Gene Set comparisons

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### Comparative analysis of available next generation sequencing datasets

Genome-wide Nup98 interaction with chromatin was assessed through available DamID-seq data, by comparing enriched DNA sequences from Dam-Nup98 or Dam-Nup98dCTD expressing HeLa-C cells to those of Dam-GFP expressing cells (GSE83692). Data analysis was performed as described in the corresponding dataset and its publication. Transcriptome-wide interaction of Nup98 with mRNA molecules was determined from available sequencing data for Nup98 RNA immunoprecipitations from K562 cells (GSE67963) (G Hendrickson et al., 2016). DHX9 interaction with RNA was determined from sequencing data for DHX9 RNA immunoprecipitation from TC32 cells, kindly provided by Dr. Hayriye Verda Erkizan and Professor Jeffrey Alan Toretsky (Georgetown University) (Erkizan et al., 2015). Data analysis was performed as described in the corresponding datasets and their indicated publication, transcripts were considered as interacting with target proteins if showing a fold enrichment above 1.5 and adjusted p-value < 0.05. Transcriptome-wide changes in transcript or splicing isoform abundance were determined from RNA-sequencing data for HepG2 or IMR90 cells upon Nup98 depletion (GSE83551)(Franks et al., 2016). Transcriptome changes in NB1 cells upon DHX9 depletion were determined from available RNA-sequencing data (GSE44585) (Chen et al., 2014). Transcriptome sequencing data was analyzed as previously described (Wolfien et al., 2016), using Galaxy (Afgan et al., 2016), R (R Core Team, 2016) and Bioconductor (Huber et al., 2015). An adjusted p-value < 0.05 was used to identify transcripts/isoforms whose abundance was significantly altered upon target protein depletion. All datasets were aligned to human reference sequence GRCh37/hg19 and annotated with corresponding UCSC genes and Ensembl genes (Huang, Loganantharaj, Schroeder, Fargo, & Li, 2013; Rosenbloom et al., 2015; Yates et al., 2016; Yu, Wang, & He, 2015). Statistically significant overlap between gene sets were calculated using the Fisher's exact test based on the hypergeometric distribution through the R package GeneOverlap (Shen, 2013).

## Load all available datasets

Datasets are stored as RData files containing lists of gene symbols.

## [[1]]  
## [1] "Allgenes"  
##   
## [[2]]  
## [1] "CRE.genes"  
##   
## [[3]]  
## [1] "Dam.all"  
##   
## [[4]]  
## [1] "RIP.all"  
##   
## [[5]]  
## [1] "Splice.all"  
##   
## [[6]]  
## [1] "Transcript"  
##   
## [[7]]  
## [1] "AllKD2"

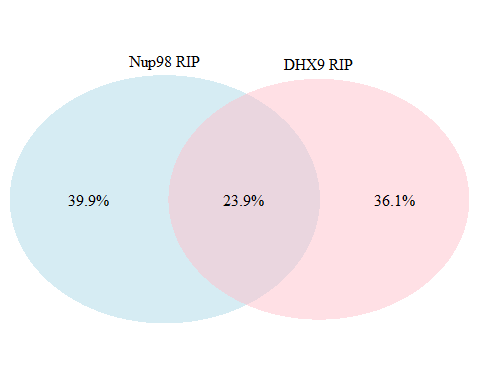
## Comparing Nup98 and DHX9 RNA-IP interacting mRNAs:

gs.RNASeq <- 48321 #Number of all possible genes from ENSG  
  
go.obj <- newGeneOverlap(RIP.all$Nup98RIP.K562,RIP.all$DHX9RIP.T32,genome.size=gs.RNASeq)  
go.obj <- testGeneOverlap(go.obj)  
print(go.obj)

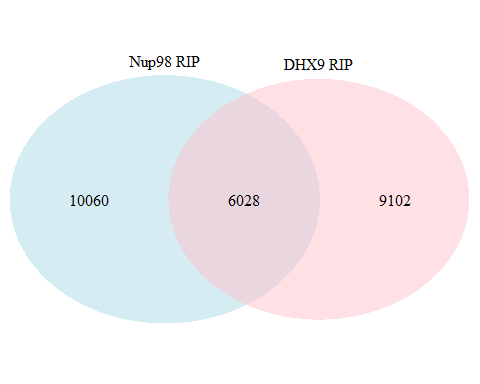
## Detailed information about this GeneOverlap object:  
## listA size=16088, e.g. STPG1 SLC7A2 CCL18  
## listB size=15130, e.g. OR4G11P SAMD11 NOC2L  
## Intersection size=6028, e.g. PDK4 COPZ2 PRR5  
## Union size=25190, e.g. STPG1 SLC7A2 CCL18  
## Genome size=48321  
## # Contingency Table:  
## notA inA  
## notB 23131 10060  
## inB 9102 6028  
## Overlapping p-value=2.5e-93  
## Odds ratio=1.5  
## Overlap tested using Fisher's exact test (alternative=greater)  
## Jaccard Index=0.2

## Loading required package: grid

## Loading required package: futile.logger



## (polygon[GRID.polygon.1], polygon[GRID.polygon.2], polygon[GRID.polygon.3], polygon[GRID.polygon.4], text[GRID.text.5], text[GRID.text.6], text[GRID.text.7], text[GRID.text.8], text[GRID.text.9])



## (polygon[GRID.polygon.10], polygon[GRID.polygon.11], polygon[GRID.polygon.12], polygon[GRID.polygon.13], text[GRID.text.14], text[GRID.text.15], text[GRID.text.16], text[GRID.text.17], text[GRID.text.18])

## Comparing changes in transcript splicing isoform upon DHX9 KD in NB1 cells, Nup98 KD in HepG2 cells and Nup98 KD in IMR90 cells

Table of p-values:

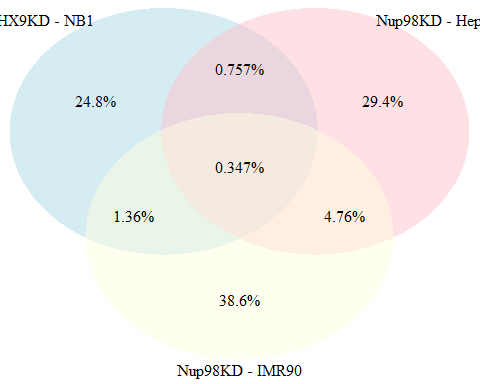
gs.RNASeq <- 23144 #ENSG spliced genes  
names(Splice.all) <- c("Nup98KD.HepG2","Nup98KD.IMR90","DHX9KD.NB1")  
gom.self <- newGOM(Splice.all, genome.size=gs.RNASeq)  
getMatrix(gom.self, name="pval")

## Nup98KD.IMR90 DHX9KD.NB1  
## Nup98KD.HepG2 9.728468e-102 3.984383e-27  
## Nup98KD.IMR90 1.000000e+00 4.956290e-24

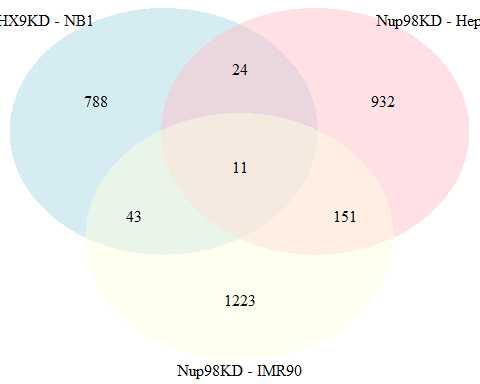
Number of genes in common:

getMatrix(gom.self, name="intersection")

## Nup98KD.IMR90 DHX9KD.NB1  
## Nup98KD.HepG2 277 119  
## Nup98KD.IMR90 0 132



## (polygon[GRID.polygon.19], polygon[GRID.polygon.20], polygon[GRID.polygon.21], polygon[GRID.polygon.22], polygon[GRID.polygon.23], polygon[GRID.polygon.24], text[GRID.text.25], text[GRID.text.26], text[GRID.text.27], text[GRID.text.28], text[GRID.text.29], text[GRID.text.30], text[GRID.text.31], text[GRID.text.32], text[GRID.text.33], text[GRID.text.34])



## (polygon[GRID.polygon.35], polygon[GRID.polygon.36], polygon[GRID.polygon.37], polygon[GRID.polygon.38], polygon[GRID.polygon.39], polygon[GRID.polygon.40], text[GRID.text.41], text[GRID.text.42], text[GRID.text.43], text[GRID.text.44], text[GRID.text.45], text[GRID.text.46], text[GRID.text.47], text[GRID.text.48], text[GRID.text.49], text[GRID.text.50])

## Compare changes in transcript level upon DHX9 KD in NB1 cells, Nup98 KD in HepG2 cells and Nup98 KD in IMR90 cells

All statistically significant genes (up or down regulated), table of p-values:

gs.RNASeq <- 29432 #Total number of genes detected in these transcriptomes  
  
gom.self <- newGOM(Transcript$all, genome.size=gs.RNASeq)  
getMatrix(gom.self, name="pval")

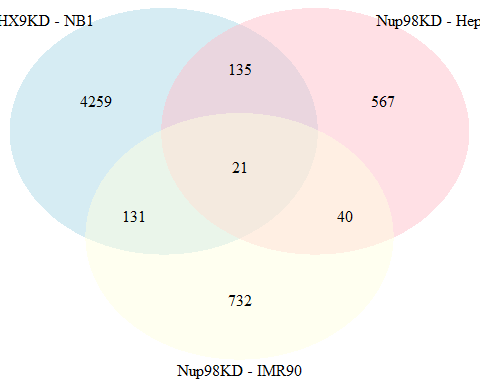
## Nup98KD.IMR90 DHX9KD.NB1  
## Nup98KD.HepG2 2.72786e-27 7.593352e-20  
## Nup98KD.IMR90 1.00000e+00 2.450127e-21

Number of genes in common:

getMatrix(gom.self, name="intersection")

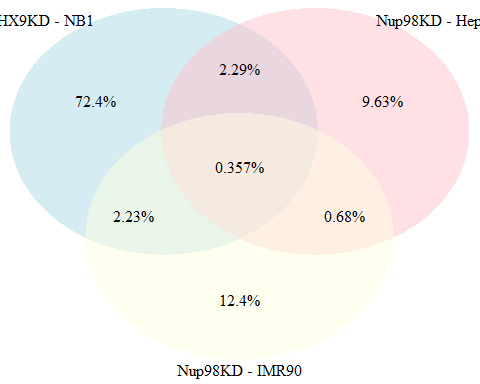
## Nup98KD.IMR90 DHX9KD.NB1  
## Nup98KD.HepG2 61 156  
## Nup98KD.IMR90 0 152

grid.newpage()  
#draw.triple.venn(area1, area2, area3, n12, n23, n13, n123,  
draw.triple.venn(4546, 763, 924, 156, 61, 152, 21, category =  
c("DHX9KD - NB1","Nup98KD - HepG2", "Nup98KD - IMR90"), lty =  
rep("blank", 3), fill = c("light blue", "pink", "light yellow"),  
alpha = rep(0.5, 3), cat.pos = c(-40,40,180), cat.dist =  
c(0.05, 0.05, 0.025))



## (polygon[GRID.polygon.51], polygon[GRID.polygon.52], polygon[GRID.polygon.53], polygon[GRID.polygon.54], polygon[GRID.polygon.55], polygon[GRID.polygon.56], text[GRID.text.57], text[GRID.text.58], text[GRID.text.59], text[GRID.text.60], text[GRID.text.61], text[GRID.text.62], text[GRID.text.63], text[GRID.text.64], text[GRID.text.65], text[GRID.text.66])

grid.newpage()  
#draw.triple.venn(area1, area2, area3, n12, n23, n13, n123,  
draw.triple.venn(4546, 763, 924, 156, 61, 152, 21, category =  
c("DHX9KD - NB1","Nup98KD - HepG2", "Nup98KD - IMR90"), lty =  
rep("blank", 3), fill = c("light blue", "pink", "light yellow"),  
alpha = rep(0.5, 3), cat.pos = c(-40,40,180), cat.dist =  
c(0.05, 0.05, 0.025),print.mode="percent")



## (polygon[GRID.polygon.67], polygon[GRID.polygon.68], polygon[GRID.polygon.69], polygon[GRID.polygon.70], polygon[GRID.polygon.71], polygon[GRID.polygon.72], text[GRID.text.73], text[GRID.text.74], text[GRID.text.75], text[GRID.text.76], text[GRID.text.77], text[GRID.text.78], text[GRID.text.79], text[GRID.text.80], text[GRID.text.81], text[GRID.text.82])

# Are genes with altered splicing upon Nup98 or DHX9 KD enriched in Nup98 or DHX9 RNA-IPs?

gs.RNASeq <- 48321 #Number of all possible genes from ENSG  
gom.obj <- newGOM(Splice.all, RIP.all, genome.size=gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98RIP.K562 DHX9RIP.T32 both  
## Nup98KD.HepG2 3.487218e-242 0.56362514 4.035794e-36  
## Nup98KD.IMR90 3.467813e-317 0.01866402 6.034974e-67  
## DHX9KD.NB1 1.534022e-164 0.26566206 5.226360e-28

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98RIP.K562 DHX9RIP.T32 both  
## Nup98KD.HepG2 889 339 287  
## Nup98KD.IMR90 1146 474 414  
## DHX9KD.NB1 668 275 223

# Are genes with altered expression upon Nup98 or DHX9 KD enriched in Nup98 or DHX9 RNA-IPs?

gom.obj <- newGOM(Transcript$all, RIP.all, genome.size=gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98RIP.K562 DHX9RIP.T32 both  
## Nup98KD.HepG2 2.631757e-67 0.0089745245 8.901021e-15  
## Nup98KD.IMR90 7.673003e-44 0.0006578878 6.382602e-16  
## DHX9KD.NB1 0.000000e+00 0.0075508145 6.099347e-109

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98RIP.K562 DHX9RIP.T32 both  
## Nup98KD.HepG2 403 213 142  
## Nup98KD.IMR90 343 209 138  
## DHX9KD.NB1 2602 1229 936

# Are genes with altered expression also enriched for CRE regulatory elements?

Table of p-values:

gom.obj <- newGOM(Transcript$all, CRE.genes, genome.size=gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## CRE  
## Nup98KD.HepG2 5.080665e-37  
## Nup98KD.IMR90 7.192518e-49  
## DHX9KD.NB1 3.594919e-127

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## CRE  
## Nup98KD.HepG2 357  
## Nup98KD.IMR90 361  
## DHX9KD.NB1 1975

# Are genes with altered splicing also enriched for CRE regulatory elements?

Table of p-values:

gom.obj <- newGOM(Splice.all, CRE.genes, genome.size=gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## CRE  
## Nup98KD.HepG2 2.401469e-29  
## Nup98KD.IMR90 1.509787e-31  
## DHX9KD.NB1 4.693071e-30

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## CRE  
## Nup98KD.HepG2 557  
## Nup98KD.IMR90 695  
## DHX9KD.NB1 456

## Compare Dam-Nup98 interacting genes with CRE element containing genes

Table of p-values for statically significant gene set overlaps:

gom.obj <- newGOM(CRE.genes, Dam.all, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98FL.CRE Nup98dCTD.CRE   
## 5.533903e-64 1.023096e-52

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98FL.CRE Nup98dCTD.CRE   
## 1411 884

## Compare Nup98DamID genes with CRE elements to genes with altered expression upon Nup98 or DHX9 KD.

Table of p-values:

gom.obj <- newGOM(N98Dam.CRE, Transcript$all, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98KD.HepG2 Nup98KD.IMR90 DHX9KD.NB1  
## DamNup98FLCRE 2.229494e-24 8.831719e-38 1.021099e-102  
## DamNup98dCTDCRE 3.211930e-14 2.694110e-20 5.277103e-77

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98KD.HepG2 Nup98KD.IMR90 DHX9KD.NB1  
## DamNup98FLCRE 72 87 370  
## DamNup98dCTDCRE 43 50 251

## Compare Nup98DamID genes with CRE elements to genes with altered splicing upon Nup98 or DHX9 KD.

Table of p-values:

gom.obj <- newGOM(N98Dam.CRE, Splice.all, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98KD.HepG2 Nup98KD.IMR90 DHX9KD.NB1  
## DamNup98FLCRE 4.757813e-32 5.605825e-39 1.326171e-24  
## DamNup98dCTDCRE 3.492706e-17 6.310816e-30 4.408208e-20

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98KD.HepG2 Nup98KD.IMR90 DHX9KD.NB1  
## DamNup98FLCRE 114 143 88  
## DamNup98dCTDCRE 66 98 62

## Compare Nup98DamID genes with CRE elements to mRNAs bound to Nup98 or DHX9 in RNA-IPs

Table of p-values:

gom.obj <- newGOM(N98Dam.CRE, RIP.all, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98RIP.K562 DHX9RIP.T32 both  
## DamNup98FLCRE 4.209607e-205 2.354996e-05 1.048003e-52  
## DamNup98dCTDCRE 3.498157e-160 8.500419e-06 1.136685e-51

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98RIP.K562 DHX9RIP.T32 both  
## DamNup98FLCRE 1023 513 386  
## DamNup98dCTDCRE 682 337 280

## Compare CRE containing genes, bound by Dam-Nup98, bound to RNA-IP of Nup98 or DHX9 to genes with altered expression upon Nup98 or DHX9 KD

Table of p-values

gom.obj <- newGOM(N98Dam.CRE.RIP, Transcript$all, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98KD.HepG2 Nup98KD.IMR90 DHX9KD.NB1  
## CRE.DamFL.N98RIP 5.985168e-22 1.463091e-26 6.839806e-89  
## CRE.DamdCT.N98RIP 8.556358e-12 5.473753e-17 1.404156e-67  
## CRE.DamFL.D9RIP 5.481425e-07 1.428984e-14 1.398558e-28  
## CRE.DamdCT.D9RIP 1.213211e-06 1.248059e-11 1.744279e-25  
## CRE.DamFL.bothRIP 1.919544e-08 3.125601e-11 2.234810e-28  
## CRE.DamdCT.bothRIP 2.450644e-06 1.218374e-10 1.971842e-23

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98KD.HepG2 Nup98KD.IMR90 DHX9KD.NB1  
## CRE.DamFL.N98RIP 58 62 290  
## CRE.DamdCT.N98RIP 34 40 205  
## CRE.DamFL.D9RIP 22 32 120  
## CRE.DamdCT.D9RIP 17 23 89  
## CRE.DamFL.bothRIP 21 24 101  
## CRE.DamdCT.bothRIP 15 20 77

getNestedList(gom.obj, name="intersection")

## $Nup98KD.HepG2  
## $Nup98KD.HepG2$CRE.DamFL.N98RIP  
## [1] "HMGCR" "CDK6" "NR6A1" "RHOBTB1" "HSD17B12"   
## [6] "MAP1B" "TPM1" "FHL2" "IFRD1" "CPS1"   
## [11] "GDA" "CLDN11" "MBNL2" "LHFPL2" "WDR3"   
## [16] "DNAJB4" "SLC2A2" "LDLR" "HTR1D" "KITLG"   
## [21] "PRRG1" "AOX1" "GCNT2" "CTH" "FYN"   
## [26] "LCP1" "ABLIM1" "MDM2" "PRPS2" "PDHX"   
## [31] "SLC4A7" "SLC25A12" "TNFRSF10B" "CTSS" "STK17B"   
## [36] "SLC16A5" "MAP4K4" "PCYT1B" "BCAT1" "YAP1"   
## [41] "TACC1" "TXNIP" "TOPBP1" "SARDH" "RRAS2"   
## [46] "MYO10" "MAT2B" "CPA4" "RNF125" "PLEKHB2"   
## [51] "ASPM" "ARHGEF3" "CNNM1" "ELOVL6" "CPEB4"   
## [56] "CYGB" "SLC39A11" "NAV2"   
##   
## $Nup98KD.HepG2$CRE.DamdCT.N98RIP  
## [1] "NR6A1" "PIM1" "SDC4" "FHL2" "IFRD1"   
## [6] "CPS1" "FDPS" "GDA" "TCEA1" "DNAJB4"   
## [11] "LDLR" "HTR1D" "KITLG" "PRRG1" "EMP2"   
## [16] "GCNT2" "AKR1B1" "CPT1A" "FYN" "MDM2"   
## [21] "WEE1" "TNFRSF10B" "STK17B" "SLC16A5" "AKAP12"   
## [26] "YAP1" "MYO10" "MAT2B" "GIPC2" "PLEKHB2"   
## [31] "ASPM" "CPVL" "SLC39A11" "NAV2"   
##   
## $Nup98KD.HepG2$CRE.DamFL.D9RIP  
## [1] "HSD17B12" "TPM1" "GDA" "CLDN11" "WDR3"   
## [6] "DNAJB4" "LIPC" "HTR1D" "PRRG1" "AOX1"   
## [11] "GCNT2" "TNFRSF10B" "PCYT1B" "BCAT1" "SARDH"   
## [16] "MYO10" "RNF125" "PLEKHB2" "ASPM" "CPEB4"   
## [21] "CYGB" "NAV2"   
##   
## $Nup98KD.HepG2$CRE.DamdCT.D9RIP  
## [1] "PIM1" "GDA" "DNAJB4" "HECA" "HTR1D"   
## [6] "PRRG1" "SLC6A2" "EMP2" "GCNT2" "WEE1"   
## [11] "TNFRSF10B" "MYO10" "GIPC2" "PLEKHB2" "ASPM"   
## [16] "CPVL" "NAV2"   
##   
## $Nup98KD.HepG2$CRE.DamFL.bothRIP  
## [1] "HSD17B12" "TPM1" "GDA" "CLDN11" "WDR3"   
## [6] "DNAJB4" "HTR1D" "PRRG1" "AOX1" "GCNT2"   
## [11] "TNFRSF10B" "PCYT1B" "BCAT1" "SARDH" "MYO10"   
## [16] "RNF125" "PLEKHB2" "ASPM" "CPEB4" "CYGB"   
## [21] "NAV2"   
##   
## $Nup98KD.HepG2$CRE.DamdCT.bothRIP  
## [1] "PIM1" "GDA" "DNAJB4" "HTR1D" "PRRG1"   
## [6] "EMP2" "GCNT2" "WEE1" "TNFRSF10B" "MYO10"   
## [11] "GIPC2" "PLEKHB2" "ASPM" "CPVL" "NAV2"   
##   
##   
## $Nup98KD.IMR90  
## $Nup98KD.IMR90$CRE.DamFL.N98RIP  
## [1] "ADAM10" "KLF5" "NEO1" "NUP98" "NCOA2"   
## [6] "MAFF" "SSX2IP" "OSBPL1A" "ATF3" "PCDH7"   
## [11] "SHB" "SLC7A2" "STAT3" "ETS2" "LHFPL2"   
## [16] "PPP1R12B" "MDGA1" "PRDM1" "ACADM" "CYP1B1"   
## [21] "LAMA3" "LAMA2" "LDLR" "CD44" "GRIA4"   
## [26] "IL1R1" "PDE3B" "PLAT" "ADM" "ETV4"   
## [31] "FMOD" "FYN" "ITPR1" "KCNMA1" "LAMA4"   
## [36] "MDM2" "SLC3A2" "MYC" "PAPPA" "PAWR"   
## [41] "TNFSF4" "SLC4A7" "PPAP2A" "TNFRSF10B" "BTRC"   
## [46] "CTSS" "SLC1A2" "PDE1A" "APBA2" "MRVI1"   
## [51] "NNMT" "TNFAIP2" "NEDD9" "CHL1" "LPHN2"   
## [56] "NOX4" "CHST11" "MAN1C1" "NAV1" "SLC12A8"   
## [61] "CYBRD1" "CYGB"   
##   
## $Nup98KD.IMR90$CRE.DamdCT.N98RIP  
## [1] "KLF5" "NUP98" "ITGA3" "OSBPL1A" "ATF3"   
## [6] "NFKB2" "STAT3" "WISP1" "EPHA2" "ETS2"   
## [11] "ELN" "LDLR" "IL6R" "BDKRB1" "ADM"   
## [16] "ACTA2" "AKR1B1" "CPT1A" "ETV4" "FYN"   
## [21] "LAMA4" "MDM2" "SLC3A2" "MYC" "PAPPA"   
## [26] "PAWR" "SVIL" "TNFRSF10B" "BTRC" "SLC1A2"   
## [31] "PDE1A" "TNFSF15" "MT2A" "NNMT" "TNFAIP2"   
## [36] "SLC25A13" "RAB30" "CARD10" "SLC40A1" "SLC12A8"   
##   
## $Nup98KD.IMR90$CRE.DamFL.D9RIP  
## [1] "KLF5" "NUP98" "OSBPL1A" "SHB" "STAT3"   
## [6] "ETS2" "SMOC1" "MDGA1" "PRDM1" "ACADM"   
## [11] "LAMA3" "PTEN" "TYRP1" "CD44" "GRIA4"   
## [16] "IL1R1" "ADM" "COL15A1" "ITPR1" "SLC3A2"   
## [21] "PAPPA" "PAWR" "TNFRSF10B" "SLC1A2" "PTGES"   
## [26] "APBA2" "TNFAIP2" "TOX" "COL5A3" "CHST11"   
## [31] "BMP5" "CYGB"   
##   
## $Nup98KD.IMR90$CRE.DamdCT.D9RIP  
## [1] "KLF5" "NUP98" "ITGA3" "OSBPL1A" "STAT3"   
## [6] "ETS2" "PTEN" "ELN" "IL6R" "BDKRB1"   
## [11] "ADM" "ACTA2" "SLC3A2" "PAPPA" "PAWR"   
## [16] "SVIL" "TNFRSF10B" "SLC1A2" "PTGES" "TNFAIP2"   
## [21] "RAB30" "CARD10" "BMP5"   
##   
## $Nup98KD.IMR90$CRE.DamFL.bothRIP  
## [1] "KLF5" "NUP98" "OSBPL1A" "SHB" "STAT3"   
## [6] "ETS2" "MDGA1" "PRDM1" "ACADM" "LAMA3"   
## [11] "CD44" "GRIA4" "IL1R1" "ADM" "ITPR1"   
## [16] "SLC3A2" "PAPPA" "PAWR" "TNFRSF10B" "SLC1A2"   
## [21] "APBA2" "TNFAIP2" "CHST11" "CYGB"   
##   
## $Nup98KD.IMR90$CRE.DamdCT.bothRIP  
## [1] "KLF5" "NUP98" "ITGA3" "OSBPL1A" "STAT3"   
## [6] "ETS2" "ELN" "IL6R" "BDKRB1" "ADM"   
## [11] "ACTA2" "SLC3A2" "PAPPA" "PAWR" "SVIL"   
## [16] "TNFRSF10B" "SLC1A2" "TNFAIP2" "RAB30" "CARD10"   
##   
##   
## $DHX9KD.NB1  
## $DHX9KD.NB1$CRE.DamFL.N98RIP  
## [1] "NF2" "HLCS" "HMGCR" "CDK6" "EPB41L2"   
## [6] "ESRRG" "GMDS" "GNS" "MEIS2" "NEO1"   
## [11] "PDE7A" "PDE8A" "RAD1" "ZYX" "MAP7"   
## [16] "TRIP12" "CREBBP" "NDUFS2" "PCYT1A" "IDH3A"   
## [21] "ACTR1A" "COG5" "USP3" "GNB5" "USP25"   
## [26] "SACM1L" "SSX2IP" "RHOBTB1" "WSB1" "HSD17B12"   
## [31] "TBC1D7" "BCAS3" "POLR1B" "ATP10D" "PREX1"   
## [36] "OSBPL8" "EGLN3" "NXN" "ASPSCR1" "ADAMTS17"   
## [41] "TTC8" "TTL" "GALC" "NR3C1" "NPC1"   
## [46] "LTBP1" "CYP51A1" "FHL2" "NDST1" "IFRD1"   
## [51] "ARNT" "ATP6V1A" "CDK2" "FTH1" "SLC7A2"   
## [56] "TMPO" "VCL" "ADAM23" "B2M" "EPB41"   
## [61] "PRKCE" "TOB1" "LHFPL2" "SPRY2" "NAB1"   
## [66] "MRC2" "ELL" "PACSIN2" "ELL2" "NLGN1"   
## [71] "PHF15" "TRIM37" "SBDS" "IRAK4" "DDX24"   
## [76] "TCF7L2" "PPP1R12B" "MSI2" "ADSL" "BCKDHB"   
## [81] "FBN1" "GALT" "ITGB3" "GPD2" "PCCB"   
## [86] "IL15" "ACACA" "DCK" "GRIA4" "HRH1"   
## [91] "IGF1R" "NQO1" "P4HA1" "PDE3A" "PLAT"   
## [96] "PLOD2" "RYR2" "ADM" "ANXA6" "BMP1"   
## [101] "CASP4" "CPD" "DOCK1" "FHL1" "GTF2I"   
## [106] "ALCAM" "CAPNS1" "CBFB" "CNN3" "COL4A2"   
## [111] "CTSB" "EPS15" "ETV4" "FHIT" "FKBP3"   
## [116] "IARS" "ITGB5" "ITPR2" "LAMB1" "LAMC1"   
## [121] "LIFR" "MAP2" "SLC3A2" "MPV17" "PNN"   
## [126] "POLA2" "MAP2K6" "PRPS2" "PTPN4" "PTPRR"   
## [131] "PXN" "PYGL" "RAP2B" "RDX" "ROBO1"   
## [136] "SDC2" "SORL1" "TBCE" "TCF12" "TIAM1"   
## [141] "TIMP2" "UVRAG" "ZNF202" "PDHX" "PIP5K1A"   
## [146] "BCAR3" "NCK2" "CDC42BPA" "RGS20" "SLC25A12"   
## [151] "VAMP4" "RIOK3" "TNFRSF10B" "SYNJ2" "ADCY3"   
## [156] "GNG11" "STK17B" "TRIP11" "BCL9" "DFNA5"   
## [161] "EPS8" "EZH2" "GALNT2" "NFATC3" "PEX14"   
## [166] "PKP2" "LATS1" "ARHGEF2" "MAP4K4" "PCYT1B"   
## [171] "ROCK2" "LITAF" "ACTN4" "NRCAM" "ABL1"   
## [176] "ABL2" "BCAT1" "LIMK2" "LOXL1" "NFIA"   
## [181] "NFIB" "NFIC" "SLC1A5" "SYT1" "GTF2IRD1"   
## [186] "ACTR2" "HIPK3" "CTDSPL" "ABCC4" "STAG1"   
## [191] "SEMA3A" "YAP1" "VAV3" "DDR2" "PPP1R2"   
## [196] "TACC1" "TYRO3" "XRCC1" "BAIAP2" "SLC25A17"   
## [201] "UNC13B" "TRIM16" "ZNF217" "AKAP13" "SSFA2"   
## [206] "RAB31" "SOX5" "ZNF33A" "WWP2" "CDC42EP1"   
## [211] "TRIO" "DDX42" "CRB1" "AK5" "CASP8AP2"   
## [216] "DDAH1" "FBXL5" "LPHN2" "RPS6KC1" "SLCO3A1"   
## [221] "SNX12" "PCOLCE2" "BAZ1A" "BAZ2B" "SOCS5"   
## [226] "TMOD3" "CYFIP1" "PHF14" "LAPTM4A" "TBC1D5"   
## [231] "BTBD3" "POGZ" "TRIM2" "CLASP1" "POLR1A"   
## [236] "AUTS2" "KCTD3" "LEF1" "CENPF" "ANKFY1"   
## [241] "GALNT10" "CHRNA9" "PLEKHB2" "PACS1" "FANCL"   
## [246] "KIRREL" "LRRN3" "CENPJ" "ERBB2IP" "CLN8"   
## [251] "ARHGEF3" "TUFT1" "EIF2B3" "PHTF2" "PELI1"   
## [256] "KIAA1324" "GPHN" "PITPNM2" "SH3RF1" "NMT1"   
## [261] "CFL2" "TEAD1" "CSNK1G1" "EGLN1" "EPB41L4A"   
## [266] "DNAJC1" "DCLRE1C" "HIVEP3" "ZDHHC14" "CPEB4"   
## [271] "DUSP16" "SLC38A1" "GABARAPL1" "SH3KBP1" "C1QTNF6"   
## [276] "KCTD10" "CHD6" "CAMKK1" "GPR124" "ZDHHC12"   
## [281] "TRIM5" "ARHGAP18" "ADAMTSL1" "S100A16" "NEK7"   
## [286] "STXBP5" "TTBK2" "JAZF1" "NCOA7" "ADCY5"   
##   
## $DHX9KD.NB1$CRE.DamdCT.N98RIP  
## [1] "HLCS" "CHEK1" "EPB41L2" "ESRRG" "CREM"   
## [6] "MPP3" "GNS" "PDE8A" "PIM1" "PTPRJ"   
## [11] "PTPRS" "RAD1" "SLC7A5" "MAP7" "PRKAB2"   
## [16] "ACTR1A" "RASSF1" "USP25" "HABP4" "MDN1"   
## [21] "PHYHIP" "CHSY1" "CHD5" "WSB1" "GADD45B"   
## [26] "KLF13" "RAB14" "WBSCR22" "POLR1B" "EML4"   
## [31] "PREX1" "NXN" "ASPSCR1" "SP1" "TTC8"   
## [36] "NR3C1" "LTBP1" "CYP51A1" "PAM" "FHL2"   
## [41] "IFRD1" "ATP6V1A" "ID1" "MAP3K11" "NFKB2"   
## [46] "UAP1" "TMPO" "VCL" "FABP3" "EPB41"   
## [51] "RAB5C" "ATP5G1" "ATP5G2" "TAF12" "SPRY2"   
## [56] "CD164" "TCEA1" "PACSIN2" "PHF15" "ACTR6"   
## [61] "TCF7L2" "MSI2" "ADSL" "FBN1" "NAGLU"   
## [66] "PCCB" "SLC11A2" "ALDH3B1" "DCK" "HRH1"   
## [71] "IGF1R" "NQO1" "PDE3A" "TKT" "ADM"   
## [76] "CASP8" "DNASE2" "DOCK1" "EMP2" "FHL1"   
## [81] "GTF2I" "AARS" "ALCAM" "CBFB" "CNN3"   
## [86] "ATF2" "CTNNA1" "ETV4" "INPP1" "ITGB5"   
## [91] "LAMC1" "LOXL2" "SLC3A2" "MPV17" "NPAS2"   
## [96] "PRDX1" "POLA2" "POLR2G" "PTPN4" "PTPRR"   
## [101] "PXN" "RANGAP1" "ROBO1" "SHC1" "SMARCA4"   
## [106] "TBCE" "TCF12" "TIMP2" "TJP1" "UVRAG"   
## [111] "WEE1" "PIP5K1A" "BCAR3" "PIK3R3" "CTSF"   
## [116] "TNFRSF10B" "SYNJ2" "ADCY3" "STK17B" "BCL9"   
## [121] "DFNA5" "GALNT2" "PSPH" "SNRPA" "LATS1"   
## [126] "HS6ST1" "ROCK2" "LITAF" "ABCG1" "ACTN4"   
## [131] "MARK2" "ABCC1" "ABL1" "ABL2" "CAPN1"   
## [136] "PODXL" "PPP1R3C" "HSPG2" "NFIA" "NFIB"   
## [141] "NFIC" "SLC1A5" "GTF2IRD1" "DPP3" "HIPK3"   
## [146] "FARP1" "RBM6" "ABCC4" "STAG1" "MT2A"   
## [151] "TBX1" "YAP1" "VAV3" "DDR2" "PPP1R2"   
## [156] "LYPLA1" "BAIAP2" "TRIM16" "NCOA3" "GMEB1"   
## [161] "TFEB" "CRB1" "PGLS" "AK5" "CASP8AP2"   
## [166] "ESPL1" "KPNA6" "RPS6KC1" "SOCS5" "HIBCH"   
## [171] "TAF5L" "ARFGAP3" "ERO1L" "PHF14" "TBC1D5"   
## [176] "AUTS2" "KCTD3" "LEF1" "ANKFY1" "PLEKHB2"   
## [181] "PACS1" "EFHC1" "CLN8" "CPVL" "SH3RF1"   
## [186] "NMT1" "POLD4" "DTNB" "LHPP" "ZDHHC14"   
## [191] "DUSP16" "SLC38A1" "MRPL9" "C1QTNF6" "CAMKK1"   
## [196] "LACTB" "ABCC10" "SOCS7" "NEK7" "STXBP5"   
## [201] "LACE1" "GJC1" "JAZF1" "NEK8" "OXR1"   
##   
## $DHX9KD.NB1$CRE.DamFL.D9RIP  
## [1] "ESRRG" "PDE8A" "ZYX" "PCYT1A" "IDH3A"   
## [6] "GNB5" "HSD17B12" "CRIM1" "BCAS3" "PREX1"   
## [11] "EGLN3" "ADAMTS17" "NR3C1" "CYP51A1" "NDST1"   
## [16] "TOP1" "B2M" "GNG7" "SPRY2" "ELL"   
## [21] "UBL3" "PACSIN2" "ELL2" "TCF7L2" "FBN1"   
## [26] "GALT" "GPD2" "IL15" "ANXA1" "GRIA4"   
## [31] "HRH1" "IGF1R" "NQO1" "PDE3A" "ADM"   
## [36] "ANXA6" "CASP4" "DOCK1" "ENO1" "GTF2I"   
## [41] "COL4A2" "FKBP3" "IARS" "KCNH1" "LIFR"   
## [46] "SLC3A2" "NTRK3" "PTPRR" "PYGL" "SDC2"   
## [51] "TBCE" "TIAM1" "TNR" "PIP5K1A" "BCAR3"   
## [56] "NCK2" "CDC42BPA" "TNFRSF10B" "EIF2S2" "ADCY3"   
## [61] "GNG11" "NEURL" "EPS8" "GALNT2" "NFATC3"   
## [66] "PCYT1B" "LITAF" "PTGES" "ACTN4" "ABL2"   
## [71] "BCAT1" "LIMK2" "LOXL1" "NFIA" "NFIB"   
## [76] "SYT1" "BAIAP2" "SLC25A17" "TRIM16" "PDE10A"   
## [81] "AKAP13" "WWP2" "CDC42EP1" "TRIO" "DDX42"   
## [86] "CRB1" "FBXL5" "SLCO3A1" "BAZ1A" "TMOD3"   
## [91] "SLK" "POLR1A" "ANKFY1" "PLEKHB2" "KIRREL"   
## [96] "LRRN3" "CLN8" "TUFT1" "EIF2B3" "KIAA1324"   
## [101] "GPHN" "NMT1" "CSNK1G1" "EPB41L4A" "HIVEP3"   
## [106] "ZDHHC14" "CPEB4" "C1QTNF6" "PHF6" "ABLIM2"   
## [111] "GPR124" "ZDHHC12" "TRIM5" "ADAMTSL1" "NEK7"   
## [116] "RAB3C" "SEPT10" "TTBK2" "THAP5" "ADCY5"   
##   
## $DHX9KD.NB1$CRE.DamdCT.D9RIP  
## [1] "CHEK1" "ESRRG" "PDE8A" "PIM1" "RNASEH2A"   
## [6] "HABP4" "NPTXR" "PHYHIP" "GADD45B" "CRIM1"   
## [11] "PREX1" "NR3C1" "CYP51A1" "ID1" "RAB5C"   
## [16] "GNG7" "ATP5G1" "SPRY2" "PACSIN2" "HECA"   
## [21] "TCF7L2" "FBN1" "NAGLU" "ANXA1" "HRH1"   
## [26] "IGF1R" "NQO1" "PDE3A" "SLC6A2" "TKT"   
## [31] "ADM" "DOCK1" "EMP2" "GTF2I" "CTNNA1"   
## [36] "INPP1" "LOXL2" "SLC3A2" "NPAS2" "PRDX1"   
## [41] "POLR2G" "PTPRR" "RANGAP1" "TBCE" "TJP1"   
## [46] "WEE1" "PIP5K1A" "BCAR3" "PIK3R3" "TNFRSF10B"  
## [51] "ADCY3" "GALNT2" "LITAF" "PTGES" "ABCG1"   
## [56] "ACTN4" "ABL2" "PPP1R3C" "HSPG2" "LAMP1"   
## [61] "NFIA" "NFIB" "DPP3" "RBM6" "TBX1"   
## [66] "BAIAP2" "TRIM16" "NCOA3" "EHD1" "TFEB"   
## [71] "CRB1" "PGLS" "HS2ST1" "KPNA6" "HIBCH"   
## [76] "ARFGAP3" "ANKFY1" "PLEKHB2" "CLN8" "CPVL"   
## [81] "NMT1" "ZDHHC14" "MRPL9" "C1QTNF6" "ABLIM2"   
## [86] "LACTB" "ABCC10" "NEK7" "NEK8"   
##   
## $DHX9KD.NB1$CRE.DamFL.bothRIP  
## [1] "ESRRG" "PDE8A" "ZYX" "PCYT1A" "IDH3A"   
## [6] "GNB5" "HSD17B12" "BCAS3" "PREX1" "EGLN3"   
## [11] "ADAMTS17" "NR3C1" "CYP51A1" "NDST1" "B2M"   
## [16] "SPRY2" "ELL" "PACSIN2" "ELL2" "TCF7L2"   
## [21] "FBN1" "GALT" "GPD2" "IL15" "GRIA4"   
## [26] "HRH1" "IGF1R" "NQO1" "PDE3A" "ADM"   
## [31] "ANXA6" "CASP4" "DOCK1" "GTF2I" "COL4A2"   
## [36] "FKBP3" "IARS" "LIFR" "SLC3A2" "PTPRR"   
## [41] "PYGL" "SDC2" "TBCE" "TIAM1" "PIP5K1A"   
## [46] "BCAR3" "NCK2" "CDC42BPA" "TNFRSF10B" "ADCY3"   
## [51] "GNG11" "EPS8" "GALNT2" "NFATC3" "PCYT1B"   
## [56] "LITAF" "ACTN4" "ABL2" "BCAT1" "LIMK2"   
## [61] "LOXL1" "NFIA" "NFIB" "SYT1" "BAIAP2"   
## [66] "SLC25A17" "TRIM16" "AKAP13" "WWP2" "CDC42EP1"   
## [71] "TRIO" "DDX42" "CRB1" "FBXL5" "SLCO3A1"   
## [76] "BAZ1A" "TMOD3" "POLR1A" "ANKFY1" "PLEKHB2"   
## [81] "KIRREL" "LRRN3" "CLN8" "TUFT1" "EIF2B3"   
## [86] "KIAA1324" "GPHN" "NMT1" "CSNK1G1" "EPB41L4A"   
## [91] "HIVEP3" "ZDHHC14" "CPEB4" "C1QTNF6" "GPR124"   
## [96] "ZDHHC12" "TRIM5" "ADAMTSL1" "NEK7" "TTBK2"   
## [101] "ADCY5"   
##   
## $DHX9KD.NB1$CRE.DamdCT.bothRIP  
## [1] "CHEK1" "ESRRG" "PDE8A" "PIM1" "HABP4"   
## [6] "PHYHIP" "GADD45B" "PREX1" "NR3C1" "CYP51A1"   
## [11] "ID1" "RAB5C" "ATP5G1" "SPRY2" "PACSIN2"   
## [16] "TCF7L2" "FBN1" "NAGLU" "HRH1" "IGF1R"   
## [21] "NQO1" "PDE3A" "TKT" "ADM" "DOCK1"   
## [26] "EMP2" "GTF2I" "CTNNA1" "INPP1" "LOXL2"   
## [31] "SLC3A2" "NPAS2" "PRDX1" "POLR2G" "PTPRR"   
## [36] "RANGAP1" "TBCE" "TJP1" "WEE1" "PIP5K1A"   
## [41] "BCAR3" "PIK3R3" "TNFRSF10B" "ADCY3" "GALNT2"   
## [46] "LITAF" "ABCG1" "ACTN4" "ABL2" "PPP1R3C"   
## [51] "HSPG2" "NFIA" "NFIB" "DPP3" "RBM6"   
## [56] "TBX1" "BAIAP2" "TRIM16" "NCOA3" "TFEB"   
## [61] "CRB1" "PGLS" "KPNA6" "HIBCH" "ARFGAP3"   
## [66] "ANKFY1" "PLEKHB2" "CLN8" "CPVL" "NMT1"   
## [71] "ZDHHC14" "MRPL9" "C1QTNF6" "LACTB" "ABCC10"   
## [76] "NEK7" "NEK8"

## Compare CRE containing genes, bound by Dam-Nup98, bound to RNA-IP of Nup98 or DHX9 to genes with altered splicing upon Nup98 or DHX9 KD

Table of p-values

gom.obj <- newGOM(N98Dam.CRE.RIP, Splice.all, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98KD.HepG2 Nup98KD.IMR90 DHX9KD.NB1  
## CRE.DamFL.N98RIP 3.568999e-34 1.330982e-39 1.359331e-22  
## CRE.DamdCT.N98RIP 8.727141e-18 1.145908e-29 7.103040e-18  
## CRE.DamFL.D9RIP 6.249886e-11 1.731011e-07 6.247124e-11  
## CRE.DamdCT.D9RIP 1.797240e-08 1.505827e-04 7.597436e-07  
## CRE.DamFL.bothRIP 2.097131e-11 1.327236e-07 4.032745e-10  
## CRE.DamdCT.bothRIP 7.034966e-09 2.640526e-05 7.120887e-07

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98KD.HepG2 Nup98KD.IMR90 DHX9KD.NB1  
## CRE.DamFL.N98RIP 99 121 71  
## CRE.DamdCT.N98RIP 58 85 51  
## CRE.DamFL.D9RIP 39 38 34  
## CRE.DamdCT.D9RIP 27 23 21  
## CRE.DamFL.bothRIP 34 32 28  
## CRE.DamdCT.bothRIP 25 22 19

getNestedList(gom.obj, name="intersection")

## $Nup98KD.HepG2  
## $Nup98KD.HepG2$CRE.DamFL.N98RIP  
## [1] "HLCS" "THRB" "MEIS2" "NFX1" "NUP155" "NOLC1"   
## [7] "MYO6" "CLIC4" "GLS" "KIFAP3" "ANGPTL4" "BCAS3"   
## [13] "GDAP2" "OSBPL8" "OSBPL9" "ZNF341" "TPM3" "UBR1"   
## [19] "DMD" "PMS2" "CDK2" "CPS1" "SLC7A2" "HIVEP2"   
## [25] "MYO9A" "IRAK4" "SFMBT1" "PKD2" "LTA4H" "ANXA6"   
## [31] "ATR" "BMP1" "CCNT2" "FLNB" "CTH" "ITPR1"   
## [37] "KRT8" "NDUFC1" "POLA2" "MAP2K5" "SPTAN1" "TBP"   
## [43] "TSSC1" "UVRAG" "ZNF202" "PIP5K1A" "PPFIBP1" "PRC1"   
## [49] "ELF3" "ARHGEF2" "RASAL2" "MAP3K8" "ETS1" "LMO7"   
## [55] "SDCBP" "HIPK3" "YAP1" "TFPI" "FRS2" "AKAP13"   
## [61] "ZNF33A" "TOPBP1" "TRIO" "CIT" "RNF24" "CHORDC1"   
## [67] "SCMH1" "SIRT4" "CNOT4" "STAU2" "MELK" "HELZ"   
## [73] "KIAA0922" "PUM2" "OPA1" "PCF11" "GALNT10" "USP47"   
## [79] "SLC30A6" "CENPJ" "ERBB2IP" "TUFT1" "NDRG4" "NMT1"   
## [85] "MTMR3" "PTBP2" "DHX35" "C14orf93" "TEAD1" "ZNF148"   
## [91] "KIF13A" "DCLRE1C" "BICC1" "TDRD3" "KCTD10" "TRIM5"   
## [97] "BTBD9" "APBB2" "NCOA7"   
##   
## $Nup98KD.HepG2$CRE.DamdCT.N98RIP  
## [1] "HLCS" "THRB" "MARK3" "NUP155" "BIN1" "NOLC1"   
## [7] "HDAC5" "NCOR2" "MAP4K5" "MDN1" "EML4" "SP1"   
## [13] "TPM3" "DMD" "CPS1" "RACGAP1" "BBX" "PSEN2"   
## [19] "LTA4H" "CASP8" "FLNB" "KRT8" "POLA2" "MAP2K5"   
## [25] "UGCG" "UVRAG" "PIP5K1A" "PLA2G6" "PRC1" "RASAL2"   
## [31] "ABCC1" "MAP3K8" "HIPK3" "YAP1" "TFPI" "GMEB1"   
## [37] "TLK2" "ZNF92" "CHEK2" "CHORDC1" "STAU2" "RAB30"   
## [43] "ARHGEF11" "HELZ" "DHX30" "KIAA0922" "USP47" "TBC1D2"   
## [49] "ABCB9" "AGTRAP" "NMT1" "MTMR3" "KIF13A" "ABCC10"   
## [55] "BTBD9" "NEK8" "OXR1" "GPR133"   
##   
## $Nup98KD.HepG2$CRE.DamFL.D9RIP  
## [1] "THRB" "DDX10" "NOLC1" "KIFAP3" "ANGPTL4" "BCAS3"   
## [7] "OSBPL9" "TPM3" "DMD" "HIVEP2" "MYO9A" "LTA4H"   
## [13] "ANXA6" "CCNT2" "FLNB" "ITPR1" "NDUFC1" "TSSC1"   
## [19] "PIP5K1A" "PRC1" "CDKN3" "FRS2" "AKAP13" "TRIO"   
## [25] "CNOT4" "STAU2" "HELZ" "TUFT1" "SMURF1" "NMT1"   
## [31] "MTMR3" "C14orf93" "KIF13A" "TDRD3" "PHF6" "TRIM5"   
## [37] "JMY" "BTBD9" "APBB2"   
##   
## $Nup98KD.HepG2$CRE.DamdCT.D9RIP  
## [1] "THRB" "BIN1" "NOLC1" "HDAC5" "MAP4K5" "TPM3" "DMD"   
## [8] "RACGAP1" "LTA4H" "FLNB" "UGCG" "PIP5K1A" "PRC1" "TLK2"   
## [15] "STAU2" "RAB30" "HELZ" "DHX30" "NMT1" "MTMR3" "KIF13A"   
## [22] "ABCC10" "JMY" "BTBD9" "GPR97" "NEK8" "GPR133"   
##   
## $Nup98KD.HepG2$CRE.DamFL.bothRIP  
## [1] "THRB" "NOLC1" "KIFAP3" "ANGPTL4" "BCAS3" "OSBPL9"   
## [7] "TPM3" "DMD" "HIVEP2" "MYO9A" "LTA4H" "ANXA6"   
## [13] "CCNT2" "FLNB" "ITPR1" "NDUFC1" "TSSC1" "PIP5K1A"   
## [19] "PRC1" "FRS2" "AKAP13" "TRIO" "CNOT4" "STAU2"   
## [25] "HELZ" "TUFT1" "NMT1" "MTMR3" "C14orf93" "KIF13A"   
## [31] "TDRD3" "TRIM5" "BTBD9" "APBB2"   
##   
## $Nup98KD.HepG2$CRE.DamdCT.bothRIP  
## [1] "THRB" "BIN1" "NOLC1" "HDAC5" "MAP4K5" "TPM3" "DMD"   
## [8] "RACGAP1" "LTA4H" "FLNB" "UGCG" "PIP5K1A" "PRC1" "TLK2"   
## [15] "STAU2" "RAB30" "HELZ" "DHX30" "NMT1" "MTMR3" "KIF13A"   
## [22] "ABCC10" "BTBD9" "NEK8" "GPR133"   
##   
##   
## $Nup98KD.IMR90  
## $Nup98KD.IMR90$CRE.DamFL.N98RIP  
## [1] "MLH1" "NF2" "HLCS" "GOLGA4" "MEIS2"   
## [6] "RAD1" "SAFB" "SRP54" "SMS" "NOLC1"   
## [11] "METTL1" "TIMM44" "FBXL2" "TLK1" "USP25"   
## [16] "SSX2IP" "OSBPL8" "ASPSCR1" "STK11IP" "TTC8"   
## [21] "TPM3" "MITF" "PHKB" "CACNA2D1" "CDK7"   
## [26] "STAT3" "ADAM23" "RUNX2" "TOB1" "TACC2"   
## [31] "KIAA0391" "PHF15" "TRIM37" "IRAK4" "PARD3"   
## [36] "PC" "TCF7L2" "CPEB2" "HADHA" "ALPL"   
## [41] "LDLR" "ATR" "AUH" "CLTCL1" "GSPT1"   
## [46] "IL7R" "ITPR1" "MYC" "PHKA1" "PIK3C2B"   
## [51] "MAP2K5" "PRPS2" "ROBO1" "TGFBR3" "ZNF202"   
## [56] "EED" "TNFRSF10B" "HERC1" "BTRC" "BCL9"   
## [61] "EZH2" "LATS1" "RASAL2" "ABL2" "APBA2"   
## [66] "DMXL1" "SDCBP" "CTDSPL" "PTPN13" "TRIM16"   
## [71] "RASA2" "CHL1" "AKAP13" "ZNF33A" "TOPBP1"   
## [76] "KATNA1" "UTRN" "CIT" "RNF13" "CHORDC1"   
## [81] "SCMH1" "RPS6KC1" "CNOT4" "NME7" "SNX12"   
## [86] "NCOA6" "TRPS1" "KCNK2" "ADAMTS6" "STAU2"   
## [91] "SENP1" "PHF14" "MELK" "HELZ" "USP33"   
## [96] "KIAA0922" "CLASP1" "OPA1" "VPS54" "NOX4"   
## [101] "CDKAL1" "PLEKHB2" "FANCL" "CDK5RAP2" "STRBP"   
## [106] "ERBB2IP" "TUFT1" "MCCC1" "PITPNM2" "PTBP2"   
## [111] "DHX35" "C14orf93" "TEAD1" "ALG8" "CYBRD1"   
## [116] "TDRD3" "SH3KBP1" "CAMKK1" "SYTL2" "FOXP1"   
## [121] "SOX6"   
##   
## $Nup98KD.IMR90$CRE.DamdCT.N98RIP  
## [1] "HLCS" "GOLGA4" "PTPRS" "RAD1" "ZFX"   
## [6] "NFKB1" "BIN1" "LRP8" "NOLC1" "LDHA"   
## [11] "PTPRU" "NCOR2" "FBXL2" "USP25" "MDN1"   
## [16] "UBAP1" "WBSCR22" "BCOR" "ASPSCR1" "TTC8"   
## [21] "TPM3" "MITF" "CASP9" "SPG7" "STAT3"   
## [26] "THRA" "WISP1" "BRAF" "TCEA1" "PHF15"   
## [31] "PPHLN1" "PC" "TCF7L2" "RFX5" "LDLR"   
## [36] "IL6R" "MYC" "PHKA1" "PIK3C2B" "MAP2K5"   
## [41] "ROBO1" "TJP1" "PLA2G6" "TNFRSF10B" "CFLAR"   
## [46] "BTRC" "CCBL1" "BCL9" "LATS1" "RASAL2"   
## [51] "MARK2" "AKAP12" "ABL2" "TRIM16" "RASA2"   
## [56] "NCOA3" "TLK2" "KATNA1" "TEP1" "UTRN"   
## [61] "ZNF92" "CHEK2" "RNF13" "CHORDC1" "FBXO22"   
## [66] "RPS6KC1" "NME7" "ADAMTS6" "STAU2" "PHF14"   
## [71] "ARHGEF11" "HELZ" "USP33" "KIAA0922" "NOSIP"   
## [76] "PLEKHB2" "CDK5RAP2" "TBC1D2" "MRPL1" "AGTRAP"   
## [81] "MPHOSPH9" "CAMKK1" "SOX6" "GATS" "OXR1"   
##   
## $Nup98KD.IMR90$CRE.DamFL.D9RIP  
## [1] "MLH1" "SAFB" "SRP54" "NOLC1" "TIMM44"   
## [6] "STK11IP" "TPM3" "PHKB" "CDK7" "STAT3"   
## [11] "TACC2" "TCF7L2" "HADHA" "TYRP1" "IL7R"   
## [16] "ITPR1" "NRIP1" "TNFRSF10B" "GLP2R" "ABL2"   
## [21] "EYA2" "APBA2" "PTPN13" "TRIM16" "PDE10A"   
## [26] "AKAP13" "RNF13" "CNOT4" "STAU2" "HELZ"   
## [31] "CDKAL1" "PLEKHB2" "STRBP" "TUFT1" "MCCC1"   
## [36] "C14orf93" "TDRD3" "SEPT10"   
##   
## $Nup98KD.IMR90$CRE.DamdCT.D9RIP  
## [1] "NFKB1" "BIN1" "NOLC1" "PTPRU" "BCOR"   
## [6] "TPM3" "STAT3" "THRA" "PPHLN1" "TCF7L2"   
## [11] "RFX5" "IL6R" "TJP1" "TNFRSF10B" "WTAP"   
## [16] "ABL2" "TRIM16" "NCOA3" "TLK2" "RNF13"   
## [21] "STAU2" "HELZ" "PLEKHB2"   
##   
## $Nup98KD.IMR90$CRE.DamFL.bothRIP  
## [1] "MLH1" "SAFB" "SRP54" "NOLC1" "TIMM44"   
## [6] "STK11IP" "TPM3" "PHKB" "CDK7" "STAT3"   
## [11] "TACC2" "TCF7L2" "HADHA" "IL7R" "ITPR1"   
## [16] "TNFRSF10B" "ABL2" "APBA2" "PTPN13" "TRIM16"   
## [21] "AKAP13" "RNF13" "CNOT4" "STAU2" "HELZ"   
## [26] "CDKAL1" "PLEKHB2" "STRBP" "TUFT1" "MCCC1"   
## [31] "C14orf93" "TDRD3"   
##   
## $Nup98KD.IMR90$CRE.DamdCT.bothRIP  
## [1] "NFKB1" "BIN1" "NOLC1" "PTPRU" "BCOR"   
## [6] "TPM3" "STAT3" "THRA" "PPHLN1" "TCF7L2"   
## [11] "RFX5" "IL6R" "TJP1" "TNFRSF10B" "ABL2"   
## [16] "TRIM16" "NCOA3" "TLK2" "RNF13" "STAU2"   
## [21] "HELZ" "PLEKHB2"   
##   
##   
## $DHX9KD.NB1  
## $DHX9KD.NB1$CRE.DamFL.N98RIP  
## [1] "RRM1" "ADAM10" "CDK6" "NEO1" "TIMM44" "USP3"   
## [7] "MAN1A2" "ASXL1" "ZFP64" "OSBPL9" "ZNF341" "NPC1"   
## [13] "ATP1B3" "STAT3" "TOB1" "NAB1" "MRPS27" "SPAG9"   
## [19] "CPEB2" "ACADM" "ADSL" "AGL" "PKD2" "UBE3A"   
## [25] "P4HA1" "ADM" "CBFB" "CNN3" "ITPR1" "MPV17"   
## [31] "MAP2K5" "MAP2K6" "RAP1A" "SPTAN1" "NSMAF" "CDC42BPA"  
## [37] "PRPF4B" "PRC1" "CDKL1" "ILK" "DGKI" "LRRFIP1"   
## [43] "APBA2" "BCAT1" "KIFC3" "LIMK2" "NFIB" "XRCC1"   
## [49] "BAIAP2" "SDCCAG8" "PKIG" "PITPNC1" "STK39" "SLCO3A1"   
## [55] "STAU2" "PDCD4" "DAAM1" "PUM2" "POLR1A" "NUP54"   
## [61] "SLC30A6" "ASPM" "STRBP" "CHST11" "SLC12A9" "NAV1"   
## [67] "MTMR3" "EPB41L4A" "ALG8" "CAMKK1" "NCOA7"   
##   
## $DHX9KD.NB1$CRE.DamdCT.N98RIP  
## [1] "CANX" "CREM" "TPD52L2" "PPFIA1" "TFCP2" "AP3S2"   
## [7] "ZFR" "NASP" "PAM" "STAT3" "MRPS27" "ADSL"   
## [13] "ACTB" "ADM" "CASP8" "CBFB" "CNN3" "CSNK1E"   
## [19] "IVD" "MPV17" "PPP2R5C" "MAP2K5" "PRPF4B" "PRC1"   
## [25] "CSRP1" "CDKL1" "TOP3A" "ABCC1" "KIFC3" "NFIB"   
## [31] "NR1H3" "DPP3" "PLTP" "RAD21" "BAIAP2" "PKIG"   
## [37] "PITPNC1" "SLC25A13" "STAU2" "TAF5L" "PDCD4" "ERO1L"   
## [43] "DAAM1" "NUSAP1" "ASPM" "ABCB9" "SLC12A9" "MTMR3"   
## [49] "CAMKK1" "ITPA" "GATS"   
##   
## $DHX9KD.NB1$CRE.DamFL.D9RIP  
## [1] "HSPA4" "TIMM44" "ASXL1" "OSBPL9" "ATP1B3" "STAT3"   
## [7] "ACADM" "ADM" "ITPR1" "PTPRG" "RAP1A" "NSMAF"   
## [13] "CDC42BPA" "PRC1" "DGKI" "APBA2" "BCAT1" "LIMK2"   
## [19] "NFIB" "BAIAP2" "PKIG" "SLCO3A1" "STAU2" "POLR1A"   
## [25] "SLC35A5" "ASPM" "STRBP" "CHST11" "SLC12A9" "MTMR3"   
## [31] "EPB41L4A" "PHF6" "RAB3C" "THAP5"   
##   
## $DHX9KD.NB1$CRE.DamdCT.D9RIP  
## [1] "CANX" "PPFIA1" "RIOK1" "NASP" "STAT3" "ADM" "PPP2R5C"  
## [8] "PTPRG" "PRC1" "CSRP1" "TOP3A" "NFIB" "DPP3" "PLTP"   
## [15] "BAIAP2" "PKIG" "STAU2" "NUSAP1" "ASPM" "SLC12A9" "MTMR3"   
##   
## $DHX9KD.NB1$CRE.DamFL.bothRIP  
## [1] "TIMM44" "ASXL1" "OSBPL9" "ATP1B3" "STAT3" "ACADM"   
## [7] "ADM" "ITPR1" "RAP1A" "NSMAF" "CDC42BPA" "PRC1"   
## [13] "DGKI" "APBA2" "BCAT1" "LIMK2" "NFIB" "BAIAP2"   
## [19] "PKIG" "SLCO3A1" "STAU2" "POLR1A" "ASPM" "STRBP"   
## [25] "CHST11" "SLC12A9" "MTMR3" "EPB41L4A"  
##   
## $DHX9KD.NB1$CRE.DamdCT.bothRIP  
## [1] "CANX" "PPFIA1" "NASP" "STAT3" "ADM" "PPP2R5C" "PRC1"   
## [8] "CSRP1" "TOP3A" "NFIB" "DPP3" "PLTP" "BAIAP2" "PKIG"   
## [15] "STAU2" "NUSAP1" "ASPM" "SLC12A9" "MTMR3"

## Subsetting genes with altered expression upon DHX9 KD and Nup98 KD that change in the same direction

Given a change in expression upon DHX9 KD, consider true if it changes in the same direction in either Nup98 KD dataset (upreg, downreg and alldir datasets).

Percent of DHX9 KD upregulated genes also upregulated in either Nup98 KD:

length(Transcript$changesameboth$upreg)/length(Transcript$up$DHX9KD.NB1)\*100

## [1] 16.32463

Percent of DHX9 KD downregulated genes also downregulated in either Nup98 KD:

length(Transcript$changesameboth$downreg)/length(Transcript$down$DHX9KD.NB1)\*100

## [1] 24.85429

For comparison, also create datasets of genes that change in the same direction upon Nup98 KD in the 2 different cell lines (datasets bothupN98 – 175 genes, bothdownN98 – 167 genes, bothallN98 – 342 genes):

Percent of Nup98 KD upregulated genes in both cell lines:

length(Transcript$changesameboth$bothupN98)/length(Transcript$up$Nup98KD.HepG2)\*100

## [1] 31.1943

Percent of Nup98 KD downregulated genes in both cell lines:

length(Transcript$changesameboth$bothdownN98)/length(Transcript$down$Nup98KD.IMR90)\*100

## [1] 41.85464

# Compare genes with similarly altered expression upon DHX9 or Nup98 KD to genes bound by Dam-Nup98

Table of p-values

gom.obj <- newGOM(Transcript$changesameboth, Dam.all, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98FL Nup98dCTD  
## upreg 1.246803e-06 1.001008e-06  
## downreg 1.251822e-03 4.783581e-01  
## alldir 5.781723e-09 1.013736e-05  
## bothupN98 7.696832e-06 7.049577e-02  
## bothdownN98 3.839536e-01 2.942224e-02  
## bothallN98 7.055005e-06 9.100411e-03

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98FL Nup98dCTD  
## upreg 18 14  
## downreg 9 2  
## alldir 27 16  
## bothupN98 12 4  
## bothdownN98 1 2  
## bothallN98 13 6

getNestedList(gom.obj, name="intersection")

## $Nup98FL  
## $Nup98FL$upreg  
## [1] "GRK5" "RHOBTB1" "YAP1" "OAF" "SRGAP1" "STON2" "ETV4"   
## [8] "MAP4K4" "SERTAD2" "FHL2" "TMEM158" "UTP3" "PALLD" "CDK6"   
## [15] "SLC7A2" "PLAT" "NCS1" "PCYT1B"   
##   
## $Nup98FL$downreg  
## [1] "PPP1R12B" "SSX2IP" "HSD17B12" "GRIA4" "TXNDC16" "CLIP4"   
## [7] "FAM105A" "ARL4A" "TACC1"   
##   
## $Nup98FL$alldir  
## [1] "GRK5" "RHOBTB1" "YAP1" "OAF" "SRGAP1" "STON2"   
## [7] "ETV4" "MAP4K4" "SERTAD2" "FHL2" "TMEM158" "UTP3"   
## [13] "PALLD" "CDK6" "SLC7A2" "PLAT" "NCS1" "PCYT1B"   
## [19] "PPP1R12B" "SSX2IP" "HSD17B12" "GRIA4" "TXNDC16" "CLIP4"   
## [25] "FAM105A" "ARL4A" "TACC1"   
##   
## $Nup98FL$bothupN98  
## [1] "C1orf9" "CTSS" "MDM2" "PHLDA1" "TTC7B"   
## [6] "CYGB" "QPCT" "SLC4A7" "LHFPL2" "FYN"   
## [11] "TNFRSF10B" "MOSPD1"   
##   
## $Nup98FL$bothdownN98  
## [1] "LDLR"  
##   
## $Nup98FL$bothallN98  
## [1] "C1orf9" "CTSS" "MDM2" "PHLDA1" "TTC7B"   
## [6] "CYGB" "QPCT" "SLC4A7" "LHFPL2" "FYN"   
## [11] "TNFRSF10B" "MOSPD1" "LDLR"   
##   
##   
## $Nup98dCTD  
## $Nup98dCTD$upreg  
## [1] "NFKB2" "ITPRIP" "YAP1" "SRGAP1" "TESC" "SLC6A2" "MT2A"   
## [8] "EMP2" "ETV4" "DOCK6" "SERTAD2" "FHL2" "PALLD" "DENND2A"  
##   
## $Nup98dCTD$downreg  
## [1] "TRNP1" "CLIP4"  
##   
## $Nup98dCTD$alldir  
## [1] "NFKB2" "ITPRIP" "YAP1" "SRGAP1" "TESC" "SLC6A2" "MT2A"   
## [8] "EMP2" "ETV4" "DOCK6" "SERTAD2" "FHL2" "PALLD" "DENND2A"  
## [15] "TRNP1" "CLIP4"   
##   
## $Nup98dCTD$bothupN98  
## [1] "ITPRIP" "MDM2" "FYN" "TNFRSF10B"  
##   
## $Nup98dCTD$bothdownN98  
## [1] "CPT1A" "LDLR"   
##   
## $Nup98dCTD$bothallN98  
## [1] "ITPRIP" "MDM2" "FYN" "TNFRSF10B" "CPT1A" "LDLR"

# Compare genes with similarly altered expression upon DHX9 or Nup98 KD to genes bound by Nup98 or DHX9 RNA-IPs

Table of p-values

gom.obj <- newGOM(Transcript$changesameboth, RIP.all, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## Nup98RIP.K562 DHX9RIP.T32 both  
## upreg 7.888894e-14 0.2728807 0.012856748  
## downreg 1.154609e-04 0.6057791 0.054196314  
## alldir 5.666073e-17 0.3187557 0.002030835  
## bothupN98 4.597944e-08 0.6898875 0.047524405  
## bothdownN98 8.752413e-02 0.7697584 0.262902872  
## bothallN98 5.144745e-09 0.6980879 0.024150298

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## Nup98RIP.K562 DHX9RIP.T32 both  
## upreg 61 29 18  
## downreg 28 14 10  
## alldir 89 43 28  
## bothupN98 33 13 10  
## bothdownN98 5 2 2  
## bothallN98 38 15 12

getNestedList(gom.obj, name="intersection")

## $Nup98RIP.K562  
## $Nup98RIP.K562$upreg  
## [1] "EPHB2" "OLFML3" "BTG2" "NFKB2" "ITPRIP" "GRK5"   
## [7] "ARHGAP12" "RHOBTB1" "PDLIM1" "HSPA12A" "CD82" "MDK"   
## [13] "TMEM132A" "PCNXL3" "YAP1" "OAF" "SRGAP1" "TPCN1"   
## [19] "TESC" "DHX37" "PROSER1" "STON2" "TLE3" "TMEM159"   
## [25] "MMP2" "MT2A" "EMP2" "ANKRD13B" "JUP" "ETV4"   
## [31] "SLC44A2" "GATAD2A" "WTIP" "FXYD5" "TRPM4" "DOCK6"   
## [37] "POU2F2" "RPIA" "MAP4K4" "ITGA6" "IGFBP2" "SERTAD2"   
## [43] "FHL2" "NR4A2" "COL18A1" "CRKL" "GPD1L" "CTNNB1"   
## [49] "PFKFB4" "UGDH" "FAM198B" "MSX2" "SOX4" "CDK6"   
## [55] "SLC7A2" "LY6E" "PLAT" "DAB2IP" "MAOA" "PCYT1B"   
## [61] "CXorf38"   
##   
## $Nup98RIP.K562$downreg  
## [1] "TRNP1" "PPP1R12B" "SSX2IP" "DPYD" "MORN4" "HSD17B12"  
## [7] "GRIA4" "MIR210HG" "MANSC1" "GPR137C" "TMOD2" "PIGN"   
## [13] "CLIP4" "ST3GAL5" "SCN3A" "PNPLA3" "PCNP" "CPZ"   
## [19] "SLIT2" "PARM1" "PIK3R1" "SERPINB6" "GSTA4" "ARL4A"   
## [25] "SEMA3C" "TMEM176B" "TACC1" "TMEM64"   
##   
## $Nup98RIP.K562$alldir  
## [1] "EPHB2" "OLFML3" "BTG2" "NFKB2" "ITPRIP" "GRK5"   
## [7] "ARHGAP12" "RHOBTB1" "PDLIM1" "HSPA12A" "CD82" "MDK"   
## [13] "TMEM132A" "PCNXL3" "YAP1" "OAF" "SRGAP1" "TPCN1"   
## [19] "TESC" "DHX37" "PROSER1" "STON2" "TLE3" "TMEM159"   
## [25] "MMP2" "MT2A" "EMP2" "ANKRD13B" "JUP" "ETV4"   
## [31] "SLC44A2" "GATAD2A" "WTIP" "FXYD5" "TRPM4" "DOCK6"   
## [37] "POU2F2" "RPIA" "MAP4K4" "ITGA6" "IGFBP2" "SERTAD2"   
## [43] "FHL2" "NR4A2" "COL18A1" "CRKL" "GPD1L" "CTNNB1"   
## [49] "PFKFB4" "UGDH" "FAM198B" "MSX2" "SOX4" "CDK6"   
## [55] "SLC7A2" "LY6E" "PLAT" "DAB2IP" "MAOA" "PCYT1B"   
## [61] "CXorf38" "TRNP1" "PPP1R12B" "SSX2IP" "DPYD" "MORN4"   
## [67] "HSD17B12" "GRIA4" "MIR210HG" "MANSC1" "GPR137C" "TMOD2"   
## [73] "PIGN" "CLIP4" "ST3GAL5" "SCN3A" "PNPLA3" "PCNP"   
## [79] "CPZ" "SLIT2" "PARM1" "PIK3R1" "SERPINB6" "GSTA4"   
## [85] "ARL4A" "SEMA3C" "TMEM176B" "TACC1" "TMEM64"   
##   
## $Nup98RIP.K562$bothupN98  
## [1] "TIMM17A" "JUN" "CTSS" "ITPRIP" "AMPD3"   
## [6] "PCNXL3" "CCND1" "MDM2" "TTC7B" "RHBDF2"   
## [11] "CYGB" "GDF15" "PPP1R15A" "GGT5" "FAM43A"   
## [16] "SLC4A7" "USP53" "FAM198B" "F2RL1" "COX7C"   
## [21] "CCNG1" "LHFPL2" "GNPDA1" "SOX4" "TNFAIP3"   
## [26] "COX7A2" "FYN" "PEG10" "LONRF1" "DLC1"   
## [31] "TNFRSF10B" "RPL12" "MOSPD1"   
##   
## $Nup98RIP.K562$bothdownN98  
## [1] "MTHFR" "PBXIP1" "CPT1A" "LDLR" "CTSA"   
##   
## $Nup98RIP.K562$bothallN98  
## [1] "TIMM17A" "JUN" "CTSS" "ITPRIP" "AMPD3"   
## [6] "PCNXL3" "CCND1" "MDM2" "TTC7B" "RHBDF2"   
## [11] "CYGB" "GDF15" "PPP1R15A" "GGT5" "FAM43A"   
## [16] "SLC4A7" "USP53" "FAM198B" "F2RL1" "COX7C"   
## [21] "CCNG1" "LHFPL2" "GNPDA1" "SOX4" "TNFAIP3"   
## [26] "COX7A2" "FYN" "PEG10" "LONRF1" "DLC1"   
## [31] "TNFRSF10B" "RPL12" "MOSPD1" "MTHFR" "PBXIP1"   
## [36] "CPT1A" "LDLR" "CTSA"   
##   
##   
## $DHX9RIP.T32  
## $DHX9RIP.T32$upreg  
## [1] "ITPRIP" "CD82" "TMEM132A" "TPCN1" "DHX37" "TMEM159"   
## [7] "MMP2" "SLC6A2" "EMP2" "ANKRD13B" "JUP" "GATAD2A"   
## [13] "IGFBP2" "COL18A1" "TCN2" "TIMP3" "CTNNB1" "TMEM158"   
## [19] "PFKFB4" "PDZRN3" "PALLD" "UGDH" "DENND2A" "LY6E"   
## [25] "C8orf31" "SFRP1" "NCS1" "PCYT1B" "LAS1L"   
##   
## $DHX9RIP.T32$downreg  
## [1] "DPYD" "MORN4" "HSD17B12" "GRIA4" "TXNDC16" "TMOD2"   
## [7] "ST3GAL5" "SCN3A" "PROS1" "CPZ" "DANCR" "PARM1"   
## [13] "GUCY1B3" "SERPINB6"  
##   
## $DHX9RIP.T32$alldir  
## [1] "ITPRIP" "CD82" "TMEM132A" "TPCN1" "DHX37" "TMEM159"   
## [7] "MMP2" "SLC6A2" "EMP2" "ANKRD13B" "JUP" "GATAD2A"   
## [13] "IGFBP2" "COL18A1" "TCN2" "TIMP3" "CTNNB1" "TMEM158"   
## [19] "PFKFB4" "PDZRN3" "PALLD" "UGDH" "DENND2A" "LY6E"   
## [25] "C8orf31" "SFRP1" "NCS1" "PCYT1B" "LAS1L" "DPYD"   
## [31] "MORN4" "HSD17B12" "GRIA4" "TXNDC16" "TMOD2" "ST3GAL5"   
## [37] "SCN3A" "PROS1" "CPZ" "DANCR" "PARM1" "GUCY1B3"   
## [43] "SERPINB6"  
##   
## $DHX9RIP.T32$bothupN98  
## [1] "ITPRIP" "RHBDF2" "CYGB" "PPP1R15A" "ODC1"   
## [6] "TIMP3" "FAM43A" "EREG" "COX7A2" "LONRF1"   
## [11] "DLC1" "TNFRSF10B" "MOSPD1"   
##   
## $DHX9RIP.T32$bothdownN98  
## [1] "MTHFR" "CTSA"   
##   
## $DHX9RIP.T32$bothallN98  
## [1] "ITPRIP" "RHBDF2" "CYGB" "PPP1R15A" "ODC1"   
## [6] "TIMP3" "FAM43A" "EREG" "COX7A2" "LONRF1"   
## [11] "DLC1" "TNFRSF10B" "MOSPD1" "MTHFR" "CTSA"   
##   
##   
## $both  
## $both$upreg  
## [1] "ITPRIP" "CD82" "TMEM132A" "TPCN1" "DHX37" "TMEM159"   
## [7] "MMP2" "EMP2" "ANKRD13B" "JUP" "GATAD2A" "IGFBP2"   
## [13] "COL18A1" "CTNNB1" "PFKFB4" "UGDH" "LY6E" "PCYT1B"   
##   
## $both$downreg  
## [1] "DPYD" "MORN4" "HSD17B12" "GRIA4" "TMOD2" "ST3GAL5"   
## [7] "SCN3A" "CPZ" "PARM1" "SERPINB6"  
##   
## $both$alldir  
## [1] "ITPRIP" "CD82" "TMEM132A" "TPCN1" "DHX37" "TMEM159"   
## [7] "MMP2" "EMP2" "ANKRD13B" "JUP" "GATAD2A" "IGFBP2"   
## [13] "COL18A1" "CTNNB1" "PFKFB4" "UGDH" "LY6E" "PCYT1B"   
## [19] "DPYD" "MORN4" "HSD17B12" "GRIA4" "TMOD2" "ST3GAL5"   
## [25] "SCN3A" "CPZ" "PARM1" "SERPINB6"  
##   
## $both$bothupN98  
## [1] "ITPRIP" "RHBDF2" "CYGB" "PPP1R15A" "FAM43A"   
## [6] "COX7A2" "LONRF1" "DLC1" "TNFRSF10B" "MOSPD1"   
##   
## $both$bothdownN98  
## [1] "MTHFR" "CTSA"   
##   
## $both$bothallN98  
## [1] "ITPRIP" "RHBDF2" "CYGB" "PPP1R15A" "FAM43A"   
## [6] "COX7A2" "LONRF1" "DLC1" "TNFRSF10B" "MOSPD1"   
## [11] "MTHFR" "CTSA"

# Compare genes with similarly altered expression upon DHX9 or Nup98 KD to genes with CRE element

Table of p-values

gom.obj <- newGOM(Transcript$changesameboth, CRE.genes, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## CRE  
## upreg 9.088663e-05  
## downreg 4.971751e-03  
## alldir 1.262064e-06  
## bothupN98 3.168789e-06  
## bothdownN98 2.436227e-02  
## bothallN98 9.455544e-08

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## CRE  
## upreg 46  
## downreg 25  
## alldir 71  
## bothupN98 31  
## bothdownN98 6  
## bothallN98 37

getNestedList(gom.obj, name="intersection")

## $CRE  
## $CRE$upreg  
## [1] "EPHB2" "CA14" "BTG2" "NFKB2" "ARHGAP12" "RHOBTB1"   
## [7] "PDLIM1" "MDK" "YAP1" "TPCN1" "DHX37" "TLE3"   
## [13] "CSPG4" "MMP2" "SLC6A2" "MT2A" "EMP2" "JUP"   
## [19] "ETV4" "FXYD5" "TRPM4" "POU2F2" "RPIA" "MAP4K4"   
## [25] "ITGA6" "IGFBP2" "FHL2" "NR4A2" "JAG1" "COL18A1"   
## [31] "CRKL" "TCN2" "TIMP3" "CTNNB1" "PFKFB4" "UGDH"   
## [37] "MSX2" "SOX4" "CDK6" "SLC7A2" "LY6E" "SFRP1"   
## [43] "PLAT" "DAB2IP" "MAOA" "PCYT1B"   
##   
## $CRE$downreg  
## [1] "UQCRH" "PPP1R12B" "SSX2IP" "DPYD" "HSD17B12"   
## [6] "GRIA4" "C14orf129" "TMOD2" "PIGN" "SCN3A"   
## [11] "PCBP3" "PCNP" "ATP2B2" "PROS1" "CPZ"   
## [16] "SLIT2" "GUCY1B3" "PIK3R1" "HIST1H3E" "SERPINB6"   
## [21] "GSTA4" "SEMA3C" "TACC1" "AGPAT2" "RPS6KA6"   
##   
## $CRE$alldir  
## [1] "EPHB2" "CA14" "BTG2" "NFKB2" "ARHGAP12"   
## [6] "RHOBTB1" "PDLIM1" "MDK" "YAP1" "TPCN1"   
## [11] "DHX37" "TLE3" "CSPG4" "MMP2" "SLC6A2"   
## [16] "MT2A" "EMP2" "JUP" "ETV4" "FXYD5"   
## [21] "TRPM4" "POU2F2" "RPIA" "MAP4K4" "ITGA6"   
## [26] "IGFBP2" "FHL2" "NR4A2" "JAG1" "COL18A1"   
## [31] "CRKL" "TCN2" "TIMP3" "CTNNB1" "PFKFB4"   
## [36] "UGDH" "MSX2" "SOX4" "CDK6" "SLC7A2"   
## [41] "LY6E" "SFRP1" "PLAT" "DAB2IP" "MAOA"   
## [46] "PCYT1B" "UQCRH" "PPP1R12B" "SSX2IP" "DPYD"   
## [51] "HSD17B12" "GRIA4" "C14orf129" "TMOD2" "PIGN"   
## [56] "SCN3A" "PCBP3" "PCNP" "ATP2B2" "PROS1"   
## [61] "CPZ" "SLIT2" "GUCY1B3" "PIK3R1" "HIST1H3E"   
## [66] "SERPINB6" "GSTA4" "SEMA3C" "TACC1" "AGPAT2"   
## [71] "RPS6KA6"   
##   
## $CRE$bothupN98  
## [1] "C1orf9" "TIMM17A" "JUN" "CTSS" "TFAM"   
## [6] "AMPD3" "CCND1" "MDM2" "PHLDA1" "CYGB"   
## [11] "PPP1R15A" "IL11" "QPCT" "ODC1" "TIMP3"   
## [16] "SLC4A7" "EREG" "F2RL1" "COX7C" "CCNG1"   
## [21] "LHFPL2" "GNPDA1" "SOX4" "ITPR3" "TNFAIP3"   
## [26] "COX7A2" "FYN" "PEG10" "DLC1" "TNFRSF10B"  
## [31] "RPL12"   
##   
## $CRE$bothdownN98  
## [1] "MTHFR" "PBXIP1" "CPT1A" "C14orf129" "LDLR" "HIST1H1C"   
##   
## $CRE$bothallN98  
## [1] "C1orf9" "TIMM17A" "JUN" "CTSS" "TFAM"   
## [6] "AMPD3" "CCND1" "MDM2" "PHLDA1" "CYGB"   
## [11] "PPP1R15A" "IL11" "QPCT" "ODC1" "TIMP3"   
## [16] "SLC4A7" "EREG" "F2RL1" "COX7C" "CCNG1"   
## [21] "LHFPL2" "GNPDA1" "SOX4" "ITPR3" "TNFAIP3"   
## [26] "COX7A2" "FYN" "PEG10" "DLC1" "TNFRSF10B"  
## [31] "RPL12" "MTHFR" "PBXIP1" "CPT1A" "C14orf129"  
## [36] "LDLR" "HIST1H1C"

# Compare genes with similarly altered expression upon DHX9 or Nup98 KD to genes bound by Dam-Nup98 and containing CRE elements

Table of p-values

gom.obj <- newGOM(Transcript$changesameboth, N98Dam.CRE, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## DamNup98FLCRE DamNup98dCTDCRE  
## upreg 7.125956e-04 0.0008336621  
## downreg 1.072400e-02 1.0000000000  
## alldir 2.416446e-05 0.0094183398  
## bothupN98 5.491088e-07 0.0491168723  
## bothdownN98 2.110880e-01 0.0087001448  
## bothallN98 2.548260e-07 0.0025877944

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## DamNup98FLCRE DamNup98dCTDCRE  
## upreg 9 7  
## downreg 5 0  
## alldir 14 7  
## bothupN98 10 3  
## bothdownN98 1 2  
## bothallN98 11 5

getNestedList(gom.obj, name="intersection")

## $DamNup98FLCRE  
## $DamNup98FLCRE$upreg  
## [1] "RHOBTB1" "YAP1" "ETV4" "MAP4K4" "FHL2" "CDK6" "SLC7A2"   
## [8] "PLAT" "PCYT1B"   
##   
## $DamNup98FLCRE$downreg  
## [1] "PPP1R12B" "SSX2IP" "HSD17B12" "GRIA4" "TACC1"   
##   
## $DamNup98FLCRE$alldir  
## [1] "RHOBTB1" "YAP1" "ETV4" "MAP4K4" "FHL2" "CDK6"   
## [7] "SLC7A2" "PLAT" "PCYT1B" "PPP1R12B" "SSX2IP" "HSD17B12"  
## [13] "GRIA4" "TACC1"   
##   
## $DamNup98FLCRE$bothupN98  
## [1] "C1orf9" "CTSS" "MDM2" "PHLDA1" "CYGB"   
## [6] "QPCT" "SLC4A7" "LHFPL2" "FYN" "TNFRSF10B"  
##   
## $DamNup98FLCRE$bothdownN98  
## [1] "LDLR"  
##   
## $DamNup98FLCRE$bothallN98  
## [1] "C1orf9" "CTSS" "MDM2" "PHLDA1" "CYGB"   
## [6] "QPCT" "SLC4A7" "LHFPL2" "FYN" "TNFRSF10B"  
## [11] "LDLR"   
##   
##   
## $DamNup98dCTDCRE  
## $DamNup98dCTDCRE$upreg  
## [1] "NFKB2" "YAP1" "SLC6A2" "MT2A" "EMP2" "ETV4" "FHL2"   
##   
## $DamNup98dCTDCRE$downreg  
## character(0)  
##   
## $DamNup98dCTDCRE$alldir  
## [1] "NFKB2" "YAP1" "SLC6A2" "MT2A" "EMP2" "ETV4" "FHL2"   
##   
## $DamNup98dCTDCRE$bothupN98  
## [1] "MDM2" "FYN" "TNFRSF10B"  
##   
## $DamNup98dCTDCRE$bothdownN98  
## [1] "CPT1A" "LDLR"   
##   
## $DamNup98dCTDCRE$bothallN98  
## [1] "MDM2" "FYN" "TNFRSF10B" "CPT1A" "LDLR"

# Compare genes with similarly altered expression upon DHX9 or Nup98 KD to genes bound by Dam-Nup98 with CRE elements and bound by Nup98 or DHX9 RNA-IPs

Table of p-values

gom.obj <- newGOM(Transcript$changesameboth, N98Dam.CRE.RIP, gs.RNASeq)  
getMatrix(gom.obj, name="pval")

## CRE.DamFL.N98RIP CRE.DamdCT.N98RIP CRE.DamFL.D9RIP  
## upreg 6.681342e-05 0.0011633060 0.58796092  
## downreg 2.814332e-03 1.0000000000 0.08579431  
## alldir 6.198465e-07 0.0098535102 0.15564014  
## bothupN98 4.202096e-05 0.0256230510 0.08262414  
## bothdownN98 1.573457e-01 0.0052642439 1.00000000  
## bothallN98 1.295256e-05 0.0008295656 0.10553581  
## CRE.DamdCT.D9RIP CRE.DamFL.bothRIP CRE.DamdCT.bothRIP  
## upreg 0.1143891 0.48637122 0.3829222  
## downreg 1.0000000 0.05231912 1.0000000  
## alldir 0.2246514 0.08350064 0.5251925  
## bothupN98 0.2702711 0.05030326 0.2302074  
## bothdownN98 1.0000000 1.00000000 1.0000000  
## bothallN98 0.3051932 0.06499076 0.2609241

Number of genes in common:

getMatrix(gom.obj, name="intersection")

## CRE.DamFL.N98RIP CRE.DamdCT.N98RIP CRE.DamFL.D9RIP  
## upreg 9 6 1  
## downreg 5 0 2  
## alldir 14 6 3  
## bothupN98 7 3 2  
## bothdownN98 1 2 0  
## bothallN98 8 5 2  
## CRE.DamdCT.D9RIP CRE.DamFL.bothRIP CRE.DamdCT.bothRIP  
## upreg 2 1 1  
## downreg 0 2 0  
## alldir 2 3 1  
## bothupN98 1 2 1  
## bothdownN98 0 0 0  
## bothallN98 1 2 1

getNestedList(gom.obj, name="intersection")

## $CRE.DamFL.N98RIP  
## $CRE.DamFL.N98RIP$upreg  
## [1] "RHOBTB1" "YAP1" "ETV4" "MAP4K4" "FHL2" "CDK6" "SLC7A2"   
## [8] "PLAT" "PCYT1B"   
##   
## $CRE.DamFL.N98RIP$downreg  
## [1] "PPP1R12B" "SSX2IP" "HSD17B12" "GRIA4" "TACC1"   
##   
## $CRE.DamFL.N98RIP$alldir  
## [1] "RHOBTB1" "YAP1" "ETV4" "MAP4K4" "FHL2" "CDK6"   
## [7] "SLC7A2" "PLAT" "PCYT1B" "PPP1R12B" "SSX2IP" "HSD17B12"  
## [13] "GRIA4" "TACC1"   
##   
## $CRE.DamFL.N98RIP$bothupN98  
## [1] "CTSS" "MDM2" "CYGB" "SLC4A7" "LHFPL2" "FYN"   
## [7] "TNFRSF10B"  
##   
## $CRE.DamFL.N98RIP$bothdownN98  
## [1] "LDLR"  
##   
## $CRE.DamFL.N98RIP$bothallN98  
## [1] "CTSS" "MDM2" "CYGB" "SLC4A7" "LHFPL2" "FYN"   
## [7] "TNFRSF10B" "LDLR"   
##   
##   
## $CRE.DamdCT.N98RIP  
## $CRE.DamdCT.N98RIP$upreg  
## [1] "NFKB2" "YAP1" "MT2A" "EMP2" "ETV4" "FHL2"   
##   
## $CRE.DamdCT.N98RIP$downreg  
## character(0)  
##   
## $CRE.DamdCT.N98RIP$alldir  
## [1] "NFKB2" "YAP1" "MT2A" "EMP2" "ETV4" "FHL2"   
##   
## $CRE.DamdCT.N98RIP$bothupN98  
## [1] "MDM2" "FYN" "TNFRSF10B"  
##   
## $CRE.DamdCT.N98RIP$bothdownN98  
## [1] "CPT1A" "LDLR"   
##   
## $CRE.DamdCT.N98RIP$bothallN98  
## [1] "MDM2" "FYN" "TNFRSF10B" "CPT1A" "LDLR"   
##   
##   
## $CRE.DamFL.D9RIP  
## $CRE.DamFL.D9RIP$upreg  
## [1] "PCYT1B"  
##   
## $CRE.DamFL.D9RIP$downreg  
## [1] "HSD17B12" "GRIA4"   
##   
## $CRE.DamFL.D9RIP$alldir  
## [1] "PCYT1B" "HSD17B12" "GRIA4"   
##   
## $CRE.DamFL.D9RIP$bothupN98  
## [1] "CYGB" "TNFRSF10B"  
##   
## $CRE.DamFL.D9RIP$bothdownN98  
## character(0)  
##   
## $CRE.DamFL.D9RIP$bothallN98  
## [1] "CYGB" "TNFRSF10B"  
##   
##   
## $CRE.DamdCT.D9RIP  
## $CRE.DamdCT.D9RIP$upreg  
## [1] "SLC6A2" "EMP2"   
##   
## $CRE.DamdCT.D9RIP$downreg  
## character(0)  
##   
## $CRE.DamdCT.D9RIP$alldir  
## [1] "SLC6A2" "EMP2"   
##   
## $CRE.DamdCT.D9RIP$bothupN98  
## [1] "TNFRSF10B"  
##   
## $CRE.DamdCT.D9RIP$bothdownN98  
## character(0)  
##   
## $CRE.DamdCT.D9RIP$bothallN98  
## [1] "TNFRSF10B"  
##   
##   
## $CRE.DamFL.bothRIP  
## $CRE.DamFL.bothRIP$upreg  
## [1] "PCYT1B"  
##   
## $CRE.DamFL.bothRIP$downreg  
## [1] "HSD17B12" "GRIA4"   
##   
## $CRE.DamFL.bothRIP$alldir  
## [1] "PCYT1B" "HSD17B12" "GRIA4"   
##   
## $CRE.DamFL.bothRIP$bothupN98  
## [1] "CYGB" "TNFRSF10B"  
##   
## $CRE.DamFL.bothRIP$bothdownN98  
## character(0)  
##   
## $CRE.DamFL.bothRIP$bothallN98  
## [1] "CYGB" "TNFRSF10B"  
##   
##   
## $CRE.DamdCT.bothRIP  
## $CRE.DamdCT.bothRIP$upreg  
## [1] "EMP2"  
##   
## $CRE.DamdCT.bothRIP$downreg  
## character(0)  
##   
## $CRE.DamdCT.bothRIP$alldir  
## [1] "EMP2"  
##   
## $CRE.DamdCT.bothRIP$bothupN98  
## [1] "TNFRSF10B"  
##   
## $CRE.DamdCT.bothRIP$bothdownN98  
## character(0)  
##   
## $CRE.DamdCT.bothRIP$bothallN98  
## [1] "TNFRSF10B"