

# simulatorAPMS

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*simulatorAPMS* is a tool that uses computational tools to simulate affinity purification (co-precipitation) technologies as well as the mass spectrometry used to ascertain protein-protein co-membership data. Simulation of the affinity purification - mass spectrometry (AP-MS) technologies is based on the bait to prey model.

```
> library(simulatorAPMS)
```

```
KernSmooth 2.22 installed
```

```
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```

## AP-MS Data

There are various bait to prey models and the fundamental principals differ slightly. For each cell or tissue under some conditions, certain portions of the genome is expressed, and the resulting proteins interact, forming multi-protein structures to perform some biological process. Based on these underlying biological principals, affinity purification employs a bait to prey technology where certain set of expressed proteins are tagged or labelled and infused into some environment (e.g. in vivo) where another set of proteins (usually not dis-joint from the bait set) reside. It is the affinity between proteins in the latter set with each protein in the bait set which is the data the technology is designed to collect. Purification of the protein to protein affiliation is possible because of the modification to the bait proteins. The most common method is physically inserting a tag or labell which can be recovered. One technique forces affiliated sets of proteins through a layer of beads which have a strong physical attraction to the tags inserted into the baits.

Once the baits (along with it affiliated proteins called prey) have been successfully extracted, mass spectrometry is used to decipher and identify which proteins comprise of each clustering.

We can represent this model of AP-MS bait to prey technology with an adjacency matrix  $A$ . This matrix is a  $\{0, 1\}$ -matrix which documents affiliation between bait proteins and prey proteins.

		Hits					
		$P_1$	$P_2$	$P_3$	$P_4$	$P_5$	$P_6$
Baits	$P_1$	1	1	0	1	0	1
	$P_2$	1	1	0	1	0	1
	$P_3$	0	0	1	1	1	0

The rows of the matrix are baits, the columns are hits, an entry of 1 in the  $i$ th row and  $j$ th column indicates that bait protein  $i$  finds protein  $j$  as a hit, and an entry of 0 in the  $i$ th row and  $j$ th column indicates that bait protein  $i$  does not find protein  $j$  as a hit. The diagonal entries are 1 since a protein is always a complex comember with itself. Note that bait proteins can be found as hits by other bait proteins. Also note that some proteins are never used as baits.

A graph of the data is useful for understanding which comembership relationships are tested in AP-MS experiments and which are not. In the graph in Figure ??, nodes represent proteins and directed edges from baits to hits represent complex comembership. Bait proteins are yellow and hit-only proteins (i.e. proteins that are found as hits but never used as baits) are white. Directed edges always originate at yellow bait proteins and point to the set of hits detected by that bait. The red reciprocated edge connecting  $P_1$  and  $P_2$  represents a bait-bait relationship that is tested twice, once in each purification. The gray unreciprocated edges represent bait-hit-only edges that are only tested once. Missing edges between baits and other baits or hit-only proteins represent comemberships that are tested, but not observed. Edges between hit-only proteins are always missing, not because the comemberships are known not to exist, but because they are never tested.

In reality, AP-MS technology is neither perfectly sensitive nor specific, resulting in false positive (FP) and false negative (FN) observations of the complex comemberships under investigation. Suppose in this experiment, we make a FN observation between  $P_2$  and  $P_4$ , i.e.  $P_4$  is not found as a hit when we use  $P_2$  as a bait. Also suppose we make two FP observations: 1) when we use  $P_3$  as a bait, we find an extraneous hit-only protein  $P_7$ , and 2) when performing a purification using  $P_8$  as a bait, we find  $P_3$  as a hit. Data for this example are contained in the matrix `apEX`. In this matrix, rows again represent baits and columns represent hits.

```
> data(apEX)
> apEX
```

	P1	P2	P3	P8	P4	P5	P6	P7
P1	1	1	0	0	1	0	1	0
P2	1	1	0	0	0	0	1	0
P3	0	0	1	0	1	1	0	1
P8	0	0	1	1	0	0	0	0

The graph of the data in Figure ?? demonstrates the observations recorded in `apEX`. Note the missing edge from  $P_2$  to  $P_4$  and the new edge from  $P_3$  to  $P_7$ . Also note the blue unreciprocated edge between  $P_3$  and  $P_8$  – this is a complex comembership that was tested twice when  $P_3$  and  $P_8$  were used as baits, but only detected once in the purification using  $P_8$  as a bait.

## 1 Preliminaries

Before we proceed onto the package itself, it is necessary to acquaint ourselves with the language we will use. We can consider any experimental technology as a black box; the input to the black box is some true state of nature (TSN) which is basically an in silico interactome (ISI), the collection of protein complexes for some cell under some conditions. The output of the black

box is an output from the simulated experiments. It is clear that the experiment begins with some representation of the truth. For complex co-membership, we begin with an ISI described by its bipartite graph: one set of nodes represents proteins; the other, protein complexes. The input is the incidence matrix representation of the bipartite graph: the rows index the proteins; the columns, protein complexes. The matrix has a one in row  $i$  and column  $j$  if protein  $i$  is part of complex  $j$ ; otherwise that entry is zero. Here is an example of such a matrix:

```
> data(simEX)
> simEX
```

	MBME1	MBME2	MBME3	MBME4	MBME5	MBME6	MBME7	MBME8	MBME9	MBME10
YAL015C	1	1	1	0	0	0	0	0	0	0
YAL017W	0	0	0	1	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	1	0	0	0	0	0
YAR019C	0	0	0	0	0	0	0	0	0	0
YBL021C	0	0	0	0	0	0	0	0	0	0
YBL026W	0	0	0	0	0	1	1	1	0	0
YBL036C	0	0	0	0	0	0	0	0	0	0
YBL049W	0	0	0	0	0	0	0	0	1	0
YBL056W	0	0	0	0	0	0	0	0	0	0
YBL088C	0	0	0	0	0	0	0	0	0	0
YBR017C	0	0	0	0	0	0	0	0	0	1
YBR055C	0	0	0	0	0	0	0	0	0	0
YBR059C	0	0	0	0	0	0	0	0	0	0
YBR082C	0	0	0	0	0	0	0	0	0	0
YBR083W	0	0	0	0	0	0	0	0	0	0
YBR088C	0	0	0	0	0	0	0	0	0	0
YBR094W	0	0	0	0	0	0	0	0	0	0
YBR103W	0	0	0	0	0	0	0	0	0	0
YBR109C	0	0	0	0	0	0	0	0	0	0
YBR114W	0	0	0	0	0	0	0	0	0	0
YBR125C	0	0	0	0	0	0	0	0	0	0
YBR130C	0	0	0	0	0	0	0	0	0	0

Each organism or cell has an unique interactome for some specified conditions and time. For our in silico interactome, we have taken the estimation of apComplex on the HMSPCI yeast data set by Ho, et al. We note that any estimate can serve as the ISI. Once we have the bipartite graph representation of the ISI, we may begin the simulation of the APMS technology.

## 2 Simulator

In this section we discuss how to use the simulator in the *simulatorAPMS* package. In describing how to use the main function, `runSimulators()`, we will work with an example:

>runSimulators(TSNMatEX, vBaitsEX, vDeformed, vSticky, rateFP, rateFN, rateD, rateS, missedProthMSPCI, Seed)

First we describe each of the inputs. Each input parameter has a wet-lab correspondent, and we describe the how each affects the output of the experiment and, thus, the simulation.

**TSNMatEX** - The first parameter is the incidence matrix of the bipartite graph representation of our ISI. It is our model true state of nature. In the wet-lab experiment, this maybe some cell line or tissue under some specified conditions. The goal of AP-MS technology is to estimate *TSNMatEX*, so too then does our simulation technology.

**vBaitsEX** - Just as AP-MS technology uses a subset of proteins from the cell or tissue of interests as bait, so too does our simulation use a subset of proteins as baits. This parameter is given as a character vector composed of the protein names used as baits which is identical to names used for the rows of the *TSNMatEx*.

**vDeformed** - In AP-MS, baits need to be tagged so that they can be identified at the end of the affinity process. Certain baits have been experimentally verified to lose normal functionality when tagged. Thus deformed baits are known to interact with very few proteins in the experimentation giving rise false negative observations. The **vDeformed** parameter is also a character vector of protein names; they are a subset of the **vBaitsEX** vector.

**vSticky** - In the course of the experiment, some baits are found to falsely interact with a large number other proteins. Proteins that have high occurrences of interactions with a large number of other proteins are called *sticky*, and as this name suggest, these proteins deliver a high number of false positive interactions. The **vSticky** parameter is also a subset of **vBaitsEX**.

**rateFP** - Through any experiment, there are a number of stochastic elements by which errors can occur. How sensitive the technology, how specific the technology, etc all contribute to error in the observed data. The **rateFP** parameter is a scalar in the unit interval dictating the probability of a false positive interaction between bait  $b$  and protein  $p$ .

**rateFN** - Analogous to **rateFP**, **rateFN** is the probability that the technology (simulation) will record a false negative interaction.

**rateD** - For each deformed bait, we need to describe how deformed the protein has become, i.e. what proportion of prey will each deformed bait miss. **rateD** is a named vector of scalars (of the same size as **vDeformed**) estimating this proportion for each deformed bait.

**rateS** - Analogous to **rateD**, **rateS** is a vector of scalars estimating how the proportion of proteins to which each proteins interacts.

**missedProthMSPCI** - The ISI's bipartite graph might not include all the proteins, since proteins not involved in any non-trivial complexes need not be recorded in the bipartite graph. These proteins need to be re-inserted to the in silico model organism's bipartite graph since they would be present in the wet-lab organism. In the simulation, these prpteins will contribute

to any false positive interactions within the simulation.

seed - The *seed* is not used in the wet-lab experiments. It is a computational parameter that sets the seed for the random integer generator for the purpose of reproducible data sets. seed is any three digit positive integer.

The output from `runSimulators()` does not represent a bipartite graph. The simulation derives the protein-protein interaction graph by  $TSNMatEX \otimes TSNMatEX^T$ . This interaction graph does not represent direct binary protein-protein interactions, but rather protein co-membership interaction. It is from this matrix that the simulated output is derived. This output reflects the data output of an actual AP-MS experiment, and it is given as the incidence matrix representation where each row indexed by the bait proteins and the columns represents all proteins found in the cell.

```
> data(TSNMatrix)
> data(vBaitsEX)
> data(missedProtEX)
> vDeformed <- vBaitsEX[2]
> vSticky <- vBaitsEX[5]
> rateFP <- 0.1
> rateFN <- 0.25
> rateD <- 0.5
> rateS <- 0.66
> seed <- 237
> runSimulators(TSNMatrix, vBaitsEX, vDeformed, vSticky, rateFP,
+   rateFN, rateD, rateS, missedProtEX, seed)
```

[1] 6 1588

	YAL015C	YAL017W	YAL021C	YAL036C	YAR003W	YAR007C	YAR019C	YBL021C	YBL026W
YAL015C	1	0	0	0	1	0	0	0	0
YAL017W	0	1	0	0	0	0	0	1	0
YAL021C	0	0	1	0	1	0	0	0	0
YAL036C	0	0	1	1	1	0	0	0	0
YAR003W	1	1	0	0	1	0	0	0	0
YAR007C	1	0	0	0	1	1	0	0	0
	YBL036C	YBL049W	YBL056W	YBL088C	YBR017C	YBR055C	YBR059C	YBR082C	YBR083W
YAL015C	0	0	0	1	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	1	0
YAL021C	0	0	0	0	0	0	0	1	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	1	0	0	0	1	0	0	0
	YBR088C	YBR094W	YBR103W	YBR109C	YBR114W	YBR125C	YBR130C	YBR135W	YBR136W
YAL015C	0	0	0	0	1	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	1

YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	1
YAR007C	0	0	0	0	0	0	0	0	0
YBR155W	YBR160W	YBR175W	YBR195C	YBR198C	YBR203W	YBR217W	YBR223C	YBR234C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	1	0	0	0	0	0	0	0
YAR003W	0	0	0	0	1	0	1	0	0
YAR007C	0	0	0	0	0	1	0	0	0
YBR264C	YBR267W	YBR274W	YBR276C	YBR280C	YBR288C	YCL011C	YCL039W	YCR001W	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	1	0	0	0	1	1	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YCR002C	YCR008W	YCR009C	YCR014C	YCR057C	YCR077C	YCR079W	YCR084C	YCR088W	
YAL015C	0	0	0	0	0	0	1	0	0
YAL017W	0	0	0	1	0	0	0	0	0
YAL021C	0	0	0	1	0	0	0	0	1
YAL036C	0	0	0	0	0	0	1	0	0
YAR003W	0	0	1	0	0	1	0	0	0
YAR007C	0	0	0	1	0	1	0	0	0
YCR091W	YCR092C	YDL003W	YDL006W	YDL013W	YDL017W	YDL025C	YDL029W	YDL043C	
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	1	0	0	0	0	0
YAR003W	1	0	1	0	0	0	0	0	1
YAR007C	0	0	1	0	0	0	0	1	0
YDL047W	YDL059C	YDL060W	YDL074C	YDL100C	YDL101C	YDL116W	YDL132W	YDL134C	
YAL015C	0	1	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	1	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	1	0	0	0	0
YDL145C	YDL147W	YDL156W	YDL164C	YDL175C	YDL179W	YDL188C	YDL190C	YDL192W	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	1	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	1	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	1	0	0	0

	YDL193W	YDL195W	YDL200C	YDL213C	YDL220C	YDL225W	YDR030C	YDR075W	YDR076W
YAL015C	1	0	0	0	0	0	0	1	0
YAL017W	0	0	1	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	1
YAL036C	0	0	0	0	0	0	0	0	1
YAR003W	0	0	0	0	0	0	0	1	0
YAR007C	0	0	0	0	0	0	0	0	0
	YDR092W	YDR097C	YDR099W	YDR113C	YDR128W	YDR129C	YDR131C	YDR138W	YDR142C
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	1	1	0
YAL036C	0	0	0	0	1	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	1	1	0	0	0	0	0	0	0
	YDR143C	YDR146C	YDR177W	YDR200C	YDR217C	YDR219C	YDR225W	YDR227W	YDR247W
YAL015C	1	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	1
YAL036C	1	0	0	0	1	0	0	1	0
YAR003W	0	0	1	0	1	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
	YDR260C	YDR266C	YDR267C	YDR283C	YDR306C	YDR313C	YDR316W	YDR324C	YDR328C
YAL015C	0	0	1	0	0	0	0	1	0
YAL017W	0	0	1	0	0	0	0	0	0
YAL021C	0	0	0	0	1	0	0	0	0
YAL036C	0	0	0	0	0	1	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
	YDR335W	YDR339C	YDR365C	YDR369C	YDR386W	YDR388W	YDR394W	YDR395W	YDR398W
YAL015C	0	0	0	0	1	0	0	1	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	0	0	0	0	0	1
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	1	0	0	0	0	0	0	0	0
	YDR419W	YDR436W	YDR460W	YDR477W	YDR480W	YDR482C	YDR488C	YDR490C	YDR499W
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	1	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	1	0	0	0	0	0	0	0	1
	YDR510W	YDR523C	YEL021W	YEL056W	YER007W	YER012W	YER017C	YER020W	YER025W
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0

YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YER041W	YER054C	YER059W	YER066C-A	YER075C	YER082C	YER095W	YER100W		
YAL015C	1	0	0	0	0	0	0	0	
YAL017W	0	0	1	0	0	0	0	0	
YAL021C	0	0	0	0	0	0	0	0	
YAL036C	0	0	0	0	1	0	0	0	
YAR003W	0	0	0	0	0	1	0	1	
YAR007C	0	0	0	0	0	0	0	0	
YER112W	YER117W	YER125W	YER133W	YER136W	YER142C	YER161C	YER171W	YER173W	
YAL015C	0	1	0	0	0	0	0	0	0
YAL017W	0	0	1	0	0	0	0	0	0
YAL021C	0	0	1	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	1	0	0	0	0	1	0	0
YER177W	YER179W	YFL008W	YFL009W	YFL014W	YFL033C	YFL034C-B	YFL034W		
YAL015C	0	0	0	0	1	1	1	0	
YAL017W	0	0	0	0	1	0	0	0	
YAL021C	0	0	0	0	0	0	0	0	
YAL036C	0	0	0	0	0	0	0	0	
YAR003W	1	0	0	0	0	0	0	0	
YAR007C	1	1	0	0	0	0	0	0	
YFL038C	YFR003C	YFR014C	YFR016C	YFR021W	YFR024C-A	YFR028C	YFR040W		
YAL015C	0	0	1	0	0	0	0	0	
YAL017W	0	0	0	1	0	0	0	0	
YAL021C	0	0	0	0	0	0	0	1	
YAL036C	0	0	0	0	0	0	0	0	
YAR003W	0	0	0	0	0	0	0	0	
YAR007C	1	0	0	0	0	0	0	0	
YGL003C	YGL004C	YGL035C	YGL058W	YGL081W	YGL087C	YGL090W	YGL100W	YGL115W	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	0	0	0	0	0	1	0	0	0
YAL021C	0	1	0	0	0	0	0	1	0
YAL036C	0	0	0	0	0	1	0	0	1
YAR003W	1	0	0	0	0	0	0	0	1
YAR007C	0	0	0	0	0	0	0	0	0
YGL116W	YGL131C	YGL137W	YGL158W	YGL163C	YGL174W	YGL179C	YGL190C	YGL208W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	1	0	0	0	0	0	0
YAL036C	0	0	0	1	0	1	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0



YAR007C	0	0	0	1	0	0	0	0	0
YGL213C	YGL220W	YGL237C	YGL244W	YGR040W	YGR052W	YGR054W	YGR067C	YGR083C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	1	0
YAL021C	0	0	0	0	0	0	0	1	0
YAL036C	0	1	0	1	0	0	0	0	0
YAR003W	0	0	0	0	1	0	0	0	0
YAR007C	0	0	0	0	0	0	0	1	0
YGR092W	YGR103W	YGR173W	YGR200C	YGR223C	YGR252W	YGR258C	YGR262C	YGR280C	
YAL015C	0	1	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YHL010C	YHR014W	YHR030C	YHR052W	YHR073W	YHR082C	YHR105W	YHR107C	YHR115C	
YAL015C	0	0	0	1	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	1	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YHR119W	YHR120W	YHR135C	YHR152W	YHR166C	YHR169W	YHR183W	YHR186C	YHR188C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	1	0	0	1	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YHR196W	YHR197W	YHR199C	YIL007C	YIL035C	YIL046W	YIL061C	YIL063C	YIL066C	
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	1	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	1	0	0	1	0
YAR007C	1	0	0	0	0	0	0	0	0
YIL079C	YIL095W	YIL113W	YIL128W	YIL131C	YIL142W	YIL143C	YIL147C	YIRO01C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	1	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	1	1	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	1	1	0
YAR007C	1	0	0	0	0	0	0	0	0
YIRO05W	YIR034C	YJL005W	YJL020C	YJL042W	YJL044C	YJL068C	YJL069C	YJL090C	
YAL015C	0	0	0	0	0	0	0	0	0

YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	1	0	0	1	0	0	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	0	1	0	0	0	0	0	0
YJL092W	YJL098W	YJL106W	YJL128C	YJL138C	YJL141C	YJL149W	YJL157C	YJL164C	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	1	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
YJL165C	YJL173C	YJL187C	YJR007W	YJR017C	YJR022W	YJR035W	YJR042W	YJR052W	
YAL015C	0	0	0	0	1	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	1	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	0	0	0	0	1	0	0	0	0
YJR053W	YJR061W	YJR062C	YJR068W	YJR076C	YJR090C	YJR110W	YKL011C	YKL021C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	1	0
YKL048C	YKL078W	YKL095W	YKL103C	YKL108W	YKL113C	YKL139W	YKL161C	YKL166C	
YAL015C	0	0	1	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	0	0	1	0	1	0	0	0	0
YKL189W	YKL190W	YKL193C	YKL210W	YKL215C	YKR026C	YKR036C	YKR055W	YLL010C	
YAL015C	0	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	0	0	0	1
YAL021C	0	0	1	0	0	0	0	0	0
YAL036C	0	1	1	1	0	0	1	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YLL011W	YLL019C	YLL036C	YLL050C	YLR006C	YLR016C	YLR019W	YLR074C	YLR096W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	1	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	1	1	0	1	0	0

YAR003W	0	0	0	1	1	0	1	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YLR097C	YLR113W	YLR148W	YLR175W	YLR186W	YLR196W	YLR208W	YLR216C	YLR222C	
YAL015C	1	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	1	0	0	0
YAL036C	0	0	0	0	0	1	1	0	0
YAR003W	1	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YLR229C	YLR233C	YLR238W	YLR247C	YLR248W	YLR262C	YLR263W	YLR288C	YLR291C	
YAL015C	0	1	0	1	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	1	1	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YLR293C	YLR306W	YLR314C	YLR320W	YLR340W	YLR352W	YLR383W	YLR403W	YLR427W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	1	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	1	0	0	1	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	1	0	0
YLR433C	YLR442C	YML016C	YML029W	YML032C	YML057W	YML058W	YML064C	YML088W	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	0	0	0	0	0	0
YAL036C	0	0	1	1	1	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YML095C	YML102W	YML112W	YML115C	YMR001C	YMR022W	YMR036C	YMR049C	YMR055C	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	0	1	0	1	0	0
YAL036C	0	0	0	0	0	0	1	0	0
YAR003W	1	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	1	0	0	0
YMR059W	YMR093W	YMR094W	YMR104C	YMR106C	YMR116C	YMR117C	YMR137C	YMR139W	
YAL015C	0	0	1	0	0	0	0	0	0
YAL017W	0	0	1	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	1	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	1	0	0	0	1
YAR007C	0	0	1	0	0	0	0	0	0
YMR146C	YMR167W	YMR198W	YMR199W	YMR201C	YMR205C	YMR235C	YMR246W	YMR284W	

YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	1	0	0
YAL021C	1	0	0	0	0	1	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	1	0	0	0	0	0	0	1	0
YMR291W	YMR311C	YNL006W	YNL023C	YNL032W	YNL035C	YNL053W	YNL056W	YNL061W	
YAL015C	0	1	0	0	0	0	1	0	0
YAL017W	0	0	0	0	0	0	1	0	0
YAL021C	0	0	1	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	1	0	0
YAR003W	1	0	0	0	1	1	0	0	0
YAR007C	0	0	0	0	0	0	0	1	0
YNL068C	YNL088W	YNL090W	YNL093W	YNL094W	YNL098C	YNL099C	YNL106C	YNL113W	
YAL015C	0	0	0	0	0	1	0	0	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	1
YNL116W	YNL128W	YNL135C	YNL154C	YNL157W	YNL161W	YNL175C	YNL180C	YNL182C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	0	1	0	0	0	0
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	1	1	0	0
YAR007C	0	0	0	0	1	0	0	0	0
YNL189W	YNL230C	YNL244C	YNL250W	YNL260C	YNL290W	YNL307C	YNL311C	YNL312W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	1	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	1	0	0
YAR007C	0	0	1	0	0	0	0	0	0
YNL317W	YNL323W	YNR010W	YNR019W	YOL006C	YOL045W	YOL054W	YOL062C	YOL087C	
YAL015C	1	0	0	1	0	0	0	0	0
YAL017W	0	0	0	0	0	1	0	0	1
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	1	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
YOL094C	YOL100W	YOL102C	YOL108C	YOL113W	YOL115W	YOL126C	YOL128C	YOL133W	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	1
YAL021C	0	0	0	0	0	0	0	0	0

YAL036C	0	0	1	0	1	0	0	0	1
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	1	0
YOL139C	YOR005C	YOR026W	YOR043W	YOR061W	YOR080W	YOR089C	YOR090C	YOR125C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	1
YOR174W	YOR181W	YOR191W	YOR212W	YOR227W	YOR229W	YOR230W	YOR272W	YOR276W	
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	1	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	1	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YOR304W	YOR319W	YOR341W	YOR351C	YOR353C	YOR386W	YPL003W	YPL022W	YPL026C	
YAL015C	1	0	0	1	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	1	0	0	0	0
YAL036C	0	0	0	1	0	0	0	0	0
YAR003W	0	0	0	0	0	0	1	0	0
YAR007C	0	0	0	0	1	0	0	0	0
YPL031C	YPL051W	YPL074W	YPL111W	YPL115C	YPL126W	YPL131W	YPL135W	YPL139C	
YAL015C	0	0	1	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	1	0	0	0	0	1	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
YPL140C	YPL149W	YPL150W	YPL151C	YPL153C	YPL164C	YPL170W	YPL179W	YPL194W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	1	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YPL203W	YPL204W	YPL235W	YPL236C	YPL256C	YPL259C	YPR015C	YPR017C	YPR018W	
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	1	0	1	0	1	0	1	0	0
YAR007C	0	0	0	0	0	0	0	0	0

	YPR054W	YPR073C	YPR093C	YPR104C	YPR110C	YPR111W	YPR119W	YPR137W	YPR165W	
YAL015C	0	0	0	0	1	0	0	0	0	
YAL017W	0	0	0	0	0	0	0	0	0	
YAL021C	0	1	0	0	0	0	0	0	0	
YAL036C	0	0	0	1	0	0	0	1	1	
YAR003W	0	0	0	1	1	0	0	0	0	
YAR007C	0	0	0	0	0	0	0	1	0	
	YPR178W	Q0032	Q0050	Q0092	REP1	YAL002W	YAL003W	YAL012W	YAL016W	YAL019W
YAL015C	1	0	0	0	0	1	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0	0
YAL036C	1	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	1	1
YAR007C	0	0	0	0	0	0	0	0	0	0
	YAL025C	YAL027W	YAL029C	YAL035W	YAL047C	YAL049C	YAL059W	YAR002W	YAR009C	
YAL015C	0	0	0	0	0	1	0	0	0	
YAL017W	1	0	1	0	0	0	1	0	0	
YAL021C	0	0	0	0	0	0	0	1	1	
YAL036C	0	0	0	0	0	0	0	0	0	
YAR003W	0	0	0	0	0	1	0	0	0	
YAR007C	0	0	0	0	0	0	0	0	0	
	YAR014C	YAR073W	YBL002W	YBL003C	YBL004W	YBL007C	YBL008W	YBL015W	YBL016W	
YAL015C	0	0	0	0	1	0	0	0	0	
YAL017W	0	0	0	0	0	0	0	0	0	
YAL021C	0	0	0	0	0	0	0	1	0	
YAL036C	0	0	0	0	0	0	0	0	0	
YAR003W	0	0	0	0	0	0	0	0	0	
YAR007C	0	0	0	0	0	0	0	0	0	
	YBL017C	YBL022C	YBL023C	YBL029W	YBL030C	YBL034C	YBL039C	YBL041W	YBL044W	
YAL015C	1	0	0	0	1	0	0	0	0	
YAL017W	0	0	0	0	0	0	0	0	0	
YAL021C	0	0	0	0	0	0	0	0	0	
YAL036C	0	0	0	0	0	0	0	1	0	
YAR003W	0	0	0	0	0	0	0	0	0	
YAR007C	1	0	0	0	0	0	0	0	0	
	YBL045C	YBL046W	YBL047C	YBL051C	YBL058W	YBL061C	YBL064C	YBL066C	YBL076C	
YAL015C	1	0	0	1	1	0	0	0	0	
YAL017W	0	0	0	0	0	0	0	0	0	
YAL021C	0	0	0	0	0	0	1	0	0	
YAL036C	0	0	1	0	0	0	0	0	1	
YAR003W	0	0	0	0	0	0	0	0	0	
YAR007C	0	0	0	0	0	0	0	0	0	
	YBL080C	YBL091C	YBL104C	YBL108W	YBR009C	YBR010W	YBR011C	YBR014C	YBR018C	
YAL015C	0	0	0	0	0	0	0	0	0	
YAL017W	0	0	0	0	0	0	0	0	0	

YAL021C	1	0	0	0	0	1	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YBR025C	YBR028C	YBR035C	YBR039W	YBR049C	YBR057C	YBR063C	YBR078W	YBR079C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	1	0	0
YBR080C	YBR081C	YBR085W	YBR087W	YBR098W	YBR105C	YBR112C	YBR120C	YBR121C	
YAL015C	0	0	0	0	0	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	0	0	0	0	0	1
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	1	0	0	0	0
YAR007C	0	0	1	0	0	0	0	0	0
YBR126C	YBR129C	YBR133C	YBR139W	YBR140C	YBR142W	YBR143C	YBR145W	YBR149W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	1
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	1	0	0	0	0	0	0	0
YBR150C	YBR154C	YBR166C	YBR170C	YBR179C	YBR184W	YBR187W	YBR202W	YBR205W	
YAL015C	1	0	0	0	0	1	0	0	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	1	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YBR208C	YBR218C	YBR225W	YBR227C	YBR228W	YBR242W	YBR245C	YBR247C	YBR249C	
YAL015C	0	0	0	0	0	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	1
YAL036C	0	0	0	0	0	0	1	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YBR252W	YBR260C	YBR272C	YBR281C	YBR286W	YCL010C	YCL014W	YCL017C	YCL028W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	1
YAR003W	0	0	0	0	0	0	0	0	0

YAR007C	0	1	0	0	1	1	0	1	0
YCL029C	YCL030C	YCL035C	YCL042W	YCL043C	YCL050C	YCL054W	YCL059C	YCR030C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	1	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	1	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YCR033W	YCR035C	YCR048W	YCR053W	YCR066W	YCR073C	YCR076C	YCR087W	YCR093W	
YAL015C	0	0	0	0	1	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	1
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	1	0	0	0	0
YDL007W	YDL014W	YDL022W	YDL031W	YDL040C	YDL042C	YDL051W	YDL052C	YDL056W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YDL063C	YDL065C	YDL078C	YDL080C	YDL084W	YDL086W	YDL097C	YDL108W	YDL111C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	1	1	0
YDL112W	YDL113C	YDL117W	YDL124W	YDL137W	YDL140C	YDL148C	YDL153C	YDL155W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	1	0	0	1
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	0	0	0	0	0	0	1	0	0
YAR007C	0	0	0	0	1	0	0	0	1
YDL159W	YDL160C	YDL165W	YDL171C	YDL185W	YDL204W	YDL208W	YDL215C	YDL235C	
YAL015C	0	0	0	1	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	1	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	1	0	0	0	0	0	0	1	0
YDR001C	YDR002W	YDR006C	YDR009W	YDR017C	YDR021W	YDR022C	YDR023W	YDR028C	
YAL015C	0	0	1	0	0	0	0	0	0



YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	1	0	0	0	0
YAR003W	0	0	0	0	0	0	1	0	0
YAR007C	0	0	1	0	0	0	0	0	0
YDR032C	YDR036C	YDR037W	YDR049W	YDR071C	YDR074W	YDR080W	YDR085C	YDR087C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	1	0	0	0	0	1	0	0	0
YAR003W	0	1	0	1	0	0	0	1	0
YAR007C	0	0	0	0	0	0	0	0	0
YDR091C	YDR098C	YDR101C	YDR102C	YDR106W	YDR116C	YDR122W	YDR127W	YDR130C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	1	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	1	0	0	0	1
YAR007C	0	0	0	0	0	1	0	0	1
YDR137W	YDR139C	YDR141C	YDR148C	YDR150W	YDR152W	YDR155C	YDR158W	YDR162C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	1	0	0	1	0	0	0	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	1	0	0
YDR168W	YDR169C	YDR170C	YDR170W-A	YDR174W	YDR175C	YDR188W	YDR190C		
YAL015C	0	1	0	0	0	0	0	0	
YAL017W	0	0	0	0	0	0	1	0	
YAL021C	0	0	0	0	0	0	0	0	
YAL036C	0	1	0	0	1	0	0	0	
YAR003W	0	0	0	0	0	0	0	0	
YAR007C	0	0	1	0	0	0	1	1	
YDR194C	YDR198C	YDR211W	YDR212W	YDR214W	YDR216W	YDR224C	YDR226W	YDR229W	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	0	1	1	0	0	0	1	1	0
YAL021C	0	1	0	0	0	0	0	1	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YDR233C	YDR238C	YDR239C	YDR240C	YDR243C	YDR255C	YDR279W	YDR289C	YDR293C	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	1	0	0

YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YDR298C	YDR299W	YDR300C	YDR301W	YDR310C	YDR312W	YDR326C	YDR341C	YDR342C	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	1	0	0	0	0	0	0	1
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	1	1	0	0	0	0	0	1	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YDR343C	YDR353W	YDR356W	YDR359C	YDR361C	YDR372C	YDR381W	YDR407C	YDR412W	
YAL015C	0	0	0	0	0	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	1
YAL036C	0	0	0	1	0	0	0	0	0
YAR003W	0	0	0	0	0	0	1	0	1
YAR007C	0	1	1	0	0	0	0	0	0
YDR416W	YDR422C	YDR424C	YDR427W	YDR429C	YDR432W	YDR448W	YDR449C	YDR453C	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	1	0
YDR457W	YDR465C	YDR473C	YDR496C	YDR507C	YDR516C	YDR517W	YDR529C	YEL002C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	1	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YEL013W	YEL015W	YEL023C	YEL024W	YEL026W	YEL030W	YEL032W	YEL034W	YEL037C	
YAL015C	0	0	0	0	0	1	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	0	0	1	0
YEL051W	YEL055C	YEL060C	YEL061C	YEL062W	YEL064C	YEL071W	YER002W	YER003C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	1	1
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	1	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YER006W	YER009W	YER015W	YER018C	YER021W	YER023W	YER027C	YER029C	YER030W	

YAL015C	0	0	0	1	0	0	0	0	1
YAL017W	0	0	0	0	0	0	1	0	0
YAL021C	0	1	0	0	0	0	0	0	0
YAL036C	0	1	0	0	0	0	0	1	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	1	0	0	0	0	0	0	0	0
YER031C	YER043C	YER047C	YER049W	YER052C	YER057C	YER062C	YER067W	YER070W	
YAL015C	0	0	0	1	0	0	0	0	1
YAL017W	0	0	0	0	0	0	1	0	0
YAL021C	0	0	0	1	0	0	0	0	0
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	0	0	1	1	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
YER073W	YER077C	YER078C	YER083C	YER084W	YER089C	YER090W	YER091C	YER093C	
YAL015C	0	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	1	0	0	0	0	0
YAL036C	1	0	1	1	0	0	1	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YER094C	YER098W	YER099C	YER111C	YER114C	YER120W	YER123W	YER126C	YER127W	
YAL015C	0	0	0	0	1	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	1	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	1	0
YAR007C	0	0	1	0	0	0	0	0	0
YER132C	YER138C	YER155C	YER160C	YER162C	YER164W	YER165W	YER167W	YER172C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	1	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	1	0	0	0	1	1	0	0	0
YER174C	YER178W	YER182W	YFL002C	YFL005W	YFL006W	YFL007W	YFL016C	YFL018C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	1
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	1	0	0	0	0	0	0	0	0
YFL022C	YFL024C	YFL030W	YFL042C	YFL045C	YFL053W	YFR001W	YFR004W	YFR008W	
YAL015C	1	0	0	1	0	0	0	0	1
YAL017W	0	1	0	1	1	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0

YAL036C	0	0	0	0	0	0	1	0	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	0	0	0	1
YFR011C	YFR015C	YFR017C	YFR024C	YFR030W	YFR039C	YFR044C	YFR051C	YFR052W	
YAL015C	0	0	0	1	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	0	0	0	0	0	1	0	0	1
YAR007C	0	0	0	0	0	0	1	0	0
YGL006W	YGL008C	YGL011C	YGL016W	YGL017W	YGL019W	YGL020C	YGL023C	YGL026C	
YAL015C	0	0	0	0	0	1	0	1	0
YAL017W	1	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	0	0	0	0	0	0	0	0	1
YAR007C	0	0	0	0	0	1	0	0	0
YGL049C	YGL060W	YGL062W	YGL068W	YGL070C	YGL092W	YGL097W	YGL104C	YGL105W	
YAL015C	0	0	1	0	0	0	0	0	1
YAL017W	1	0	0	0	0	0	0	0	1
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YGL106W	YGL111W	YGL112C	YGL117W	YGL120C	YGL121C	YGL122C	YGL130W	YGL141W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	1	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
YGL146C	YGL150C	YGL151W	YGL156W	YGL171W	YGL192W	YGL195W	YGL197W	YGL200C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	1	0	0	1
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	1	1	0	0	0	0
YAR007C	0	0	0	0	0	0	1	0	0
YGL205W	YGL207W	YGL210W	YGL216W	YGL227W	YGL234W	YGL241W	YGL245W	YGL256W	
YAL015C	1	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	1	0	1	0	0	0	0	0
YAR003W	0	0	0	0	1	0	0	0	0
YAR007C	0	0	0	0	1	0	0	0	0

	YGR002C	YGR005C	YGR016W	YGR017W	YGR033C	YGR041W	YGR047C	YGR061C	YGR066C
YAL015C	1	1	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	1	0	0	0	0	0	1	1	1
YAR007C	1	0	0	0	0	0	0	1	0
	YGR086C	YGR087C	YGR090W	YGR091W	YGR094W	YGR111W	YGR130C	YGR135W	YGR136W
YAL015C	0	0	0	0	0	0	1	0	0
YAL017W	0	0	0	1	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	1	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
	YGR142W	YGR145W	YGR150C	YGR154C	YGR155W	YGR159C	YGR161C	YGR162W	YGR165W
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
	YGR175C	YGR184C	YGR186W	YGR187C	YGR193C	YGR196C	YGR198W	YGR202C	YGR204W
YAL015C	0	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	1	0	0	0	0	0	1
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	1	0	0
	YGR205W	YGR209C	YGR210C	YGR218W	YGR232W	YGR233C	YGR234W	YGR238C	YGR240C
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	1
YAL036C	0	0	0	0	0	1	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	1
	YGR250C	YGR253C	YGR256W	YGR263C	YGR264C	YGR266W	YGR267C	YGR270W	YGR279C
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	1	0	0	0	0	0	0	0	0
	YGR282C	YGR296W	YHL007C	YHL011C	YHL030W	YHL035C	YHL038C	YHL039W	YHR001W
YAL015C	1	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	1	0	0	0

YAL021C	0	1	0	0	0	1	0	0	0
YAL036C	0	1	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	1	0	0
YHR005C	YHR008C	YHR009C	YHR011W	YHR016C	YHR018C	YHR019C	YHR020W	YHR024C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	1	0	0
YAR003W	0	0	0	0	0	0	0	0	1
YAR007C	0	0	0	0	0	0	1	0	0
YHR027C	YHR033W	YHR043C	YHR044C	YHR046C	YHR051W	YHR059W	YHR060W	YHR064C	
YAL015C	0	0	0	0	0	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	1
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
YHR065C	YHR066W	YHR069C	YHR074W	YHR075C	YHR076W	YHR084W	YHR086W	YHR087W	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	0	0	1	1	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YHR088W	YHR089C	YHR096C	YHR098C	YHR099W	YHR102W	YHR112C	YHR114W	YHR122W	
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	1
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	1	0	0	0	0	0	0	1
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YHR128W	YHR137W	YHR143W-A	YHR149C	YHR154W	YHR158C	YHR165C	YHR167W		
YAL015C	1	0	0	0	0	0	0	0	
YAL017W	1	0	0	0	0	0	0	0	
YAL021C	1	0	0	1	0	0	0	0	
YAL036C	0	0	0	0	0	1	0	0	
YAR003W	0	0	0	1	0	1	0	0	
YAR007C	0	0	0	0	0	0	0	0	
YHR170W	YHR171W	YHR179W	YHR193C	YHR200W	YHR201C	YHR208W	YHR214W-A		
YAL015C	0	0	0	0	1	0	0	0	
YAL017W	0	0	0	0	0	0	0	0	
YAL021C	0	0	0	0	1	0	0	1	
YAL036C	0	0	0	0	0	0	0	0	
YAR003W	0	0	0	0	0	0	0	0	

YAR007C	0	0	0	0	0	0	0	0	0
YHR216W	YIL017C	YIL021W	YIL026C	YIL028W	YIL033C	YIL034C	YIL037C	YIL050W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	1	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	1	0
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	1	1	0
YAR007C	0	1	0	0	0	0	0	1	0
YIL053W	YIL055C	YIL062C	YIL068C	YIL070C	YIL076W	YIL078W	YIL093C	YIL094C	
YAL015C	0	0	0	1	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	0	0	0	1	0	1	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YIL097W	YIL104C	YIL105C	YIL106W	YIL108W	YIL112W	YIL124W	YIL125W	YIL126W	
YAL015C	0	0	0	0	1	0	1	0	1
YAL017W	0	0	0	0	0	1	0	0	0
YAL021C	0	0	0	0	1	0	0	0	0
YAL036C	0	0	0	0	0	0	1	1	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
YIL129C	YIL136W	YIL137C	YIL149C	YIL156W	YIL159W	YIR002C	YIR003W	YIR012W	
YAL015C	0	1	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	1	0	0
YAR007C	0	0	0	0	0	0	0	1	0
YJL001W	YJL013C	YJL014W	YJL026W	YJL045W	YJL047C	YJL050W	YJL074C	YJL076W	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	0	0	1	1	0	1
YAL036C	0	0	0	0	0	1	0	0	0
YAR003W	0	0	0	0	0	1	1	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YJL080C	YJL081C	YJL085W	YJL087C	YJL095W	YJL107C	YJL109C	YJL115W	YJL117W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	1	0	0	0	0	0	1	1
YAR003W	0	0	0	0	1	0	0	0	1
YAR007C	0	0	0	0	0	0	1	0	1
YJL122W	YJL124C	YJL154C	YJL156C	YJL167W	YJL197W	YJL207C	YJR016C	YJR027W	
YAL015C	0	0	0	0	0	0	0	0	1

YAL017W	1	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	1	0	0	0	0
YAL036C	0	0	1	1	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	1	0	1	0	0	1	0	0
YJR028W	YJR029W	YJR041C	YJR063W	YJR064W	YJR065C	YJR070C	YJR072C	YJR074W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	1	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YJR089W	YJR093C	YJR104C	YJR105W	YJR109C	YJR127C	YJR132W	YJR134C	YJR139C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	1	0	0	1	0	0	0
YJR140C	YJR141W	YJR144W	YKL007W	YKL009W	YKL010C	YKL012W	YKL013C	YKL014C	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	0	0	0	0	0	0
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	1	1	0	1	0	1
YKL016C	YKL022C	YKL029C	YKL045W	YKL054C	YKL056C	YKL057C	YKL062W	YKL067W	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YKL073W	YKL080W	YKL081W	YKL082C	YKL085W	YKL099C	YKL104C	YKL119C	YKL120W	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	1	0	0	0	0	0	0	1	0
YAL021C	0	0	0	1	1	0	0	0	0
YAL036C	0	0	0	0	1	0	0	0	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YKL127W	YKL129C	YKL135C	YKL140W	YKL143W	YKL144C	YKL145W	YKL150W	YKL157W	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0



YAR003W	0	1	0	0	1	0	0	0	0
YAR007C	0	0	0	0	0	1	0	0	0
YKL168C	YKL172W	YKL176C	YKL204W	YKL205W	YKL206C	YKL211C	YKL212W	YKL214C	
YAL015C	0	0	1	1	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
YKL216W	YKL218C	YKR001C	YKR002W	YKR007W	YKR014C	YKR017C	YKR018C	YKR024C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	1	0
YAL036C	0	0	1	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	1	0
YAR007C	0	0	0	0	0	0	1	1	1
YKR028W	YKR029C	YKR038C	YKR046C	YKR048C	YKR051W	YKR060W	YKR063C	YKR067W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	1	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YKR081C	YKR082W	YKR096W	YKR101W	YLL001W	YLL008W	YLL013C	YLL018C	YLL022C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	0	0	0	0	1	1
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YLL026W	YLL027W	YLL029W	YLL034C	YLL039C	YLL040C	YLL041C	YLL048C	YLR002C	
YAL015C	0	1	0	0	0	0	0	0	0
YAL017W	0	0	0	0	1	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	1	0	0	0	0	0	0	0	0
YLR009W	YLR015W	YLR024C	YLR027C	YLR035C-A	YLR039C	YLR058C	YLR059C		
YAL015C	0	1	0	0	0	0	0	0	
YAL017W	0	0	0	0	0	0	0	0	
YAL021C	0	0	0	0	0	0	0	0	
YAL036C	0	0	0	0	0	0	0	0	
YAR003W	0	0	0	0	0	0	0	1	
YAR007C	1	0	0	0	0	0	0	0	
YLR071C	YLR081W	YLR086W	YLR092W	YLR100W	YLR105C	YLR106C	YLR109W	YLR117C	

YAL015C	0	0	0	0	1	0	0	0	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	1	0	0
YLR127C	YLR129W	YLR133W	YLR134W	YLR136C	YLR138W	YLR152C	YLR153C	YLR154C	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	1	1	1	0	0	0
YAL036C	0	0	0	0	0	0	0	0	1
YAR003W	1	0	0	0	0	0	0	0	1
YAR007C	0	1	0	0	0	0	1	0	0
YLR163C	YLR174W	YLR187W	YLR197W	YLR199C	YLR206W	YLR215C	YLR219W	YLR226W	
YAL015C	0	0	0	0	1	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	0	0	1	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	1	1	0
YLR231C	YLR241W	YLR243W	YLR258W	YLR267W	YLR270W	YLR271W	YLR274W	YLR276C	
YAL015C	0	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	0	0	1	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	1	0	0	0	0	0	0	0
YAR003W	1	0	0	0	1	1	0	0	0
YAR007C	1	0	0	0	1	0	0	1	0
YLR287C	YLR289W	YLR300W	YLR304C	YLR309C	YLR310C	YLR313C	YLR326W	YLR328W	
YAL015C	0	0	0	0	1	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	1
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	1	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	1	0	0	0
YLR331C	YLR335W	YLR336C	YLR337C	YLR347C	YLR354C	YLR355C	YLR359W	YLR362W	
YAL015C	1	1	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	1	1	0	0	0	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	1	0	0	0	1	0	0	1	0
YLR368W	YLR369W	YLR370C	YLR371W	YLR384C	YLR386W	YLR389C	YLR392C	YLR396C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	1

YAL036C	0	0	0	1	0	1	0	0	0
YAR003W	0	0	1	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	1
YLR397C	YLR398C	YLR409C	YLR413W	YLR421C	YLR422W	YLR423C	YLR429W	YLR430W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	1	0	0	0	0	0	0	0
YLR432W	YLR438W	YLR447C	YLR449W	YLR450W	YML001W	YML006C	YML008C	YML010W	
YAL015C	0	0	0	0	0	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	0	0	1	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YML020W	YML022W	YML036W	YML048W	YML049C	YML056C	YML062C	YML069W	YML072C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	1	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	1	0	0
YAR007C	0	0	0	0	1	0	0	0	0
YML074C	YML078W	YML091C	YML092C	YML093W	YML100W	YML109W	YML123C	YML126C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	1	1	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
YMR005W	YMR012W	YMR019W	YMR028W	YMR029C	YMR056C	YMR058W	YMR083W	YMR086W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	0	0	0	0	0	1	0	0
YAR003W	0	0	0	1	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YMR092C	YMR100W	YMR102C	YMR105C	YMR108W	YMR109W	YMR120C	YMR125W	YMR135C	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	1	1	0	0	0	0	0	0	0
YAL021C	0	0	0	0	1	0	0	0	0
YAL036C	0	0	1	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	1	0
YAR007C	0	0	0	0	0	0	0	1	0

	YMR144W	YMR145C	YMR153W	YMR155W	YMR172W	YMR190C	YMR196W	YMR209C	YMR213W
YAL015C	0	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	1	0	1	1	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	0
	YMR218C	YMR223W	YMR224C	YMR226C	YMR229C	YMR239C	YMR241W	YMR266W	YMR268C
YAL015C	0	1	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
	YMR275C	YMR276W	YMR285C	YMR287C	YMR290C	YMR302C	YMR303C	YMR304W	YMR307W
YAL015C	0	0	1	0	0	0	0	0	1
YAL017W	0	1	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	1	0	0
YAL036C	0	0	0	0	0	0	0	1	1
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	1	1	1	1	0	0	0
	YMR308C	YMR309C	YMR314W	YMR315W	YMR318C	YMR319C	YMR323W	YNL002C	YNL004W
YAL015C	0	1	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	1	0	0	1	0
YAL036C	0	0	0	0	1	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
	YNL007C	YNL008C	YNL014W	YNL016W	YNL025C	YNL027W	YNL037C	YNL038W	YNL040W
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	0	0	0	0	0	0
YAL036C	0	0	0	0	1	0	0	0	0
YAR003W	0	0	0	0	0	0	0	1	1
YAR007C	0	1	0	0	0	0	0	0	0
	YNL055C	YNL063W	YNL073W	YNL078W	YNL085W	YNL103W	YNL110C	YNL112W	YNL118C
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	1	1	1	0
YAL036C	0	0	0	1	0	0	0	0	0
YAR003W	0	0	0	0	1	0	1	1	0
YAR007C	0	0	0	0	0	0	0	0	1
	YNL124W	YNL132W	YNL134C	YNL138W	YNL139C	YNL141W	YNL147W	YNL160W	YNL169C
YAL015C	0	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	0	0	0	0

YAL021C	0	1	0	0	0	1	0	0	0
YAL036C	0	1	0	0	0	0	0	0	0
YAR003W	0	0	1	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YNL172W	YNL181W	YNL192W	YNL199C	YNL201C	YNL207W	YNL208W	YNL210W	YNL213C	
YAL015C	1	0	0	0	0	1	0	0	0
YAL017W	0	0	1	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	1	1	0	0	0	0	0	0	0
YAR007C	0	0	0	1	0	0	0	0	1
YNL223W	YNL227C	YNL229C	YNL238W	YNL242W	YNL248C	YNL253W	YNL262W	YNL271C	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	0	0	1	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	1	0	0	0
YAR003W	1	0	1	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YNL272C	YNL278W	YNL281W	YNL287W	YNL308C	YNL329C	YNL330C	YNL334C	YNR003C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	1	0	0
YAL021C	0	0	0	0	0	0	0	1	1
YAL036C	0	0	0	0	0	1	0	0	0
YAR003W	0	0	0	1	0	0	1	0	1
YAR007C	0	0	0	0	0	1	0	0	0
YNR008W	YNR016C	YNR031C	YNR035C	YNR039C	YNR047W	YNR052C	YNR053C	YNR054C	
YAL015C	0	1	0	0	0	0	0	0	0
YAL017W	0	1	0	0	0	0	0	0	0
YAL021C	0	0	0	0	1	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YNR058W	YNR065C	YOL004W	YOL005C	YOL010W	YOL012C	YOL016C	YOL021C	YOL033W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	1	1	0	0	1	0	0
YAL036C	1	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YOL038W	YOL041C	YOL044W	YOL051W	YOL058W	YOL059W	YOL061W	YOL077C	YOL078W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	1	0	0	0	0	0	0	0
YAL036C	0	0	1	0	0	1	0	0	1
YAR003W	0	0	0	0	0	0	0	0	0

YAR007C	0	0	0	0	1	0	0	0	0
YOL081W	YOL082W	YOL090W	YOL103W	YOL111C	YOL123W	YOL149W	YOR001W	YOR007C	
YAL015C	0	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	1	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	1	0	0	0	0	1	0	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	0	1	1	0
YOR014W	YOR017W	YOR018W	YOR023C	YOR027W	YOR028C	YOR032C	YOR035C	YOR038C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	1	0	0	0	0	0	0	0
YAL021C	0	1	0	0	0	0	0	0	0
YAL036C	0	0	0	1	0	0	0	0	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	1	1	0	0	0	0	0	0
YOR039W	YOR042W	YOR054C	YOR056C	YOR057W	YOR073W	YOR086C	YOR098C	YOR100C	
YAL015C	0	0	0	0	1	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	1
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	1	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	1	0	0	0	1	0	0	0
YOR101W	YOR110W	YOR116C	YOR117W	YOR120W	YOR136W	YOR142W	YOR144C	YOR145C	
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YOR154W	YOR155C	YOR172W	YOR173W	YOR176W	YOR177C	YOR178C	YOR184W	YOR185C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	1	0	0	1
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	0	0	0	0	0	1	0	0	0
YAR007C	0	0	0	0	0	1	0	0	1
YOR187W	YOR201C	YOR204W	YOR206W	YOR207C	YOR208W	YOR210W	YOR215C	YOR217W	
YAL015C	0	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	1	0	0	0
YAL021C	0	1	0	0	0	0	0	0	1
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	1	0	0	0	0	0	0	0
YAR007C	1	0	0	1	0	0	0	0	0
YOR220W	YOR232W	YOR244W	YOR259C	YOR260W	YOR261C	YOR266W	YOR267C	YOR283W	
YAL015C	0	0	0	0	0	0	0	0	0

YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	1	0	0	1	0	0	0	0	0
YAR003W	1	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YOR299W	YOR303W	YOR308C	YOR310C	YOR317W	YOR323C	YOR326W	YOR329C	YOR332W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	1	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	1	0	0	1	0	0	0	0	0
YAR003W	0	0	1	1	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YOR335C	YOR340C	YOR358W	YOR362C	YOR367W	YOR368W	YOR370C	YOR378W	YPL001W	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	1	0	0	0	0	0	0
YPL004C	YPL009C	YPL012W	YPL013C	YPL016W	YPL018W	YPL028W	YPL029W	YPL032C	
YAL015C	0	0	0	0	0	1	0	0	0
YAL017W	0	0	0	0	0	1	0	0	0
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	1	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YPL036W	YPL037C	YPL038W	YPL040C	YPL043W	YPL046C	YPL049C	YPL050C	YPL055C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	1	0	0	0	0	0
YAL036C	0	0	0	1	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YPL078C	YPL082C	YPL086C	YPL093W	YPL104W	YPL110C	YPL113C	YPL127C	YPL128C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	1	0	0
YAL021C	0	0	0	0	1	0	0	1	0
YAL036C	0	0	1	0	0	0	0	0	1
YAR003W	0	0	0	0	1	0	0	1	0
YAR007C	0	0	0	0	1	0	1	0	0
YPL129W	YPL146C	YPL160W	YPL161C	YPL166W	YPL171C	YPL181W	YPL195W	YPL208W	
YAL015C	0	0	0	0	0	0	1	0	1
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	1	0	1	1	0

YAR003W	0	0	0	0	0	0	1	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YPL211W	YPL215W	YPL217C	YPL218W	YPL222W	YPL226W	YPL237W	YPL247C	YPL249C	
YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	1	0	0	0	0	0	0	0	0
YPL254W	YPL258C	YPL262W	YPL265W	YPL266W	YPR003C	YPR010C	YPR016C	YPR019W	
YAL015C	0	0	0	0	0	0	1	0	0
YAL017W	0	0	0	0	0	0	0	0	1
YAL021C	1	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	1	0	0	0	0	0	0	0	0
YPR023C	YPR025C	YPR029C	YPR030W	YPR033C	YPR034W	YPR040W	YPR049C	YPR067W	
YAL015C	0	0	0	0	0	0	0	1	0
YAL017W	1	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	1	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	1
YAR007C	0	0	0	0	0	0	0	0	0
YPR069C	YPR085C	YPR088C	YPR090W	YPR101W	YPR103W	YPR108W	YPR115W	YPR120C	
YAL015C	0	0	0	0	0	0	0	0	1
YAL017W	0	0	0	0	0	0	1	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YPR121W	YPR122W	YPR124W	YPR135W	YPR143W	YPR159W	YPR160W	YPR164W	YPR167C	
YAL015C	0	1	0	0	0	0	0	1	0
YAL017W	0	0	0	0	0	0	0	1	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	1	0	0
YAR003W	0	0	0	0	0	0	0	0	1
YAR007C	0	0	0	0	0	0	0	0	0
YPR175W	YPR181C	YPR183W	YPR184W	YPR187W	YPR188C	YPR189W	YPR190C	YPR191W	
YAL015C	0	0	1	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	0	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YPR181C	YML014W	YNL042W	YPR180W	YHR050W	YIL069C	YGL015C	YJL087C	YOL145C	



YAL015C	0	0	0	0	0	0	0	0	0
YAL017W	0	0	0	0	0	0	0	0	0
YAL021C	0	0	0	0	0	0	0	0	0
YAL036C	0	0	0	1	0	0	0	0	0
YAR003W	0	0	0	0	0	0	0	0	0
YAR007C	0	0	0	0	0	0	0	0	0
YML101C									
YAL015C	0								
YAL017W	0								
YAL021C	0								
YAL036C	0								
YAR003W	0								
YAR007C	0								

### 3 Complex Estimation Algorithm

From the simulated data, the *simulatorAPMS* package calls the `findComplexes()` function in the *apComplex* package, a complex co-membership algorithm. For detailed instructions concerning the *apComplex* package, the user can refer to its own vignette. One of the functionality of the *simulatorAPMS* is its ability to test the effectiveness of the complex estimation algorithms. Though the *simulatorAPMS* defaults to *apComplex* as the complex estimator, the user can chose to use any other complex estimator.

```
> data(runSimEX)
> data(vBaitsEX)
> runAPComplex(runSimEX, vBaitsEX)
```

```
[1] "Finding Initial Maximal BH-complete Subgraphs"
[1] "Combining Complex Estimates"
      Complex1 Complex2 Complex3 Complex4 Complex5 Complex6
YAL015C      1       0       0       1       0       0
YAL017W      0       0       0       0       1       0
YAL021C      1       0       0       0       0       0
YAL036C      0       1       0       0       0       0
YAR003W      0       0       1       0       0       0
YAR007C      1       1       1       1       1       1
YAR019C      0       0       0       0       0       1
YBL021C      0       0       0       0       1       1
YBL026W      0       0       0       0       0       1
YBL036C      0       0       0       0       1       1
YBL049W      0       0       0       0       0       1
YBL056W      0       0       0       1       0       1
YBL088C      0       0       0       0       0       1
YBR055C      0       0       0       1       0       1
YBR059C      0       0       0       0       0       1
```

YBR082C	0	0	0	1	0	1
YBR083W	0	0	0	1	1	1
YBR088C	0	0	0	0	0	1
YBR094W	0	0	0	1	0	1
YBR109C	0	0	0	1	0	1
YBR114W	0	0	0	0	1	1
YBR125C	0	0	0	0	0	1
YBR130C	0	0	0	1	0	1
YML014W	0	0	0	0	1	0
YHR050W	0	0	0	0	1	1
YGL015C	0	0	0	0	1	1
YOL145C	0	0	0	0	1	0
YML101C	0	0	0	0	0	1

The output from *apComplex* is the incidence matrix representation of the bipartite graph of proteins to protein complexes. This output is an estimate for the in silico model organism  $A^*$ . After calculating this estimate, it is necessary to ascertain how accurate this estimate is - either with respect to the in silico model organism or compared to other estimation algorithms.

## 4 Statistical Tools

The last component of *simulatorAPMS* is its statistical tools. It is necessary to compare the simulated test results with the in silico model organism's true state of nature,  $A$ . When we have calculated an estimate,  $\hat{A}$  using *apComplex*, the first step in the comparison between  $A$  and  $\hat{A}$  is calculating three statistics between the complexes  $C_i \in A$  and  $K_j \in \hat{A}$ : (1)  $C_i \cap K_j$ ; (2)  $C_i \setminus K_j$ ; and (3)  $K_j \setminus C_i$ . To calculate these three statistics, we call the `runCompareComplex()` function.

The return value of `runCompareComplex` is a list containing three matrices. The first component of the list is a matrix of intersection values between the complexes of  $A$  and  $\hat{A}$ . The second and third components are a matrix of the difference values between the complexes of  $A$  and  $\hat{A}$  and a matrix of the difference values between the complexes of  $\hat{A}$  and  $A$  respectively. Once we have calculated these statistics, we can compute similarity measures between the complexes of  $A$  and  $\hat{A}$ .

The first method involves using the Jaccard similarity coefficient. This coefficient is a simple measure of similarity between two complexes by taking the ratio of overlapping sections of the complexes to combining the two complexes. For complex  $C_i$  and  $K_j$ , we define the Jaccard Matrix as  $JC$  with the  $\{i, j\}$ th entry as

$$JC_{ij} = \frac{|C_i \cap K_j|}{|C_i \cup K_j|} \quad (1)$$

To call the `JaccardCoef` function, we only need the return value of the `runCompareComplex` function:

The Jaccard index has its benefits. The main benefit of the Jaccard index is that it is a very intuitive statistic. It is clear that if two complexes have almost identical composition, the similarity measure ought to reflect this. It is pretty easy to see that if the two complexes

are identical, the Jaccard index is one, and if they are completely different, the index is zero. Because of its relatively easy structure, the index is a good measure of similarity. The matrix of Jaccard coefficients above has its rows indexed by the complexes of  $A$  and the columns indexed by the estimate  $\hat{A}$ .

The second method uses a variant of the Kullback-Liebler formula to calculate the independence of two probability distributions. For a random protein  $p$ , we can calculate three probabilities: 1. the probability that  $p$  is in the complex  $C_i$ ; 2. the probability that  $p$  is in the complex  $K_j$ ; and 3. the probability that  $p$  is in both the complexes  $C_i$  and in  $K_j$ . With these three probabilities, we can calculate the degree of independence of (1) and (2) with respect to (3). Independence implies that the estimate is not be closely aligned to the truth. To call the `compIndep()`, we need three parameters, the matrix of the bipartite graph of  $A$ , the matrix of the bipartite graph of  $\hat{A}$ , and the intersection matrix of the function `runCompareComplex()`.

After we have calculated a similarity measures, we need to align complexes of  $A$  to complexes of  $\hat{A}$ . To find an optimal alignment, we employ a version of a greedy algorithm we call `compBijection`. We find the largest entry in the similarity matrix (either Jaccard or the Kullback-Liebler); its row and column correspond to particular complexes in  $A$  and in the estimate  $\hat{A}$ , and so we align these complexes. We then delete this row and column from the matrix and recursively call `compBijection()` on the smaller matrix. If there is a tie in one row (or one column), we chose larger complexes to align first, since the relative size of the complexes is an important indicator of how well the estimation algorithm works. To call the alignment function, we need three parameters: the matrix of  $A$ , the matrix of  $\hat{A}$ , and either the Jaccard Matrix or the Kullback-Liebler Matrix:

The output of the `runAlignment` function is a matrix where the row contains the alignment of the complexes of  $A$  and  $\hat{A}$  with the similarity coefficient (whichever one the user decided to use) is given in the third column. Thus is it easy to see how well the estimation algorithm performed the complexes of the estimate are aligned with those of the ISI. There is one particular caveat for this function; the greedy algorithm is known not to return optimal alignments is some pathological cases though in most cases it does.

## Where do we go

The *simulatorAPMS* is developed for many reasons, one of which is to test the significance of interactome estimation algorithms. The second part of the package uses the estimation algorithm *apComplex* as the tool to predict the ISI, but *simulatorAPMS* can just as easily test significance of any estimation algorithm. In fact, *simulatorAPMS* could compare and contrast the estimations of different estimation algorithms under variable conditions, i.e. different rates of FP/FN, using different baits, etc.

One of the most substantial elements to *simulatorAPMS* is that if an estimation algorithm can be shown to be highly accurate and statistically significant, we would then have a reasonably clear description of the interactome. Bait selection for AP-MS technology is highly related to how much information one can discern from the interactome. The more we understand about the interactome, the more intelligent we can make our bait selections, and thus we can garner more detail from the actual wet-lab experiment.

## References

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