	Paroligolophus agrestis	Phalangiidae	Oligolophinae	Paroligolophus
12	Paroligolophus meadii	Phalangiidae	Oligolophinae	Paroligolophus
13	Lacinius ephippiatus	Phalangiidae	Oligolophinae	Lacinius
14	Odiellus spinosus	Phalangiidae	Oligolophinae	Odiellus

The order in which you specify the columns does not matter – the taxonomic order of the ranks is indicated on the characters worksheet. See ‘The group column’ section for the characters worksheet to complete your understanding of how to specify taxonomy. Note that the taxonomy you specify must be expressible as a strict hierarchy – so all taxa that have the same value for a given taxonomic rank, must also have the same values at all higher taxonomic ranks. This is a general truism of all hierarchical taxonomies in the tree of life. If you break this rule, you can expect unexpected results!

### 3.2 The characters worksheet

The example below shows the character worksheet from the biscuits knowledge-base.

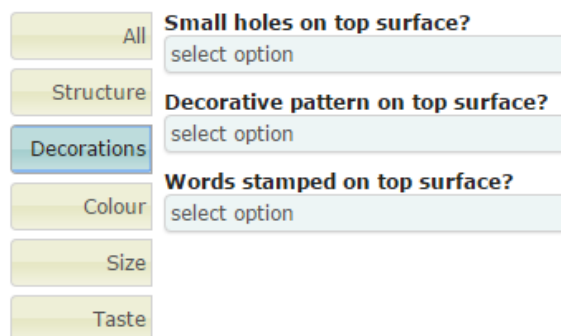
	A	B	C	D	E	F	G	H	I	J	K	L
1	Group	Character	Label	Help	HelpShort	Status	ValueType	ControlType	Params	Weight	Strictness	Source
2	Taxonomy	Taxon	Taxon									
3	Structure	Shape	Shape	The actual shape of the biscuit	The actual shape of the biscuit	key	text	single		10		
4	Structure	SingleDouble	Single or Double Biscuit	Is the biscuit a single layer, or is it a chocolate coating?	Is the biscuit a single layer, or is it a chocolate coating?	key	text	single		10		
5	Structure	Coating	Coating	Does the biscuit have a chocolate coating?	Does the biscuit have a chocolate coating?	key	text	single		8		
6	Decorations	Holes	Small holes on top	If the biscuit has small holes (e.g. the key)	If the biscuit has small holes (e.g. the key)	key	text	single		8		
7	Decorations	Pattern	Decorative pattern	Is there any sort of decorative pattern?	Is there any sort of decorative pattern?	key	text	single		8		
8	Decorations	Words	Words stamped on	As part of the decoration, some biscuits have words stamped on them	As part of the decoration, some biscuits have words stamped on them	key	text	single		10		
9	Colour	BiscuitColour	Biscuit Colour	The base colour of the biscuit, ignoring the filling	The base colour of the biscuit, ignoring the filling	key	text	multi		5		
10	Colour	FillingColour	Filling Colour	The colour of the filling which sandwiches the biscuits	The colour of the filling which sandwiches the biscuits	key	text	single		5		
11	Size	Width	Width	The width of the biscuit, measured in mm	The width of the biscuit, measured in mm	key	numeric	spin	1,100,1	8	0	
12	Size	Length	Length	The length of the biscuit, measured in mm	The length of the biscuit, measured in mm	key	numeric	spin	1,100,1	8	0	
13	Taste	ChocTaste	How chocolatey?	Indicate how chocolatey the biscuit is	Indicate how chocolatey the biscuit is	key	ordinal	single		10	0	
14	Other	Availability	Availability	When was the biscuit 'found'?	When was the biscuit 'found'?	key	ordinalCircular	multi		10	0	
15	Other	TopTen	Top ten biscuit?			display						http://t
16												

Regardless of the columns specified on the taxa worksheet, they will only be considered as true characters by the framework if they have an entry on the characters worksheet – i.e. they appear under the ‘Character’ column. So every character that you want to use in the visualisations must have a line on this worksheet.



### 3.2.1 The Group column

The first column – ‘Group’ – is used to group characters in the visualisations on the state input controls. The illustration on the right shows the appearance of the state input controls for the biscuits knowledge-base. Here the ‘Decorations’ tab is selected causing only those characters marked with this group on the characters worksheet to be shown.



If the value under ‘Group’ for every character is set to ‘None’ (except for taxonomy characters – see below), then the framework’s state input controls do not group characters at all and the grouping tabs shown in the illustration here are completely hidden. Groups are useful when you are specifying a knowledge-base with lots of characters but can just be a hindrance if there are only a few, so it’s useful to be able to specify ‘None’ in such cases.

The special group name ‘Taxonomy’ is used to indicate to the framework that the character represents a taxonomic rank and that the values in the taxa worksheet represent the taxonomic group to which each taxon belongs for this rank. The order in which taxonomy ranks are specified the on characters worksheet is critical. The higher ranks must appear at the top and the lowest (Taxon) must appear at the bottom. An example for harvestmen is shown below.

	A	B	C	D	E	F	G	H	I	J	K
1	Group	Character	Label	Help	Status	ValueType	ControlType	Params	Weight	Strictness	Source
2	Taxonomy	Family	Family		display						
3	Taxonomy	SubFamily	Sub-family		display						
4	Taxonomy	Genus	Genus		display						
5	Taxonomy	Taxon	Species								

Note that the values of taxonomy characters can also be displayed to users along with morphological characters, or even be used for key input, just like any other character (see section on ‘The status column’ below).

### 3.2.2 The Label column

The ‘Label’ column is where you specify how the character is actually represented to users of the visualisations. So while the character name, as specified on the taxa worksheet (and in the ‘Character’ column of the character worksheet) is short and succinct and convenient for you as a knowledge-base author, it may not be that meaningful to a user of the visualisations. So in the ‘Label’ column you indicate the text that will appear to a user in place of the character name used in the knowledge-base. If you like, you can frame these labels as short questions – as in the example for the decoration characters in the biscuits knowledge-base. Alternatively you can use something simpler and leave the questions for the next column we will discuss – the ‘Help’ column.

Character	Label
SingleDouble	Single or Double Biscuit

### 3.2.3 The Help and HelpShort columns

Character	Label	Help
Pattern	Decorative pattern on top surface?	Is there any sort of <i>&lt;i&gt;deliberate&lt;/i&gt;</i> decorative pattern on all or part of the top surface of the biscuit? Natural 'cracking' during baking or an uneven texture does not count as a pattern.

The 'Help' column is where you can specify a much lengthier explanation of the character – including instructions on how to use it – to users of the visualisations. When you specify text in this column it is presented to users when they click on the character's label in the state input controls as shown on the right.

#### Decorative pattern on top surface?

select option

#### Character help and information

#### Decorative pattern on top surface?

Is there any sort of *deliberate* decorative pattern on all or part of the top surface of the biscuit? Natural 'cracking' during baking or an uneven texture does not count as a pattern.

You can use plain text in this column, but you can also use simple HTML mark-up if you like, e.g. to embolden or italicise text.

But help on a character is also displayed to a user in a tooltip as they move the mouse over the label for the character. The text displayed will be that in the 'Help' column, but if you want a shorter version for the tooltip help, then put that in the 'HelpShort' column and that will be used instead.

Note that for numeric characters, you should indicate to the user what units the character is specified in. Sometimes you may want to do that in the 'Label' column, but more usually you would do it in the 'Help' column.

### 3.2.4 The Status column

The 'Status' column is where you can indicate how the character is to be treated by the visualisations. There are currently only two recognised values for this: 'key' and 'display'. A character with any other value in this column, or no value, will be ignored by the visualisations. (The exception is the 'Taxon' character which must appear on the characters worksheet, but which does not need to have a value specified here.)

If you specify a value of 'key' in the 'Status' column, the character against which you specify it will be included in the character state input controls for the visualisations which use them (e.g. multi-access keys). This is the usual state of affairs, but sometimes you might specify a character that you want users to be able to see – because it contains useful information – but not use for character state input.

For such characters, use a value of 'display'. In the biscuits knowledge-base, the 'TopTen' character is specified with a status of 'display', so it does not appear in the state input controls, but users can see its value elsewhere in the visualisations, for example when clicking on a taxon name in either of the two multi-access key visualisations. Doing this invokes a dialog showing the knowledge-base values for the taxon

	A	B	C	D	E
1	Group	Character	Label	Help	Status
13	Taste	ChocTaste	How chocolatey?	Indicate how <i>&lt;i&gt;ch&lt;/i&gt;</i>	key
14	Other	TopTen	Top ten biscuit?		display

**Shortcake**

Colour	
Biscuit Colour	Pale brown
Filling Colour	None
Size	
Width	37
Length	61
Taste	
How chocolatey?	none
Other	
Top ten biscuit?	no

as shown in the illustration on the right. Here you can see values for all characters including those that can be used for character state input (values in bold) and those which are display only (values in normal font weight).

### 3.2.5 The ValueType column

Under the 'ValueType' column you specify the data type of the character. In the section on the taxa worksheet we noted that there were three types of character state values – text, numeric and ordinal – these are indicated in the 'ValueType' column simply by entering the words, 'text', 'numeric' and 'ordinal' respectively.

But there is a special class of ordinal values – circular ordinals – that we need to think about. Consider an ordinal character that whose values could take the name of any month of the year. This could be a 'peak emergence' character or something like that. You can see why it would be specified as ordinal – if the user specifies a value of 'june', then taxa with the values 'may' and 'july' should score equally and both would be a closer match than taxa with values of 'april' or 'august'. But what if the user specified a value of

B	F
Character	ValueType
Words	text
BiscuitColour	text
FillingColour	text
Width	numeric
Length	numeric
ChocTaste	ordinal
Availability	ordinalCircular

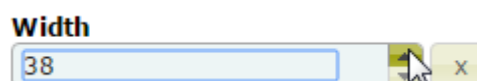
'december'? Taxa with values of 'november' would score a close match, but those with a value of 'january' would score a low match because that's at the other end of the ordinal scale. To account for situations like these, you can specify a 'ValueType' of 'ordinalCircular'. This effectively joins the two extremities of the ordinal range to each other – i.e. a 'circular ordinal' – and in this case, taxa with a value of 'january' would score the same as those with a value of 'november'.

(Note that for both ordinal and circular ordinal characters, we have to specify the ranking order – this is done on the values worksheet.)

### 3.2.6 The ControlType and Params columns

The 'ControlType' column is used to specify the type of input control used by the character state input controls on the visualisations. Currently this can only accept one value – 'spin' – for characters with a

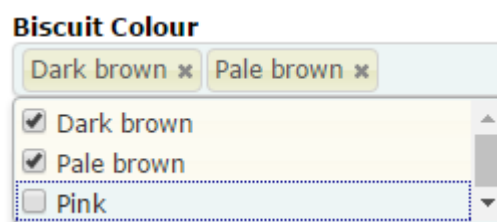
'ValueType' of 'numeric'. So any character with a



'ValueType' of 'numeric' must also have a 'ControlType' of 'spin'. This creates a 'spin' input control like that shown on the right. For each spin control you specify, you also need to provide a value in the '**Params**' column to indicate the minimum and maximum values that the spinner will travel between when you use the up and down arrows and an increment value that indicates how much the value will increase/decrease when you click the up/down arrows.

The params value is specified in the form 'min,max,incr' – with no spaces. So the value for the character 'Width' in the biscuits knowledge-base – '1,100,1' – indicates that the control will spin between the values of 1 and 100 and increase/decrease by a value of 1. Note that fractional values are permissible for any of these values, e.g. '5.0,15.0, 0.25'. Currently, this is the only use of the 'Params' column.

The 'ControlType' column can accept one of two values – 'single' or 'multi' – for characters with a 'ValueType' of 'text' or 'ordinal'. Both 'single' and 'multi' control types are drop-down lists from which the user can select the appropriate value. The difference between them is that for 'single' controls, only one value can be specified at once whilst for 'multi' controls, more than one value can be specified. The illustration on the right shows the 'multi' type control specified in the biscuits knowledge-base for the character 'BiscuitColour'.



Normally it is best to specify 'single' for 'ControlType' – it makes for a clearer specification of knowledge and more transparent working of the visualisations. But it can be handy to allow the user to 'hedge their bets' for text characters that are particularly variable or subjective such as colour. (See separate document for details on the scoring/matching mechanism.)

### 3.2.7 The Weight column

Each character with a 'Status' of 'key' can be given a value in the 'Weight' column of between 1 and 10 to indicate its relative importance/reliability as an identification character. The matching scores for each character are adjusted by this value to reflect this relative importance. (See separate document for details on the scoring/matching mechanism.)

Your most reliable characters should be given a weighting of 10 and the weighting of all the others specified relative to this. In the biscuits knowledge-base, the characters with a weighting of 10 are 'Shape', 'SingleDouble' and 'Words' – all characters with are not variable and very unlikely to be misinterpreted by a user. (There's a good argument for giving the 'Width' and 'Length' characters of the biscuits a 'Weight' of 10 since they are likely to vary very little, however it is considered that a user is as likely to estimate these values as measure them, so they have been given a lower weighting.)

B	I
Character	Weight
Taxon	
Shape	10
SingleDouble	10
Coating	8
Holes	8
Pattern	8
Words	10
BiscuitColour	5
FillingColour	5
Width	8
Length	8
ChocTaste	3

### 3.2.8 The Strictness column

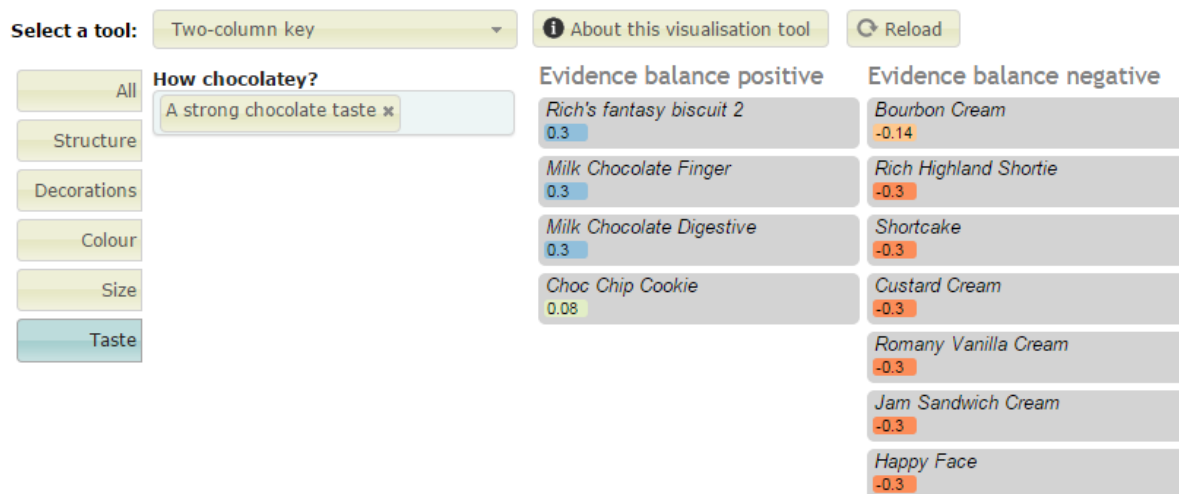
The 'Strictness' column is only relevant for characters with a 'ValueType' of 'numeric', 'ordinal' or 'ordinalCircular'. You can use it to specify how much latitude to give to user-specified values that are not exact matches for a taxon but are relatively close. A strictness value of 10 – the strictest value – requires an exact match between character values specified by the user and those recorded in the knowledge-base for a taxon to score any sort of match for that character. But with a lower strictness value, values that are close but not an exact match can also score. The lower the strictness value, the more latitude there is for a match of some sort.

Imagine a character 'BodyLength' in a knowledge-base for Harvestmen (Opiliones). Suppose that you could populate this field from the literature, but the best data at your disposal was an average body length. You don't have the information required to specify a 'normal' range for the species, so you just use the average body length. Say for species A this was 5.5 mm and for species B 11.0 mm. If you

B	F	J
Character	ValueType	Strictness
Width	numeric	0
Length	numeric	0
ChocTaste	ordinal	0

specified a 'Strictness' value of 10 for this character, then a value of 10.5 mm specified by a user for the character would not match either taxon. But with strictness value of 0, species B would score a partial match. Species A might also score a partial match but the score for species B would be much higher.

Similarly, for the ordinal character 'ChocTaste' in the biscuit knowledge-base, a user specified value of 'very' would only score a perfect match for taxa with a value of 'very'. And if the 'Strictness' value for this character was 10, then those taxa with a value of 'moderate' would score nothing – just like those with a value of 'none'. But with a 'Strictness' value of 0, those taxa with a value of 'moderate' would score less than those with a value of 'very' but more than those with a value of 'none'. (See separate document for details on the scoring/matching mechanism.)



**Select a tool:** Two-column key

**How chocolatey?**  
A strong chocolate taste x

**Evidence balance positive**

Biscuit	Score
Rich's fantasy biscuit 2	0.3
Milk Chocolate Finger	0.3
Milk Chocolate Digestive	0.3
Choc Chip Cookie	0.08

**Evidence balance negative**

Biscuit	Score
Bourbon Cream	-0.14
Rich Highland Shortie	-0.3
Shortcake	-0.3
Custard Cream	-0.3
Romany Vanilla Cream	-0.3
Jam Sandwich Cream	-0.3
Happy Face	-0.3

The illustration above of the 'two-column key' visualisation working on the biscuits knowledge-base shows how each taxon (biscuit) is scored when a single character – 'ChocTaste' – is specified by the user as 'strong' (the value 'strong' has been translated to 'A strong chocolate taste' – see the section on the values worksheet for an explanation of that).

The top three matches have the maximum score 0.3 (this is a low maximum because the character has a low weighting of 3). But because this is an ordinal character with a low strictness value of 0, even those values which are not strict matches can score positively, e.g. 'Choc Chip Cookie' which has a value of 'moderate' for this character state.

You can experiment with different values of the 'Strictness' column but, in practice, 10 and 0 are likely to be most useful.



### 3.3 The values worksheet

The image below shows the values worksheet from the biscuits knowledge-base.

	A	B	C	D	E	F	G	H
1	Character	CharacterState	CharacterStateTranslation	StateHelp	StateHelpShort			
2	ChocTaste	none	No chocolate taste					
3	ChocTaste	little	A slight chocolate taste					
4	ChocTaste	moderate	A moderate chocolate taste					
5	ChocTaste	very	A strong chocolate taste					
6	BiscuitColour	Dark brown		The overall colour of the bi	The overall colour of the biscuit is dark brown.			
7	BiscuitColour	Pale brown			The overall colour of the biscuit is pale brown.			
8	Coating	Chocolate		The biscuit has a chocolate coating.				
9	Coating	None		The biscuit does not have a coating.				
10	Shape	Round		The biscuit is round.				
11	Shape	Rectangular		The biscuit is rectangular.				
12	Shape	Hexagonal		The biscuit is hexagonal.				
13	Shape	Cigar	Cigar shaped	The biscuit is cigar shaped.				
14	FillingColour	Dark brown		The bisuit has a dark brown filling.				
15	FillingColour	White		The biscuit has a <i>white</i> filling.				
16	FillingColour	White and red		The biscuit has a filling of two layers - one red and one white.				
17	Holes	Yes		The biscuit has small holes on the top surface.				
18	Holes	No		The biscuit has no holes in top surface.				
19	Pattern	Yes		The biscuit has a clear an deliberate pattern on the top surface.				
20	Pattern	No		The biscuit has no clear or deliberate pattern (words or holes may be present)				
21	SingleDouble	Double		There are two separate layers of biscuit.				
22	SingleDouble	Single		There is only a single layer biscuit.				
23	Words	Yes		The biscuit has words stamped on top.				
24	Words	No		There are no words on the biscuit (pattern or holes may be present).				

It should be noted right away that a knowledge-base will work without any rows in the values worksheet. You *do not* have to enter every character state into the values worksheet, but there are some circumstances under which doing so is necessary or just desirable. These are the reasons you might want to make entries in the values worksheet:

- To provide help to the user on a particular character state value.
- To translate the character state text that appears on the taxa worksheet to something more meaningful to users of the visualisations.
- To rank character state values for an ordinal character.
- To specify an order for text character state values in drop-down lists.

Each of these situations is dealt with below.

### 3.3.1 Providing help on character state values

	A	B	D	E	F	G	H
1	Character	CharacterState	StateHelp	StateHelpShort			
19	Pattern	Yes	The biscuit has a clear an deliberate pattern on the top surface.				
20	Pattern	No	The biscuit has no clear or deliberate pattern (words or holes may be present).				

To provide help on character state values, it is first necessary to ensure that the character itself has some help text specified on the characters worksheet. Providing help text for one or more character states gives maximum help to users of the visualisations who are trying to input character state values for a specimen. To provide help for a character state, enter the character and character state values (as they appear in the taxa worksheet) in the columns 'Character' and 'CharacterState' respectively and then enter the help text under 'StateHelp'.

The illustration on the right shows the effect of doing this for the character states 'Yes' and 'No' for the 'Pattern' characters. The relevant entries on the values worksheet are also shown.

Note that like help text for characters themselves, you can use either plain text in the 'StateHelp' column of the values worksheet, or simple HTML mark-up, e.g. to embolden or italicise text.

#### Decorative pattern on top surface?

select option

#### Character help and information

#### Decorative pattern on top surface?

Is there any sort of *deliberate* decorative pattern on all or part of the top surface of the biscuit? Natural 'cracking' during baking or an uneven texture does not count as a pattern.

**Yes:** The biscuit has a clear an deliberate pattern on the top surface.

**No:** The biscuit has no clear or deliberate pattern (words or holes may be present).

	A	B	D	E	F	G	H
1	Character	CharacterState	StateHelp	StateHelpShort			
	BiscuitColour	Dark brown	The overall colour of the biscuit is dark brown. There may be other colours present, but this is the dominant colour.	The overall colour of the biscuit is dark brown.			
6							
7	BiscuitColour	Pale brown	The overall colour of the biscuit is pale brown.				

As well as displaying help text for state values in the help dialog window as shown above, the values are also displayed in tooltips when a user moves the mouse over a selected value in the state input controls. If you want to provide a briefer version of the state help for a tooltip, then specify it in the 'StateHelpShort' column (as has been done for the 'Dark brown' state for the 'BiscuitColour' character in the Biscuits knowledge-base shown above).

### 3.3.2 Translating character state values

When entering character state values into the taxa worksheet, wordy text character values can be unwieldy and really make it hard for the author to work with the knowledge-base. And yet, since users of the visualisations see and select character state values, they must be meaningful to them. To help with this there is a facility whereby succinct character state values specified on the taxa worksheet can be translated into more meaningful text that the users actually see.



To provide a translated value for a character state, enter the character and character state values (as they appear in the taxa worksheet) in the columns 'Character' and 'CharacterState' respectively and then enter the translated text for the character state under 'CharacterStateTranslation'.

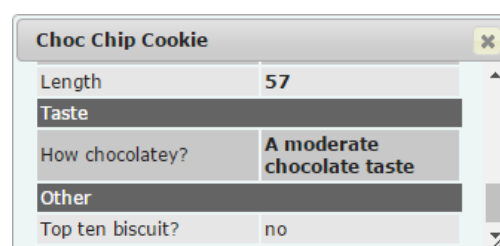
	A	B	C
1	<b>Character</b>	<b>CharacterState</b>	<b>CharacterStateTranslation</b>
2	ChocTaste	none	No chocolate taste
3	ChocTaste	little	A slight chocolate taste
4	ChocTaste	moderate	A moderate chocolate taste
5	ChocTaste	very	A strong chocolate taste

#### How chocolatey?

select option

No chocolate taste  
A slight chocolate taste  
A moderate chocolate taste  
A strong chocolate taste

In the biscuits knowledge-base, the character states for the character 'ChocTaste' have been provided with translated values. So whilst it is the succinct values of 'none', 'little', 'moderate' and 'very' that appear in the knowledge-base on the taxa worksheet, these are translated, by means of the values worksheet, to the values 'No chocolate taste', 'A slight chocolate taste', 'A moderate chocolate taste' and 'A strong chocolate taste' respectively.



**Choc Chip Cookie**

Length: 57

Taste: [dropdown menu]

How chocolatey?: A moderate chocolate taste

Other: [dropdown menu]

Top ten biscuit?: no

The images show the effects of this translation in the character state selection control and the knowledge-base values display dialog.

### 3.3.3 Ranking ordinal character state values

Ordinal characters have been described under the relevant parts of the section on the characters worksheet. But ordinal (and circular ordinal) characters can only operate if a ranking is assigned to each possible character state value and this is done on the values worksheet. A number is not explicitly assigned to define rank; instead, rank is implicitly assigned on the basis of the order in which the values are listed on the values worksheet.

The relevant part of the worksheet is shown on the right for the 'ChocTaste' character in the biscuits knowledge-base. It does not matter whether the values are ranked in 'ascending' or 'descending' order - the effect on scoring will be the same. The important thing is that they appear in rank order. (However the exact order does dictate the order in which they are presented to the user in drop-down lists - see below.)

	A	B
1	<b>Character</b>	<b>CharacterState</b>
2	ChocTaste	none
3	ChocTaste	little
4	ChocTaste	moderate
5	ChocTaste	very

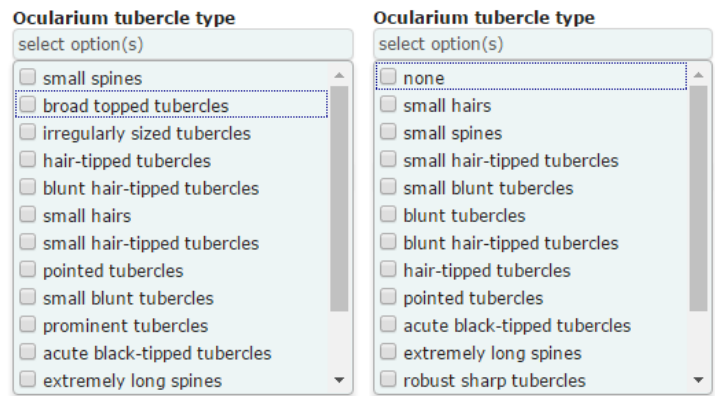
### 3.3.4 Specifying order for text character values in drop-down lists

When the framework creates drop-down lists of character states for use in the visualisation's state input controls, the lists are created, by default, simply by adding state values in the order that they are encountered as the taxa worksheet is read from the first row to the last. Therefore the order in which the character states appear in the lists is, essentially, random. Sometimes this is okay –



especially if there are very few possible character state values. But sometimes this can lead to ugly and unintuitive lists, as in the case of the left-most list above which shows the drop-down list generated by default from a harvestman knowledge-base.

The list on the right was generated after all the possible character state values for this character were specified on the values worksheet in the order in which the knowledge-base author wanted them to be presented to the user. As you can see, this makes for a more intuitively navigable list.



Remember that unless this is an 'ordinal' or 'circularOrdinal' character, the order has no effect whatsoever on the scoring of the character, only the order in which the state values appear to visualisation users.

### 3.4 The media worksheet

The image below shows part of the media worksheet from the biscuits knowledge-base.

	A	B	C	D	E	F	G	H	I	J
1	URI	ImageWidth	Type	Priority	Caption	Taxon	Character	State	UseFor	TipStyle
2	# 'Words' character help images									
3	resources/BourbonTop.jpg	100%	image-local		Words on the top of a Bourbon		Words			
4	# 'FillingColour' character state help									
5	resources/CusCreamFilling.jpg	100%	image-local		The filling of a Custard Cream		FillingColour	White		
6	resources/CusCreamXSection.jpg	100%	image-local		White filling in a Custard Cream		FillingColour	White		
7	resources/BourbonFilling.jpg	100%	image-local		The filling inside a Bourbon		FillingColour	Dark brown		
8	resources/BourbonXSection.jpg	100%	image-local		Dark brown filling in a Bourbon		FillingColour	Dark brown		
9	resources/JSCreamXSection.jpg	100%	image-local	2	White and red filling in a Jam Sandwich Cream		FillingColour	White and red		
10	resources/HappyFaceFilling.jpg	100%	image-local	1	White and red filling inside a Happy Face		FillingColour	White and red		
11	# Taxon images...									
12	resources/MCC1.jpg	100%	image-local		A photo showing a top down view of a Choc Chip Cookie					
13	resources/MCC2.jpg	100%	image-local		A photo showing an oblique view of a Choc Chip Cookie					
14	# Taxon HTML files...									
15	resources/DigestivesHist.htm		html-local	2	History of the Digestive	Milk Chocolate Digestive				
16	resources/DigestivesRecipe.htm		html-local	1	Recipe for a Digestive	Milk Chocolate Digestive				
17	resources/Bourbon.htm		html-local	1	About the Bourbon biscuit	Bourbon Cream				

The media worksheet is where media files are associated with taxa, characters or character states. Framework visualisations can then display these files in appropriate situations. Situations where you might want to specify media files with the current visualisation tools include the following:

- Images to supplement help text for characters for visualisations that use the state input controls.
- Images to supplement help text for character state values for visualisations that use the state input controls.
- Images to illustrate taxa for visualisations capable of displaying.
- HTML files to provide further information on taxa.

Each of these situations is dealt with below.

### 3.4.1 Images to supplement help text

We have seen how to use the characters worksheet and the values worksheet to specify help text for characters and character state values respectively. You can also provide images to be displayed in the appropriate places on the same help dialog by specifying the images on the media tab.

Images should be stored in sub-folders of the folder which contains your knowledge-base (and therefore CSV files). The 'URI' column is used to specify the relative path, from this folder, to the image file.

An image is associated with a character by specifying it in the 'Character' column (the 'State' column must be blank to associate an image with the character itself).

To associate an image with a specific character state value, then values must be supplied for both the 'Character' and the 'State' columns.

It is normally best to use the value of '100%' in the 'ImageWidth' column. This will ensure that the image is resized to fit the help dialog. Without this value, the image is shown at its natural size.

Currently you must specify a value of 'image-local' for the 'Type' column.

The 'Priority' column can be used to specify the order in which images are presented when more than one is specified for a given character or character state value. Lower numbers have the highest priority. Fractional numbers are permitted.

The 'Caption' column is used to specify a caption for an image. It's a useful place to credit copyright holders. You can use plain text or basic HTML mark-up in captions.

The top image on the right shows an image specified in the biscuits knowledge-base for the 'Words' character with no images specified for either of the valid character states.

The bottom image on the right shows the two images specified in the biscuits knowledge-base for the 'White and red' state value for the 'FillingColour' character. Although the Happy Face image is listed on the row below the Sandwich Cream image on the media worksheet, it has a higher priority (i.e. '1' in the 'Priority' column) and is therefore displayed first.



The image below shows the rows from the media worksheet responsible for specifying these images.

	A	B	C	D	E	F	G	H	I	J
1	URI	ImageWidth	Type	Priority	Caption	Taxon	Character	State	UseFor	TipStyle
2	# 'Words' character help images									
3	resources/BourbonTop.jpg	100%	image-local		Words on the top of a Bourbon		Words			
4	# 'FillingColour' character state help									
5	resources/CusCreamFilling.jpg	100%	image-local		The filling of a Custard Cream		FillingColour	White		
6	resources/CusCreamXSection.jpg	100%	image-local		White filling in a Custard Cream		FillingColour	White		
7	resources/BourbonFilling.jpg	100%	image-local		The filling inside a Bourbon		FillingColour	Dark brown		
8	resources/BourbonXSection.jpg	100%	image-local		Dark brown filling in a Bourbon		FillingColour	Dark brown		
9	resources/JScreamXSection.jpg	100%	image-local	2	White and red filling in a Jam Sandwich Cream		FillingColour	White and red		
10	resources/HappyFaceFilling.jpg	100%	image-local	1	White and red filling inside a Happy Face		FillingColour	White and red		

### 3.4.2 Images to illustrate taxa

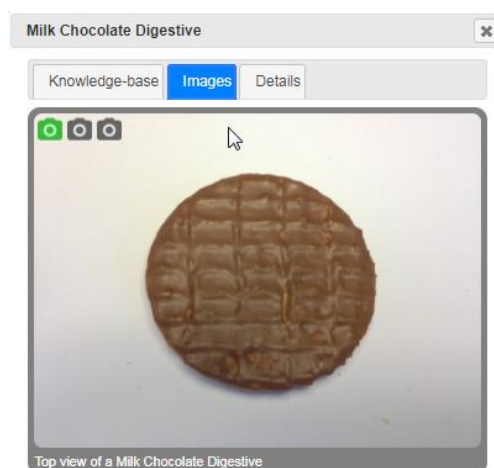
Images to illustrate taxa are specified in exactly the same way as those to illustrate character and state values, except that instead of specifying a value for the columns 'State' and/or 'Character' (which must both be left blank), you specify the name of the associated taxon in the 'Taxon' column.

The 'Priority' column is used in the same way. Make sure that if you have more than one image associated with a taxon the highest priority (lowest number) is associated with an image that is suitable to illustrate the taxon under most circumstances since, if only one image is required by a visualisation (e.g. the 'two-column key' visualisation), this is the one it will use.

The image on the right shows an image group viewer (included in a number of the visualisations) for a taxon (Choc Chip Cookie) for which two images have been specified in the biscuits knowledge-base.

The first image displayed is either that with the highest priority (lowest priority number) or, if no priorities are specified, that listed first in the knowledge-base.

The image below shows the rows from the media worksheet responsible for specifying the images for the 'Choc Chip Cookie' taxon.



	A	B	C	D	E	F	G	H
1	URI	ImageWidth	Type	Priority	Caption	Taxon	Character	State
11	# Taxon images...							
12	resources/MCC1.jpg	100%	image-local		A photo showing a top down view of a Chc Choc Chip Cookie			
13	resources/MCC2.jpg	100%	image-local		A photo showing an oblique view of a Chc Choc Chip Cookie			

### 3.4.3 The UseFor and TipStyle columns

Images specified against particular characters (as opposed to character states) will, by default, be displayed to the user in the character help tooltip. If you wish to restrict an image defined for a character so that it is only displayed in the full help window, then set the value of the 'UseFor' column to 'full'. If you want to restrict an image defined for a character so that it is only displayed in the help tooltip, then set the value of the 'UseFor' column to 'tip'. To display in both situations, you can either leave the column blank, or set the value to 'full, tip' (or 'tip, full').

By default, images displayed in tooltips take up the full width of the tooltip. You can restrict them to part of the width using the 'TipStyle' column. For example, a value of 'left-40' means that the image will only take up 40% of the width of the tool tip and be placed on the left-hand side. Similarly, a

value of 'right-50' means that the image will take up 50% of the width of the tool tip and be placed on the right-hand side.

### 3.4.4 HTML files to provide further information on taxa

If the very phrase 'HTML file' makes you feel queasy, fear not! Think instead of a Microsoft Word file containing detailed information about a taxon. You can use Word's 'Save As' function to save this file with a file type of 'Web Page (\*.htm; \*.html)' – then you will be able to display it using the framework.

HTML files should be stored in sub-folders of the folder which contains your knowledge-base (and therefore CSV files). The 'URI' column is used to specify the relative path, from this folder, to the HTML file.

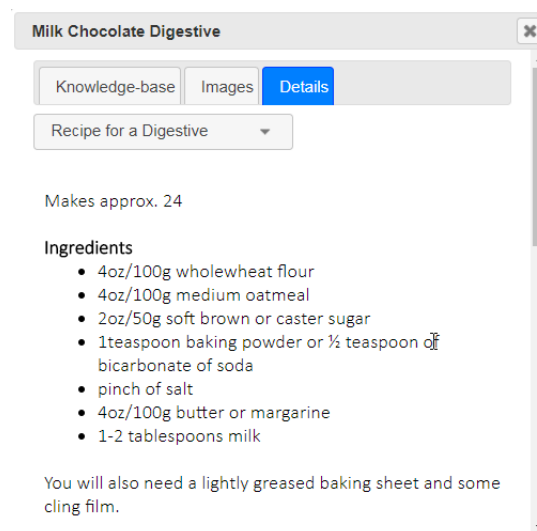
If you have saved an HTML file that just contains text, all is very simple. But if you want your HTML file to reference external resources like images, you will need to be careful about how you specify the image URLs. Unless you are very competent with dealing with HTML and websites, it is best not to include images in your HTML files.

Using the media worksheet to specify HTML files associated with taxa is very similar to specifying images associated with taxa. Follow the same steps as for images, but use a value of 'html-local' in the 'Type' column. The value of the 'Priority' column is used by the framework to decide which file to show first if more than one is specified for a taxon.

A few simple examples have been included with the biscuits knowledge-base. Two files are specified for the 'Milk Chocolate Digestive' taxon and one for the 'Bourbon' taxon.

The image on the right is from the 'taxon details' dialog box that appears when you select the name of a taxon from any of the default visualisations. The image shows one of the two text files specified for Chocolate Digestive. The other can be displayed by selecting it from the drop-down list (shaded darker green and currently showing 'History of the Digestive').

The lines from the media worksheet which are responsible for specifying the text images for the 'Milk Chocolate Digestive' taxon are shown below.



	A	B	C	D	E	F	G	H
1	URI	ImageWidth	Type	Priority	Caption	Taxon	Character	State
14	# Taxon HTML files...							
15	resources/DigestivesHist.htm		html-local	2	History of the Digestive	Milk Chocolate Digestive		
16	resources/DigestivesRecipe.htm		html-local	1	Recipe for a Digestive	Milk Chocolate Digestive		

### 3.4.5 General comments on the media worksheet

Blank rows and those that start with a hash symbol ('#') in the first column – to denote a comment – can be used to organise the information on the media worksheet to help you as a knowledge-base author keep track of what's on there.



Where a single image is used for several purposes – e.g. illustrate a taxon *and* illustrate a character state value – there must be a separate entry (i.e. a separate row) on the media worksheet to specify each way in which the image is used.

### 3.5 The config worksheet

The image below shows the config worksheet from the biscuits knowledge-base.

	A	B	C	D	E	F	G	H
1	Key	Type	Mandatory	Value	Date	Notes		
2	#Tools - those default tools to exclude and non-default tools to include							
3	excludedDefaultTools	config	no			e.g. 'vis1, vis3' to remove the 'Two-column key' and 'Side-by-side comparison' visualisations		
4	otherIncludedTools	config	no			e.g. 'visEarthworm' to add a custom visualisation (must be installed to work)		
5	selectedTool	config	no	vis2		e.g. 'vis2' to start the framework with the 'Single-column key' visualisation selected		
6	checkValidity	config	no	yes		If value set to 'yes' (lower case) validity checks and reporting will be carried out by the visualisation software.		
7	defaultControlGroup	config	no	Structure		Set to the name of a group specified on the characters tab to select this group by default (leave blank for group 'All')		
8	#Main metadata about the key (e.g. for citing the key)							
9	title	metadata	yes	Family Circle Biscuits				
10	year	metadata	yes	2016				
11	authors	metadata	yes	Bell, C.				
12	publisher	metadata	no	Field Studies Council				
13	location	metadata	no	Preston Montford, Shrewsbury				
14	contact	metadata	no					
15	version	metadata	yes	1.0				
16	#Releases - keep track of the release history below this line. Most recent releases at the top. The version code in the 'value' column below this line should match that of the current release above it.							
17	release	history	no	1.0	22/11/2016	Modified by RB to illustrate some of the different features of knowledge representation.		
18	release	history	no	0.1	11/11/2016	CB published an initial test version		
19								

The config worksheet is used to specify some configuration options for the visualisation framework and metadata about the knowledge-base itself.

The basic format of entries in on this worksheet is simple key/value pairs corresponding to the columns 'Key' and 'Value'. Any keys with the value of the 'Mandatory' column set to 'yes' must be specified in order for the framework to function correctly – those set to 'no' are optional. The 'Type' column indicates the type of key/value pair corresponding to the three sections below.

#### 3.5.1 Framework configuration (type 'config')

The key '**excludedDefaultTools**' can be used to remove one or more of the default visualisations from the framework when used with your knowledge-base. There are currently four default tools:

- Two-column key (vis1)
- Single-column key (vis2)
- Circle-pack key (vis5)
- Side by side comparison (vis3)

The codes in parentheses can be used in the 'Values' column for the 'excludedDefaultTools' key to exclude the visualisation when the framework starts. For example set the value to 'vis1, vis3' to remove the 'Two-column key' and 'Side-by-side comparison' visualisations from the 'Select a tool' drop-down list in the framework.

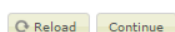
The key '**otherIncludedTools**' can be used to specify non-default visualisation tools that you have access to. You are unlikely to need to use this unless you have access to a non-default visualisation, e.g. you are a programmer who has created a new visualisation for the framework.

The key '**selectedTool**' can be used to specify the visualisation that you want the framework to show upon initialisation. By default this is the first included visualisation – 'Two-column key (vis1)' if you haven't excluded it. For example to instruct the framework to initialise with the 'Single-column key' visualisation, set the value of this key to 'vis2'.



The key '**checkValidity**' is a very important one if you are creating a new knowledge-base. Setting the value of this to 'yes' instructs the framework to carry out and report on some validity checks on your knowledge base when it is initialising. The image below shows some example output for these checks.

The key '**defaultControlGroup**' allows you to indicate the name of a control group to select by default when your visualisation starts up. The value you specify must correspond to one of the value in the 'Group' column of the characters worksheet. In the biscuits knowledge-base, the value is set to 'Structure' when means that when the visualisation starts it will do so with the 'Structure' group selected rather than the 'All' group (which is the default).



#### First fix these knowledge-base problems...

Some problems were found with the knowledge-base. They should be easy enough to fix. Read on for more details and guidance.

When you've fixed one or more problems, use the *Save worksheets as CSV* button on the KB to regenerate the CSVs and then click the *Reload* button above.

The problems are colour-coded according to the schema shown below:

- These are serious problems that could cause the visualisation software to malfunction.
- These problems are not likely to cause the visualisation software to malfunction, but you might not see what you expect.
- These are for information only - it may be what you intended to do, but if not, you may as well sort them out. These will not cause the visualisation software to malfunction.

#### On the characters worksheet...

- There is no row on the *characters* worksheet for the character 'BiscuitColour' represented by a column (column 3) on the *taxa* worksheet. All columns on the *taxa* tab must be represented by a row in the *characters* worksheet regardless of whether or not they are used. Names are case sensitive.
- There is no column on the *taxa* worksheet for the character '#BiscuitColour' which is represented in the *characters* worksheet.
- You must specify a 'Weight' value for 'Coating' because it has a 'Status' value of 'key'.
- '1,100,' is an invalid spin control 'Param' value for 'Width'. It must have the form 'n,n,n' (where n can be any valid numeric value, including decimal).

#### On the values worksheet...

- There is no row on the *characters* worksheet for the character 'BiscuitColour' represented in the *values* worksheet.

#### Values on the taxa worksheet...

- The value 'Pink' listed on the *taxa* worksheet for the character 'BiscuitColour' is not specified on the *values* worksheet.

#### On the media worksheet...

- An image is specified for the character 'BiscuitColour' on the media worksheet, but that character is not on the characters worksheet.
- An image is specified for the character 'BiscuitColour' on the media worksheet, but that character is not on the characters worksheet.
- An image is specified for the character 'BiscuitColour' on the media worksheet, but that character is not on the characters worksheet.

The validity check is very valuable whilst you are developing a knowledge-base and should always be enabled. However once you have developed your knowledge-base, you may want to set the value of this key to 'no' in order to speed up the initialisation of the framework.

### 3.5.2 Knowledge-base metadata

Knowledge-base metadata provides your users some important information about your knowledge base. It is used to build a citation for users of your knowledge-base.

The citation is available from the 'Get citation text' option of the 'Select a tool' drop-down list in the framework.

The metadata key values for the biscuits knowledge-base

#Main metadata about the key (e.g. for citing the key)			
title	metadata	yes	Family Circle Biscuits
year	metadata	yes	2016
authors	metadata	yes	Bell, C.
publisher	metadata	no	Field Studies Council
location	metadata	no	Preston Montford, Shrewsbury
contact	metadata	no	
version	metadata	yes	1.0





shown in the illustration here result in the following citation:

Bell, C. (2016) *Family Circle Biscuits* (Version 1.0) [Knowledge-base] (for Tom.bio Framework for ID visualisations). Field Studies Council. Preston Montford, Shrewsbury. Accessed Wed Nov 23 2016. <http://localhost:54236/general.html>

Citation text is important because it allows people who make determinations based on your knowledge-base to reference it when required (e.g. for the purposes of verification).

The keys 'title', 'year', 'authors' and 'version' are mandatory whilst 'publisher', 'location' and 'contact' are optional. The value of the 'author' key will be used 'as is' in the citation so it is best to use a format, e.g. 'Surname, initial.', that is most frequently used in citations.

### 3.5.3 Release history

You can use 'release' keys to keep track of the release history of your knowledge-base. You can include any number of release keys – the value of each of them should be the version number of a milestone version of the knowledge-base. There are a couple of extra columns associated with 'release' keys that you should provide values for: 'Date' and 'Notes'. The date should correspond to a release date and you can use the notes to give a very brief description of the release. Unlike the other keys on the config worksheet, the 'Date' and 'Notes' column values are reported by the framework: a release history is displayed when the 'About the knowledge-base' option is selected from the 'Select a tool' dropdown list (see below).

#### Knowledge-base revision history

**Current version: 1.0**

Date	Version	Notes
22/11/2016	1.0	Modified by RB to illustrate some of the different features of knowledge representation.
11/11/2016	0.1	CB published an initial test version

The release history is simply presented in the order the keys are entered into the knowledge-base. It makes sense to have the most recent versions at the top of the list and the oldest at the bottom. Note that the 'current version' in the above report is taken from the value of the 'version' key – not the most recent 'release' key – so you should make sure that the value of the 'version' key always matches the value of the most recent 'release' key.

### 3.6 Including an information file about your knowledge-base

When a user selects the 'About the knowledge-base' option from the 'Select a tool' dropdown list the framework looks for an HTML file called 'info.html' in the same folder that the knowledge-base CSV files are found. If it finds the file, it is rendered before the release history table generated from the config worksheet (see previous section) as shown below for the biscuits knowledge-base.

## The Biscuits knowledge-base

This knowledge-base was developed by Charlie Bell. It is a 'template' knowledge-base designed to demonstrate some of the features of the Tom.bio Framework for ID Visualisations. Most of the examples in the documentation describing how to build a knowledge-base refer to this knowledge-base. If you are building a completely new knowledge-base, consider making a copy of this template as a starting point for your work.



### Knowledge-base revision history

Current version: 1.0

Date	Version	Notes
22/11/2016	1.0	Modified by RB to illustrate some of the different features of knowledge representation.
11/11/2016	0.1	CB published an initial test version

If you want to include external resources in your 'info.html' file, they need to be included in sub-folders of the folder containing your knowledge-base. Furthermore, you need to reference them in a particular way in your knowledge-base as shown below for the Tom.bio logo:

```

```

An important part in the above HTML image tag is the '##tombiokbpath##' token. The framework replaces this token with the URL of the knowledge-base folder. That means that the knowledge-base can be moved around – e.g. from local computer to a web-server – without having to edit this file every time.

## 3.7 Dealing with sexual dimorphism

You have a couple of options for representing knowledge for sexually dimorphic organisms. The first option is to create a separate line on the taxa worksheet of your knowledge base for each sex – sometimes referred to as a 'taxon-sex'. So, for example, if biscuits were sexually dimorphic, you would have one line on the taxa workbook for 'Shortcake male' and one line for 'Shortcake female'. An advantage of this approach is its simplicity and a disadvantage is that you need to maintain two lines in your knowledge base for each sexually dimorphic species, repeating much of the information that is common to both sexes.

The framework also supports a second approach which is to tag character state values on the taxa worksheet with sex where the value is specific to one sex or another.

The example right shows part of the taxa worksheet for a knowledge-base on harvestmen showing how saddle visibility is represented for a number of different species and sexes within a species.

	A	M
1	Taxon	Saddle
22	Platybunus triangularis	indistinct
23	Platybunus pinetorum	indistinct   distinct
24	Lophopilio palpinalis	indistinct   distinct
25	Dicranopalpus ramosus	no (m)   distinct (f)
26	Dicranopalpus caudatus	no (m)   distinct (f)
27	Leiobunum rotundum	no (m)   indistinct (m)   distinct (f)
28	Leiobunum blackwalli	no (m)   distinct (f)
29	Leiobunum tisciae	no   indistinct
30	Leiobunum sp. A	no   indistinct
31	Nelima gothica	no (m)   indistinct (f)

If you represent sexually dimorphic characters in this way, then you need to have a character called 'Sex' (with an uppercase 'S') and the possible values must be 'male' and 'female' (all lower case). This text-type character must have a 'ControlType' of 'single' specified on the characters worksheet. Users will be able to specify sex just like any other morphological character.

To understand how this all works, consider the following scenarios for the harvestman knowledge-base shown above.



Scenario 1: user specifies a saddle visibility as 'distinct' and does *not specify a value for sex*. The result (for the 'Two-column visualisation') is shown below:

Un-used characters:	Evidence balance positive	Evidence balance negative
show hide		
Reset all		
<b>Saddle visibility</b>	<i>Leiobunum blackwalli</i>	<i>Platybunus triangularis</i>
distinct ✕	1	-1
	<i>Leiobunum rotundum</i>	<i>Leiobunum tisciae</i>
	1	-1
	<i>Dicranopalpus caudatus</i>	<i>Leiobunum sp. A</i>
	1	-1
	<i>Dicranopalpus ramosus</i>	<i>Nelima gothica</i>
	1	-1
	<i>Lophopilio palpinalis</i>	
	1	
	<i>Platybunus pinetorum</i>	
	1	

Scenario 2: user specifies a saddle visibility as 'distinct' and *specifies sex as 'male'*. The result (for the 'Two-column visualisation') is shown below:

Un-used characters:	Evidence balance positive	Evidence balance negative
show hide		
Reset all		
<b>Sex</b>	<i>Lophopilio palpinalis</i>	<i>Dicranopalpus ramosus</i>
male ✕	2	0
<b>Saddle visibility</b>	<i>Platybunus pinetorum</i>	<i>Dicranopalpus caudatus</i>
distinct ✕	2	0
		<i>Leiobunum blackwalli</i>
		0
		<i>Leiobunum rotundum</i>
		0
		<i>Leiobunum sp. A</i>
		0
		<i>Leiobunum tisciae</i>
		0
		<i>Platybunus triangularis</i>
		0
		<i>Nelima gothica</i>
		0

If no sex is specified, then it is as if no sex tags are present in the knowledge-base - *the values are still there, but without the sex tags*. They only come into play if a user specifies a sex.

### 3.8 The macros worksheet

At the start of this document the 'Save worksheets as CSV' macro was described. There are some other convenience tools on the macro worksheets that you might find useful.

- The 'Get unique values' macro was developed to ease the process of extracting unique values for a character from the taxa worksheet for use on the values worksheet.
- The 'Get max and min' macro was developed to ease the process of extracting min and maximum values for a numeric character for use with the 'Params' column of the characters worksheet.



To get the unique values for a character, select the cells from which you want to extract the values on the taxa worksheet and then go to the macros worksheet and click the 'Get unique values' button – the unique values are copied to the computer's buffer and you can simply paste them anywhere you like. (Don't select an entire column by clicking on the header – the macro won't work if you do that.) The macro takes care of sorting out cells where multiple values are specified with the 'or' character ('|') and it also strips out any '(m)' and '(f)' sex suffixes. Special values (e.g. 'n/a' and '?') are ignored.

To get the minimum and maximum values for a numeric character, select the cells from which you want to extract the values on the taxa worksheet and then go to the macros worksheet and click the 'Get max and min' button – the min and max values are copied to the computer's buffer (as a string – 'min,max,') and you can simply paste them anywhere you like – usually to the corresponding 'Params' column of the characters worksheet. (Don't select an entire column by clicking on the header – the macro won't work if you do that.) The macro takes care dealing with ranges specified as '[n1-n2]'. Special values (e.g. 'n/a' and '?') are ignored.

To use any of the macros in the knowledge-base, you need to ensure that your Excel security settings enable you to do so.

### 3.9 Using other spreadsheet features

You are free to use whatever features your particular spreadsheet (e.g. Excel) provides when constructing a knowledge-base – e.g. formulas, data ranges, comments, etc. None of these should interfere with the production of the CSV files and it is the CSV files that the framework actually reads.

In Excel, for example, you can create as many extra worksheets as you like containing supplementary information to help you as a knowledge-base author. For example if you are converting an existing spreadsheet of knowledge to the framework's format, it is convenient to copy the existing spreadsheet, as is, into extra worksheets. They won't interfere with the framework.

Another Excel feature that people like to make use of is creating a data range to use as a drop-down list when entering data. You could, for example, create a range from the possible state values for a character as specified on the values worksheet and use Excel's data validation feature to use these values in a drop-down list for the relevant column on the taxa worksheet.

That's an advantage of making use of a spreadsheet format for representing knowledge – it leverages all your existing experience of using spreadsheets and managing information within them.