scRNAseq analysis using Rmarkdown

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07/14/2020

```
## R code here
```

Goal

The primary goal of this study is to identify gene expression difference between conditions using a toy dataset.

Rmarkdown reference can be found in here: Reference

Mathematics in Rmarkdown

Seurat - Guided Clustering Tutorial

Run Seurat strandard workflow

Load dataset

Using raw read count as input.

```
##          OoCyte_1 OoCyte_2 OoCyte_3 Zygote_1 Zygote_2 Zygote_3
## CREB3L1       953     1249     1414     1169      790      527
## GPR98        3889     6625     6059     3332     4434     7063
## RTN1         9423    12507    10256     3759     2757     1499
## KBTBD8        180      285      141     1113      675     1178
## ZEB1        11760    14258    10912    12724     8528    14400
## FAT4            0        0        0        0        0        0
## BANK1       18373    15971    11918    10526     8703    14819
## PIR           379       79       47        0      237        0
## KIAA1199        0      635        0      805      245      561
## SORL1        5898     5279     2714     2234     1519     1849
##          X2_Cell_embryo_1_Cell_1 X2_Cell_embryo_1_Cell_2
## CREB3L1                     1613                    1366
## GPR98                       2916                    4079
## RTN1                       10850                   11434
## KBTBD8                      1115                    1278
## ZEB1                       16406                   16338
## FAT4                           0                       0
## BANK1                       5464                    8777
## PIR                          253                     237
## KIAA1199                     439                       0
## SORL1                       1316                    2065
```

```
##          X2_Cell_embryo_2_Cell_1 X2_Cell_embryo_2_Cell_2
## CREB3L1                    1744                    1480
## GPR98                      6220                    5468
## RTN1                       5341                    4754
## KBTBD8                     1051                    1198
## ZEB1                      10348                   13699
## FAT4                          0                       0
## BANK1                      9110                   12009
## PIR                           0                     300
## KIAA1199                    757                     511
## SORL1                      1500                    1216
##          X2_Cell_embryo_3_Cell_1 X2_Cell_embryo_3_Cell_2
## CREB3L1                     707                     593
## GPR98                      6916                    5626
## RTN1                       2252                    3259
## KBTBD8                     1099                    1243
## ZEB1                      17865                   25951
## FAT4                          0                       0
## BANK1                     10193                   10940
## PIR                         110                       0
## KIAA1199                   1073                     756
## SORL1                      1235                    1453
##          X4_Cell_embryo_1_Cell_1 X4_Cell_embryo_1_Cell_2
## CREB3L1                       0                    5877
## GPR98                     51591                   14006
## RTN1                      31308                       0
## KBTBD8                     2020                    1195
## ZEB1                       6550                   98411
## FAT4                          0                       0
## BANK1                     67194                   10253
## PIR                           0                       0
## KIAA1199                      0                       0
## SORL1                      9464                       0
##          X4_Cell_embryo_1_Cell_3 X4_Cell_embryo_1_Cell_4
## CREB3L1                       0                       0
## GPR98                      2722                    7718
## RTN1                          0                       0
## KBTBD8                     1515                     489
## ZEB1                      45384                   33983
## FAT4                          0                       0
## BANK1                     91234                       0
## PIR                          78                       0
## KIAA1199                      0                    1900
## SORL1                      4841                    3827
##          X4_Cell_embryo_2_Cell_1 X4_Cell_embryo_2_Cell_2
## CREB3L1                     279                     772
## GPR98                     12340                   11176
## RTN1                       2002                       0
## KBTBD8                      323                     655
## ZEB1                      76176                   65691
## FAT4                          0                       0
## BANK1                     22005                   21010
## PIR                        1639                       0
## KIAA1199                      0                    1366
```

```
## SORL1                        2132                       7707
##          X4_Cell_embryo_2_Cell_3 X4_Cell_embryo_2_Cell_4
## CREB3L1                     1413                       3385
## GPR98                       2918                      14963
## RTN1                        5835                      20079
## KBTBD8                       923                        969
## ZEB1                       55470                      40926
## FAT4                           0                          0
## BANK1                      23412                      29282
## PIR                            0                          0
## KIAA1199                    1562                       5092
## SORL1                       3347                        551
##          X4_Cell_embryo_3_Cell_1 X4_Cell_embryo_3_Cell_2
## CREB3L1                     3335                       2974
## GPR98                       5400                      12982
## RTN1                       12997                       5917
## KBTBD8                      1246                       1298
## ZEB1                       49037                      73249
## FAT4                           0                          0
## BANK1                      26555                      74687
## PIR                            0                       1418
## KIAA1199                    1339                       1462
## SORL1                       3030                       4259
##          X4_Cell_embryo_3_Cell_3 X4_Cell_embryo_3_Cell_4
## CREB3L1                     3614                       6129
## GPR98                       5519                       7777
## RTN1                        3666                      12667
## KBTBD8                       376                       1263
## ZEB1                       41604                      35097
## FAT4                           0                          0
## BANK1                      19352                      55923
## PIR                          567                          0
## KIAA1199                       0                          0
## SORL1                       1648                       1414
##          X8_Cell_embryo_1_Cell_1 X8_Cell_embryo_1_Cell_2
## CREB3L1                      274                       1519
## GPR98                       4216                       1421
## RTN1                           0                          0
## KBTBD8                       161                       2783
## ZEB1                       14867                      13579
## FAT4                           0                          0
## BANK1                      25068                      30084
## PIR                            0                          0
## KIAA1199                       0                        681
## SORL1                       3549                        785
##          X8_Cell_embryo_1_Cell_3 X8_Cell_embryo_1_Cell_4
## CREB3L1                      787                       1812
## GPR98                       4043                       7133
## RTN1                           0                          0
## KBTBD8                       995                       1485
## ZEB1                        2810                        350
## FAT4                           0                          0
## BANK1                       9335                      21950
## PIR                           54                        652
```

```
## KIAA1199                      0                      0
## SORL1                         0                   5393
##          X8_Cell_embryo_2_Cell_1 X8_Cell_embryo_2_Cell_2
## CREB3L1                       0                      0
## GPR98                      6546                   5897
## RTN1                          0                      0
## KBTBD8                      999                    938
## ZEB1                        282                   4404
## FAT4                          0                      0
## BANK1                         0                      0
## PIR                           0                      0
## KIAA1199                      0                      0
## SORL1                         0                      0
##          X8_Cell_embryo_2_Cell_3 X8_Cell_embryo_2_Cell_4
## CREB3L1                       0                      0
## GPR98                      9533                      0
## RTN1                      14726                      0
## KBTBD8                       59                   1230
## ZEB1                       5809                   4947
## FAT4                          0                      0
## BANK1                         0                  12518
## PIR                           0                      0
## KIAA1199                      0                      0
## SORL1                      1256                      0
##          X8_Cell_embryo_2_Cell_5 X8_Cell_embryo_2_Cell_6
## CREB3L1                       0                      0
## GPR98                         0                    892
## RTN1                          0                    569
## KBTBD8                     1934                   1251
## ZEB1                      11432                    790
## FAT4                          0                      0
## BANK1                         0                  10653
## PIR                           0                      0
## KIAA1199                   1332                      0
## SORL1                         0                      0
##          X8_Cell_embryo_2_Cell_7 X8_Cell_embryo_2_Cell_8
## CREB3L1                       0                      0
## GPR98                         0                   2138
## RTN1                       1616                      0
## KBTBD8                     1269                   1660
## ZEB1                       1436                   2421
## FAT4                          0                      0
## BANK1                      2715                   1393
## PIR                           0                      0
## KIAA1199                      0                      0
## SORL1                         0                      0
##          X8_Cell_embryo_3_Cell_1 X8_Cell_embryo_3_Cell_2
## CREB3L1                       0                      0
## GPR98                     26885                   3699
## RTN1                          0                      0
## KBTBD8                     1383                    473
## ZEB1                          0                   3686
## FAT4                          0                      0
## BANK1                     47193                      0
```

```
## PIR                           0                       0
## KIAA1199                      0                       0
## SORL1                         0                       0
##          X8_Cell_embryo_3_Cell_3 X8_Cell_embryo_3_Cell_4
## CREB3L1                       0                       0
## GPR98                      3417                   28858
## RTN1                          0                       0
## KBTBD8                      160                    1902
## ZEB1                       7233                       0
## FAT4                          0                       0
## BANK1                         0                       0
## PIR                           0                       0
## KIAA1199                      0                    2100
## SORL1                      3283                    1501
##          X8_Cell_embryo_3_Cell_5 X8_Cell_embryo_3_Cell_6
## CREB3L1                       0                       0
## GPR98                      3890                   16101
## RTN1                          0                       0
## KBTBD8                      727                      58
## ZEB1                          0                       0
## FAT4                          0                       0
## BANK1                     10178                   75304
## PIR                           0                       0
## KIAA1199                      0                       0
## SORL1                         0                       0
##          X8_Cell_embryo_3_Cell_7 X8_Cell_embryo_3_Cell_8 Morulae_1_Cell_1
## CREB3L1                       0                    6612                0
## GPR98                      7158                   12089             3667
## RTN1                          0                    5338                0
## KBTBD8                      866                       0              398
## ZEB1                      23496                   20928            19054
## FAT4                          0                       0                0
## BANK1                         0                   16806                0
## PIR                           0                       0                0
## KIAA1199                   3002                       0                0
## SORL1                         0                       0             5428
##          Morulae_1_Cell_2 Morulae_1_Cell_3 Morulae_1_Cell_4 Morulae_1_Cell_5
## CREB3L1                 0                0              510                0
## GPR98                3045             1507                0                0
## RTN1                    0                0                0                0
## KBTBD8                  0                0              329              335
## ZEB1                    0            23326                0              778
## FAT4                    0             1191                0                0
## BANK1                   0            38416             8284                0
## PIR                     0                0                0                0
## KIAA1199                0                0                0                0
## SORL1                   0                0                0                0
##          Morulae_1_Cell_6 Morulae_1_Cell_7 Morulae_1_Cell_8 Morulae_2_Cell_1
## CREB3L1                 0                0                0                0
## GPR98                   0             2669                0                0
## RTN1                    0                0                0                0
## KBTBD8                  0              124               64               75
## ZEB1                    0             4869              270             3416
## FAT4                    0                0                0                0
```

```
## BANK1                   0             6791             1076                0
## PIR                     0                0                0                0
## KIAA1199                0                0                0                0
## SORL1                   0                0              833              668
##          Morulae_2_Cell_2 Morulae_2_Cell_3 Morulae_2_Cell_4 Morulae_2_Cell_5
## CREB3L1                 0                0                0                0
## GPR98                2929                0             4655                0
## RTN1                    0                0                0                0
## KBTBD8                 30                0              169                0
## ZEB1                 9272             7472                0             1422
## FAT4                    0                0                0                0
## BANK1                   0                0                0                0
## PIR                     0                0                0                0
## KIAA1199                0                0                0                0
## SORL1                   0                0                0                0
##          Morulae_2_Cell_6 Morulae_2_Cell_7 Morulae_2_Cell_8
## CREB3L1              280              198                0
## GPR98               3838                0                0
## RTN1                   0                0                0
## KBTBD8               144               75              704
## ZEB1                   0                0             8231
## FAT4                   0                0                0
## BANK1                  0                0                0
## PIR                    0                0                0
## KIAA1199            3103                0                0
## SORL1                  0                0                0
##          Late_blastoCyst_1_Cell_1 Late_blastoCyst_1_Cell_2
## CREB3L1                        0                        0
## GPR98                          0                        0
## RTN1                           0                        0
## KBTBD8                         0                        0
## ZEB1                           0                        0
## FAT4                           0                        0
## BANK1                          0                        0
## PIR                        27001                     2646
## KIAA1199                       0                        0
## SORL1                          0                        0
##          Late_blastoCyst_1_Cell_3 Late_blastoCyst_1_Cell_4
## CREB3L1                        0                        0
## GPR98                          0                        0
## RTN1                           0                        0
## KBTBD8                        94                      199
## ZEB1                           0                        0
## FAT4                           0                        0
## BANK1                          0                        0
## PIR                         5229                    11897
## KIAA1199                       0                        0
## SORL1                          0                        0
##          Late_blastoCyst_1_Cell_5 Late_blastoCyst_1_Cell_6
## CREB3L1                        0                        0
## GPR98                          0                        0
## RTN1                           0                        0
## KBTBD8                         0                       77
## ZEB1                           0                        0
```

```
## FAT4                            0                          0
## BANK1                           0                          0
## PIR                           126                        520
## KIAA1199                        0                          0
## SORL1                           0                          0
##          Late_blastoCyst_1_Cell_7 Late_blastoCyst_1_Cell_8
## CREB3L1                         0                          0
## GPR98                           0                          0
## RTN1                            0                          0
## KBTBD8                          0                         91
## ZEB1                            0                          0
## FAT4                            0                          0
## BANK1                           0                          0
## PIR                         12113                       6099
## KIAA1199                        0                          0
## SORL1                           0                          0
##          Late_blastoCyst_1_Cell_9 Late_blastoCyst_1_Cell_10
## CREB3L1                         0                          0
## GPR98                           0                          0
## RTN1                            0                          0
## KBTBD8                          0                         19
## ZEB1                            0                          0
## FAT4                            0                          0
## BANK1                           0                          0
## PIR                             0                       7688
## KIAA1199                        0                          0
## SORL1                           0                          0
##          Late_blastoCyst_1_Cell_11 Late_blastoCyst_1_Cell_12
## CREB3L1                          0                          0
## GPR98                            0                          0
## RTN1                             0                          0
## KBTBD8                           0                         25
## ZEB1                             0                          0
## FAT4                             0                          0
## BANK1                            0                          0
## PIR                           6900                       3216
## KIAA1199                         0                          0
## SORL1                         1947                       2581
##          Late_blastoCyst_2_Cell_1 Late_blastoCyst_2_Cell_2
## CREB3L1                       313                       3337
## GPR98                           0                          0
## RTN1                            0                          0
## KBTBD8                        327                         55
## ZEB1                            0                          0
## FAT4                            0                          0
## BANK1                           0                          0
## PIR                          1927                        899
## KIAA1199                        0                          0
## SORL1                         668                       5481
##          Late_blastoCyst_2_Cell_3 Late_blastoCyst_2_Cell_4
## CREB3L1                       855                          0
## GPR98                           0                          0
## RTN1                            0                          0
## KBTBD8                         53                          0
```

```
## ZEB1                            0                           0
## FAT4                            0                           0
## BANK1                           0                           0
## PIR                            31                        3341
## KIAA1199                        0                           0
## SORL1                           0                           0
##          Late_blastoCyst_2_Cell_5 Late_blastoCyst_2_Cell_6
## CREB3L1                         0                           0
## GPR98                           0                           0
## RTN1                            0                           0
## KBTBD8                          0                        1091
## ZEB1                            0                           0
## FAT4                            0                           0
## BANK1                           0                           0
## PIR                         19050                       55733
## KIAA1199                        0                           0
## SORL1                       13518                           0
##          Late_blastoCyst_2_Cell_7 Late_blastoCyst_2_Cell_8
## CREB3L1                         0                           0
## GPR98                           0                           0
## RTN1                            0                           0
## KBTBD8                         83                         288
## ZEB1                            0                           0
## FAT4                            0                           0
## BANK1                           0                           0
## PIR                         20319                        1025
## KIAA1199                        0                           0
## SORL1                           0                        9633
##          Late_blastoCyst_2_Cell_9 Late_blastoCyst_2_Cell_10
## CREB3L1                         0                          0
## GPR98                           0                          0
## RTN1                            0                          0
## KBTBD8                       1915                        171
## ZEB1                            0                          0
## FAT4                            0                          0
## BANK1                           0                          0
## PIR                           410                        252
## KIAA1199                        0                          0
## SORL1                         366                          0
##          Late_blastoCyst_3_Cell_1 Late_blastoCyst_3_Cell_2
## CREB3L1                         0                          0
## GPR98                           0                          0
## RTN1                            0                          0
## KBTBD8                          0                        515
## ZEB1                            0                          0
## FAT4                            0                          0
## BANK1                           0                          0
## PIR                         40656                       8995
## KIAA1199                        0                          0
## SORL1                           0                          0
##          Late_blastoCyst_3_Cell_3 Late_blastoCyst_3_Cell_4
## CREB3L1                         0                          0
## GPR98                           0                          0
## RTN1                            0                          0
```

```
## KBTBD8                          116                          0
## ZEB1                              0                          0
## FAT4                              0                          0
## BANK1                             0                          0
## PIR                            3864                      22416
## KIAA1199                          0                          0
## SORL1                             0                          0
##          Late_blastoCyst_3_Cell_5 Late_blastoCyst_3_Cell_6
## CREB3L1                     11797                          0
## GPR98                           0                          0
## RTN1                            0                          0
## KBTBD8                         30                        340
## ZEB1                            0                          0
## FAT4                            0                          0
## BANK1                           0                          0
## PIR                           710                      41818
## KIAA1199                        0                          0
## SORL1                           0                          0
##          Late_blastoCyst_3_Cell_7 Late_blastoCyst_3_Cell_8
## CREB3L1                         0                      16569
## GPR98                           0                          0
## RTN1                            0                          0
## KBTBD8                          0                          0
## ZEB1                            0                          0
## FAT4                            0                          0
## BANK1                           0                          0
## PIR                         24796                      48961
## KIAA1199                        0                          0
## SORL1                        3983                      11703

##                               Cluster Time Condition
## OoCyte_1                       OoCyte    1   Control
## OoCyte_2                       OoCyte    1   Control
## OoCyte_3                       OoCyte    1   Control
## Zygote_1                       Zygote    1   Control
## Zygote_2                       Zygote    1   Control
## Zygote_3                       Zygote    1   Control
## X2_Cell_embryo_1_Cell_1 2_Cell_embryo    2   Control
## X2_Cell_embryo_1_Cell_2 2_Cell_embryo    2   Control
## X2_Cell_embryo_2_Cell_1 2_Cell_embryo    2   Control
## X2_Cell_embryo_2_Cell_2 2_Cell_embryo    2   Control
```

Load dataset in Seurat

```
# choose whahtever column as design
obj <- CreateSeuratObject(counts = counts, project = "scRNAseq", min.cells = 3, min.features = 200)
obj <- AddMetaData(object = obj, metadata = meta)
```

Normalizing the data

After removing unwanted cells from the dataset, the next step is to normalize the data. By default, we employ a global-scaling normalization method "LogNormalize" that normalizes the feature expression measurements

for each cell by the total expression, multiplies this by a scale factor (10,000 by default), and log-transforms the result. Normalized values are stored in obj[["RNA"]]@data.

```
obj <- NormalizeData(obj)
```

Identification of highly variable features (feature selection)

We next calculate a subset of features that exhibit high cell-to-cell variation in the dataset (i.e, they are highly expressed in some cells, and lowly expressed in others). We and others have found that focusing on these genes in downstream analysis helps to highlight biological signal in single-cell datasets.

Our procedure in Seurat3 is described in detail here, and improves on previous versions by directly modeling the mean-variance relationship inherent in single-cell data, and is implemented in the FindVariableFeatures function. By default, we return 2,000 features per dataset. These will be used in downstream analysis, like PCA.

```
obj <- FindVariableFeatures(obj, selection.method = "vst", nfeatures = 2000)
```

Scaling the data

Next, we apply a linear transformation ('scaling') that is a standard pre-processing step prior to dimensional reduction techniques like PCA. The ScaleData function:

- Shifts the expression of each gene, so that the mean expression across cells is 0
- Scales the expression of each gene, so that the variance across cells is 1
- This step gives equal weight in downstream analyses, so that highly-expressed genes do not dominate
- The results of this are stored in obj[["RNA"]]@scale.data

```
all.genes <- rownames(obj)
obj <- ScaleData(obj, features = all.genes)
```

```
## Centering and scaling data matrix
```

Perform linear dimensional reduction (PCA)

Next we perform PCA on the scaled data. By default, only the previously determined variable features are used as input, but can be defined using features argument if you wish to choose a different subset.

```
obj <- RunPCA(obj, features = VariableFeatures(object = obj))
```

```
## PC_ 1
## Positive:  BCAT1, RBM47, ST6GAL1, LAMA1, TXNRD1, DAB2, ALPL, psiTPTE22, GLIPR2, ASRGL1
##     S100A10, PVRL2, PI4KAP2, SHMT1, ANXA2, NR2F6, SEMA6A, DHCR24, SLC7A2, AKAP12
##     CTNNAL1, CTSL1, DSG2, SLC2A3, TEAD1, TMC7, KRT18, MALAT1, PLS3, TNS3
## Negative:  FAM46C, THSD7A, PLEKHG1, PDE8B, GNA14, PTK2B, MRC1, USP2, RIMKLA, ADAMTSL1
##     TMEM200A, CREB5, FHOD3, SLCO3A1, DNAH10, KALRN, ZNF618, PRR15, ACAD11, ABCB4
##     LYPD1, CRMP1, PDK1, TMEM163, FBLN7, MCTP1, JAG1, FBLN5, MCTP2, ELOVL4
## PC_ 2
## Positive:  KITLG, BIK, TMEM92, STAG3L2, KHDC1, C6orf204, STAG3L3, GPR155, DRAM1, SLC16A6
##     TESK2, PPP1R3B, HIST1H2BD, C21orf91, HIST1H2BK, GABARAPL1, CCNE1, STX11, ZNF296, KIAA0802
```

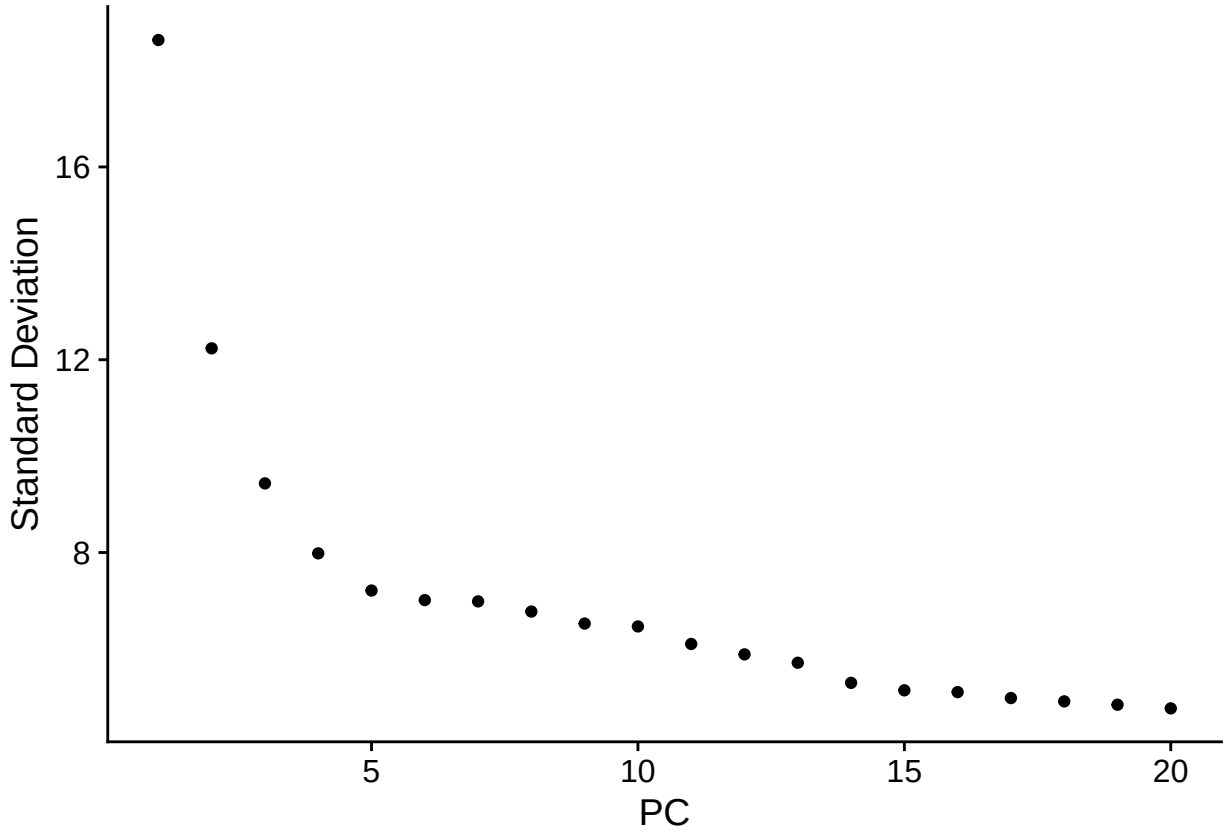
```
##     YPEL2, NBPF10, CAB39L, HIST2H2BF, ZNF675, STAP2, BAMBI, TCN2, INPP5J, GLS
## Negative:  DNMT3B, MOBKL2B, JUP, GCH1, GAB2, ASAH1, C8orf42, C4orf19, GRHL1, PITPNC1
##     REEP1, PTGR1, RHOC, EFHD1, C9orf140, KRT18, SH2D4A, RHOU, PRSS8, PHKA1
##     SLC1A3, ANXA6, CLDN4, ANXA2, C6orf132, ENPEP, MTHFD1L, CALD1, GATA3, GATA2
## PC_ 3
## Positive:  GYPC, ARHGEF35, LIMCH1, RRAD, IFI16, GPRC5C, PRDM1, MAN1C1, LARP6, MT1G
##     VCAN, TMEM63A, FLRT2, APOC2, GK, APOE, TNFRSF25, CXCL12, SPP1, PMEPA1
##     PRUNE2, TSPAN33, TRIM56, FCGBP, DACT1, MAP4K1, KRTCAP3, TNFRSF8, ARMCX2, MEG3
## Negative:  DAB2, SLC7A2, PVT1, PLCD3, TFRC, CLDN4, EMP2, EFNA1, RAB20, RALGAPA2
##     GATA2, ENPEP, GALNT10, DNAJC6, CTSH, FHL2, SEMA6D, PTGES, TEAD1, TACSTD2
##     GATA3, DLC1, OAF, TMEM56, MAGI3, GPR126, C7orf50, KIAA1161, CEBPA, C19orf21
## PC_ 4
## Positive:  XAF1, PDK4, TNFRSF10C, HOXA5, F5, HCG26, KCNJ2, C6orf174, SEMA3C, CTAGE4
##     CMYA5, PCDH17, CXCR4, GOLGA8B, FAM84A, SLC16A14, FOLR2, HHIPL1, ADCY4, ADAMTS5
##     LCA5, TAP2, ALOX15B, FOXC1, CH25H, RAPGEF5, ACCS, ZNF239, PCDHGA9, SLFN11
## Negative:  FTL, GNA11, CCNE1, PDPR, PTTG1, KANK2, TMEM51, ABTB2, PECAM1, ZNF296
##     C1orf38, STXBP1, GPNMB, ELOVL6, MITF, SLC45A4, PPP1R16B, PLLP, TROAP, PLK1S1
##     BAMBI, TMEM92, BLVRB, CHAC1, ACOT11, GTF2IRD1, STAP2, ITGA5, CACNB3, ZNF395
## PC_ 5
## Positive:  LAX1, PODNL1, MUC1, GBP1, APOBEC3C, APOBEC3G, HCK, SEMA7A, ANKRD34A, NIPSNAP3B
##     CCDC68, PLAU, CDC42BPG, AXL, SPAG4, MYO1G, SGK1, ZKSCAN1, CCRN4L, GPC3
##     STIL, NLGN3, FOS, PLEKHG6, IL1RN, RHOD, TEC, C19orf33, CADM1, GPR19
## Negative:  VPS37D, PDLIM4, C3orf54, LOC100270804, ZNF287, N4BP2L1, FNDC5, ZNF491, WNT2B, BEND5
##     C1QTNF2, SOX18, NUDT12, CARD14, SSC5D, KDR, TYROBP, DENND2C, PCDHGB6, MAGEH1
##     PCDHB14, C11orf45, RIMS3, MFNG, RAB17, RAB37, SH3PXD2B, CDKN2C, RGAG4, CLTCL1
```

Determine the 'dimensionality' of the dataset

To overcome the extensive technical noise in any single feature for scRNA-seq data, Seurat clusters cells based on their PCA scores, with each PC essentially representing a 'metafeature' that combines information across a correlated feature set. The top principal components therefore represent a robust compression of the dataset. However, how many componenets should we choose to include? 10? 20? 100?

In Macosko et al, we implemented a resampling test inspired by the JackStraw procedure. We randomly permute a subset of the data (1% by default) and rerun PCA, constructing a 'null distribution' of feature scores, and repeat this procedure. We identify 'significant' PCs as those who have a strong enrichment of low p-value features.

```
ElbowPlot(obj)
```



Cluster the cells

Seurat v3 applies a graph-based clustering approach, building upon initial strategies in (Macosko et al). Importantly, the distance metric which drives the clustering analysis (based on previously identified PCs) remains the same. However, our approach to partioning the cellular distance matrix into clusters has dramatically improved. Our approach was heavily inspired by recent manuscripts which applied graph-based clustering approaches to scRNA-seq data [SNN-Cliq, Xu and Su, Bioinformatics, 2015] and CyTOF data [PhenoGraph, Levine et al., Cell, 2015]. Briefly, these methods embed cells in a graph structure - for example a K-nearest neighbor (KNN) graph, with edges drawn between cells with similar feature expression patterns, and then attempt to partition this graph into highly interconnected 'quasi-cliques' or 'communities'.

As in PhenoGraph, we first construct a KNN graph based on the euclidean distance in PCA space, and refine the edge weights between any two cells based on the shared overlap in their local neighborhoods (Jaccard similarity). This step is performed using the FindNeighbors function, and takes as input the previously defined dimensionality of the dataset (first 10 PCs).

To cluster the cells, we next apply modularity optimization techniques such as the Louvain algorithm (default) or SLM [SLM, Blondel et al., Journal of Statistical Mechanics], to iteratively group cells together, with the goal of optimizing the standard modularity function. The FindClusters function implements this procedure, and contains a resolution parameter that sets the 'granularity' of the downstream clustering, with increased values leading to a greater number of clusters. We find that setting this parameter between 0.4-1.2 typically returns good results for single-cell datasets of around 3K cells. Optimal resolution often increases for larger datasets. The clusters can be found using the Idents function.

PCA plot colored by time

```
obj <- FindNeighbors(obj, dims = 1:10)
```

```
## Computing nearest neighbor graph
```

```
## Computing SNN
```

```
obj <- FindClusters(obj, resolution = 0.5)
```

```
## Modularity Optimizer version 1.3.0 by Ludo Waltman and Nees Jan van Eck
##
## Number of nodes: 90
## Number of edges: 1396
##
## Running Louvain algorithm...
## Maximum modularity in 10 random starts: 0.8195
## Number of communities: 3
## Elapsed time: 0 seconds
```

Run non-linear dimensional reduction (UMAP/tSNE)

```
obj <- RunUMAP(obj, dims = 1:10)
```

```
## 14:04:50 UMAP embedding parameters a = 0.9922 b = 1.112
```

```
## 14:04:50 Read 90 rows and found 10 numeric columns
```

```
## 14:04:50 Using Annoy for neighbor search, n_neighbors = 30
```

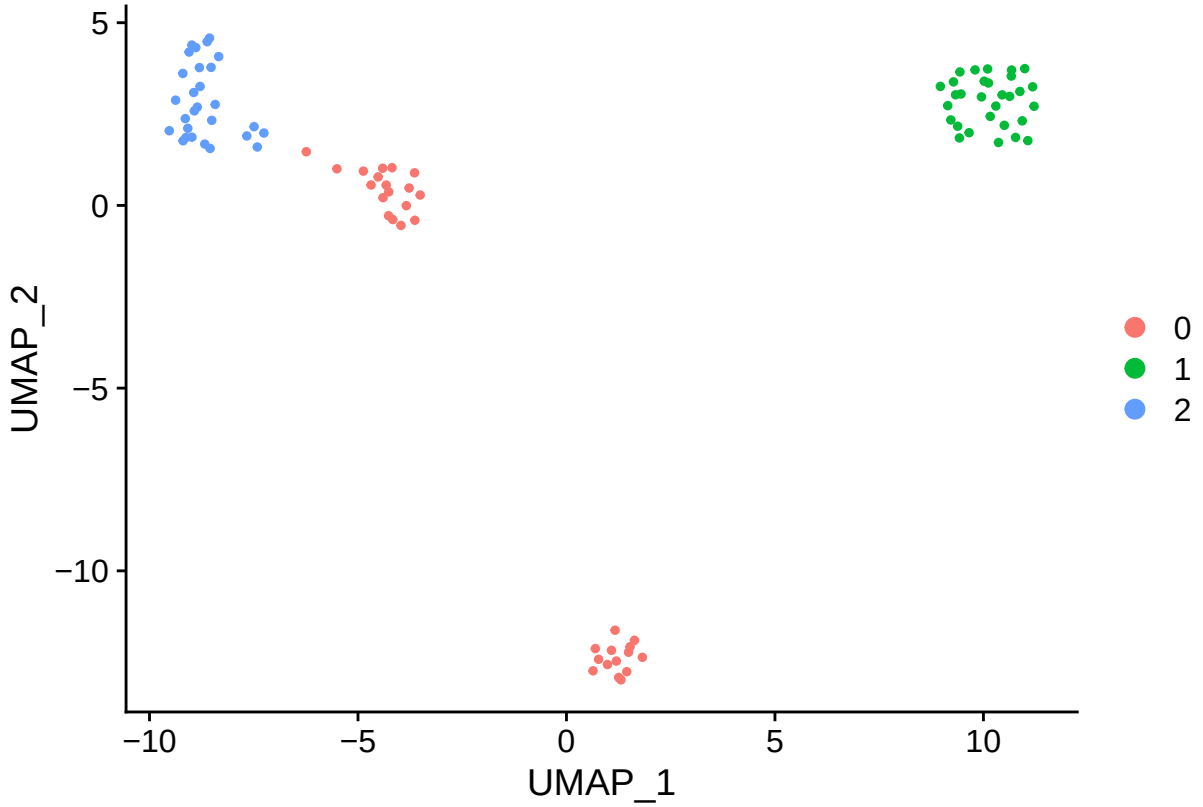
```
## 14:04:50 Building Annoy index with metric = cosine, n_trees = 50
```

```
## 0%   10   20   30   40   50   60   70   80   90   100%
```

```
## [----|----|----|----|----|----|----|----|----|----|
```

```
## **************************************************|
## 14:04:50 Writing NN index file to temp file C:\Users\flyku\AppData\Local\Temp\Rtmp02ZMj1\file78946ac
## 14:04:50 Searching Annoy index using 1 thread, search_k = 3000
## 14:04:50 Annoy recall = 100%
## 14:04:50 Commencing smooth kNN distance calibration using 1 thread
## 14:04:51 Initializing from normalized Laplacian + noise
## 14:04:51 Commencing optimization for 500 epochs, with 2234 positive edges
## 14:04:51 Optimization finished
```

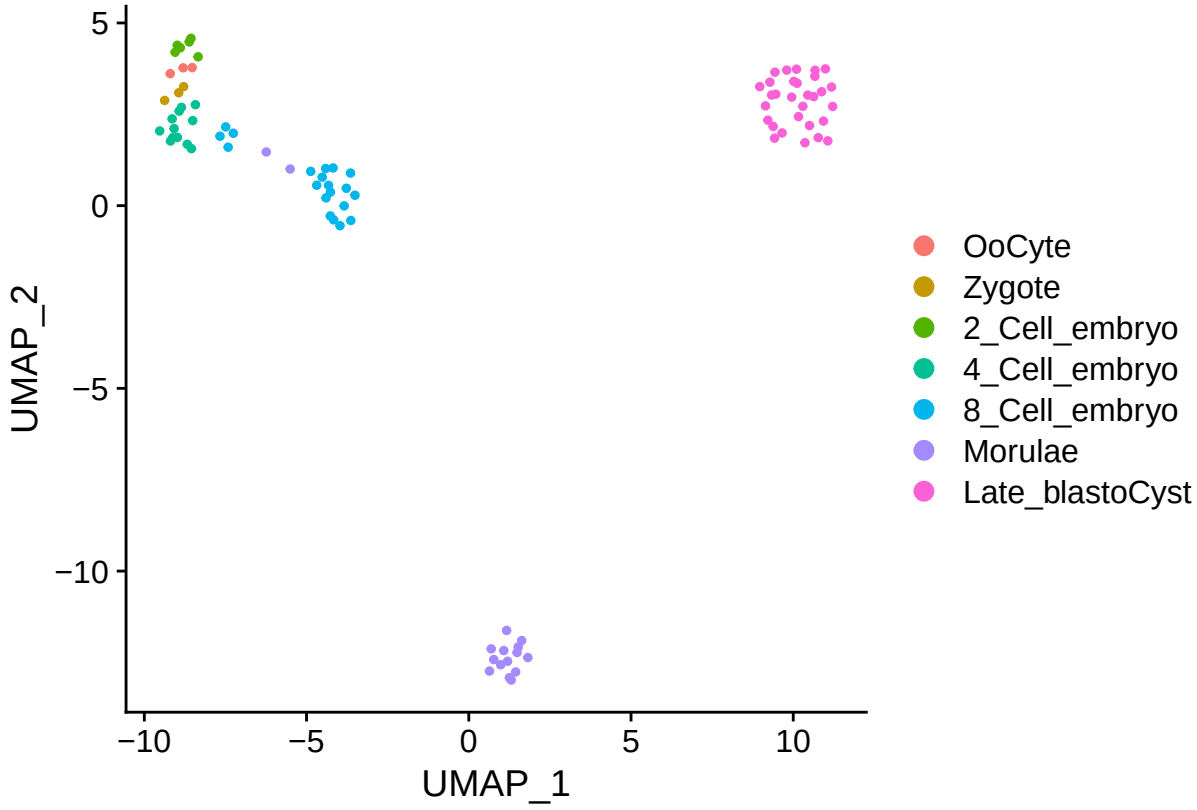
```
DimPlot(obj, reduction = "umap")
```



Plot UMAP colored by custom metadata

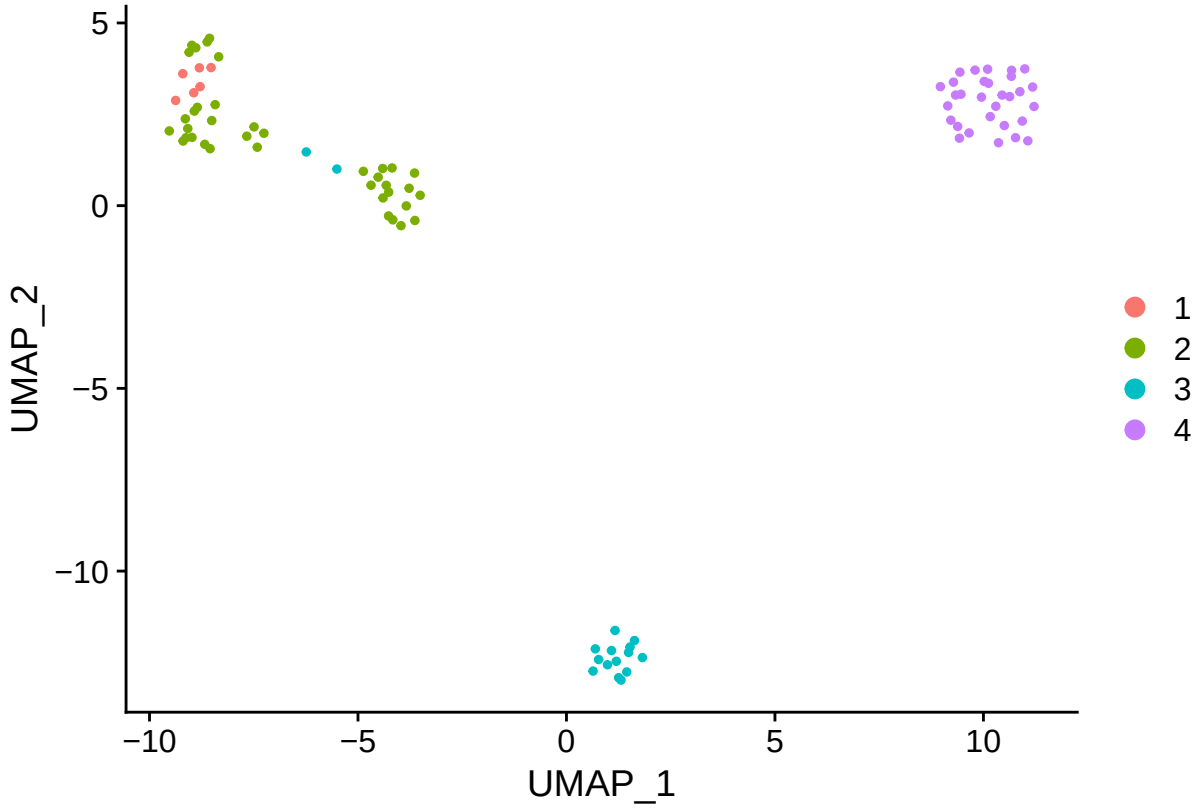
UMAP plot colored by cell types

```
Idents(obj) <- obj$Cluster
DimPlot(obj, reduction = "umap")
```



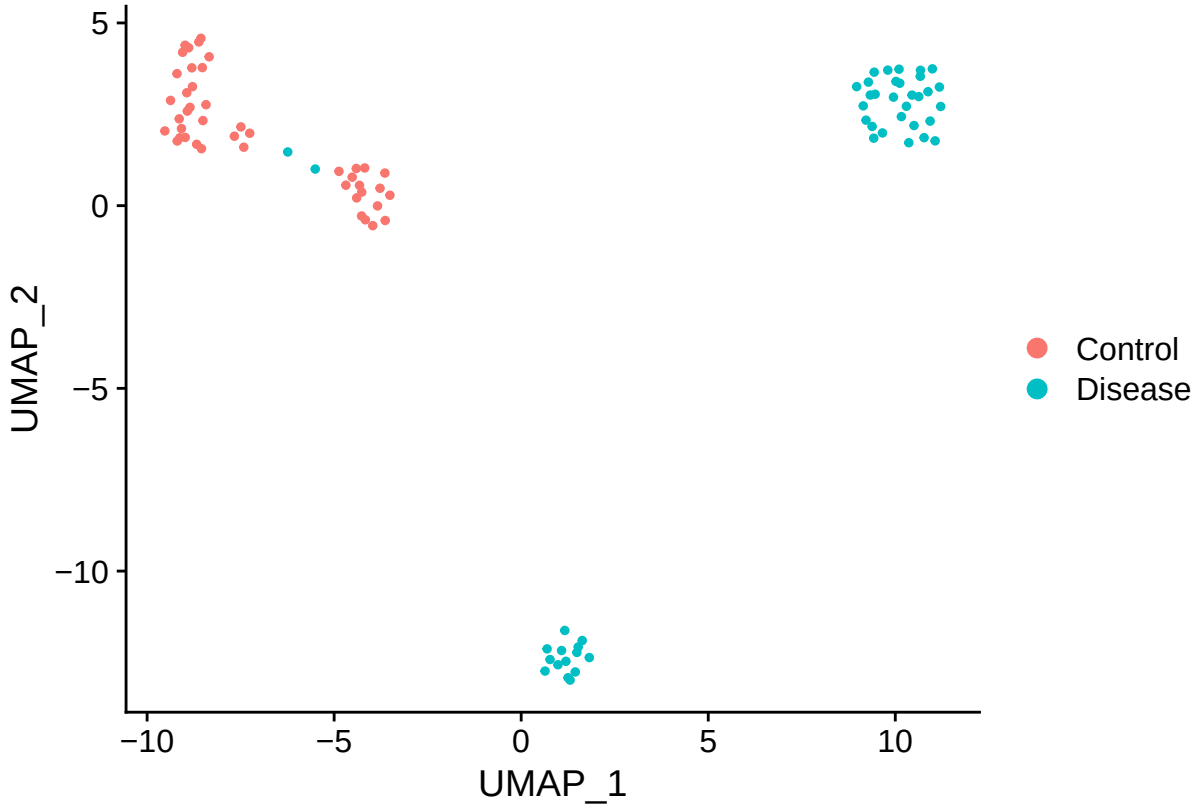
UMAP plot colored by time

```
Idents(obj) <- obj$Time
DimPlot(obj, reduction = "umap")
```



UMAP plot colored by condition

```
Idents(obj) <- obj$Condition
DimPlot(obj, reduction = "umap")
```



Finding differentially expressed features

Find cell type specific genes between control and disease group

```
Idents(obj) <- obj$Condition
cts_de_genes <- FindMarkers(obj, ident.1 = "Control", ident.2 = "Disease")

kable(cts_de_genes)
```

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
CLEC10A	0.0000000	0.6535568	1.000	0.022	0.0000000
C11orf41	0.0000000	1.5716403	1.000	0.087	0.0000000
TMEM163	0.0000000	2.9257802	1.000	0.239	0.0000000
ENG	0.0000000	0.7380097	1.000	0.239	0.0000000
PDK1	0.0000000	1.1270502	0.977	0.174	0.0000000
C21orf7	0.0000000	0.6862599	1.000	0.304	0.0000000
PDE8B	0.0000000	3.7330361	1.000	0.413	0.0000000
GDF9	0.0000000	2.3430204	1.000	0.587	0.0000000
MRC1	0.0000000	1.2680825	0.977	0.239	0.0000000
DNAH10	0.0000000	1.7650057	1.000	0.261	0.0000000
TMEM200A	0.0000000	1.5258964	0.909	0.000	0.0000000
FBLN5	0.0000000	1.6605395	0.955	0.109	0.0000000
FAM46C	0.0000000	2.5273579	1.000	0.500	0.0000000
TOX2	0.0000000	2.3288898	1.000	0.370	0.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
LYPD1	0.0000000	0.8254808	1.000	0.304	0.0000000
TESC	0.0000000	1.3170113	0.977	0.217	0.0000000
COX4I2	0.0000000	0.4068809	1.000	0.283	0.0000000
GPR137B	0.0000000	1.6367645	0.955	0.109	0.0000000
PTTG1	0.0000000	1.7710574	1.000	1.000	0.0000000
ALPL	0.0000000	-3.1992330	0.227	0.978	0.0000000
TCTN1	0.0000000	0.9041435	0.977	0.130	0.0000000
TRIM36	0.0000000	1.2468499	1.000	0.348	0.0000000
PRR15	0.0000000	1.1594417	1.000	0.326	0.0000000
LAMA1	0.0000000	-3.1948661	0.409	1.000	0.0000000
ABCC6	0.0000000	1.4735055	1.000	0.348	0.0000000
MTP18	0.0000000	-0.4862883	0.295	0.978	0.0000000
ELOVL4	0.0000000	1.3220434	0.977	0.283	0.0000000
RND1	0.0000000	0.9051316	0.977	0.239	0.0000000
CRMP1	0.0000000	1.9563517	0.955	0.130	0.0000000
DEPDC7	0.0000000	1.8240991	1.000	0.391	0.0000000
NME1-NME2	0.0000000	-1.6608055	1.000	1.000	0.0000000
SLC37A4	0.0000000	-0.6649210	0.318	0.978	0.0000000
KALRN	0.0000000	2.7026124	0.977	0.261	0.0000000
CD36	0.0000000	0.6631757	0.977	0.304	0.0000000
PARVG	0.0000000	0.5623636	0.886	0.022	0.0000000
KRT18	0.0000000	-3.2098391	1.000	1.000	0.0000000
ST6GAL1	0.0000000	-3.2228267	0.341	0.978	0.0000000
LRRK1	0.0000000	1.0659505	0.909	0.087	0.0000000
MCTP1	0.0000000	2.2007034	1.000	0.304	0.0000000
PRODH	0.0000000	-1.3270007	0.250	1.000	0.0000000
ELMO1	0.0000000	0.8721151	1.000	0.522	0.0000000
HSF2BP	0.0000000	2.3913629	1.000	0.652	0.0000000
SERHL2	0.0000000	1.5584741	1.000	0.609	0.0000000
HSPA12A	0.0000000	0.6791781	0.864	0.022	0.0000000
SLCO3A1	0.0000000	2.0170152	0.955	0.174	0.0000000
NR2F6	0.0000000	-1.2644049	0.409	1.000	0.0000000
S100A11	0.0000000	-0.5290551	0.614	1.000	0.0000000
RPL13AP20	0.0000000	-0.3179660	1.000	1.000	0.0000000
AKAP12	0.0000000	-1.9997725	0.455	1.000	0.0000000
PVRL2	0.0000000	-1.7457315	0.386	0.978	0.0000000
RBM47	0.0000000	-3.2814417	0.614	1.000	0.0000000
STAG3	0.0000000	0.4741139	1.000	0.891	0.0000000
RASA4	0.0000000	0.3357726	1.000	0.500	0.0000000
HOXA7	0.0000000	0.3694152	1.000	0.304	0.0000000
PSTPIP1	0.0000000	1.5177593	0.886	0.087	0.0000000
TXNRD1	0.0000000	-2.5811659	1.000	1.000	0.0000000
LRP5	0.0000000	0.4108779	1.000	0.261	0.0000000
EML1	0.0000000	1.3524061	0.909	0.109	0.0000000
PTK2B	0.0000000	1.8456541	0.932	0.196	0.0000000
EIF4EBP1	0.0000000	-0.4602481	0.864	1.000	0.0000000
SLIT3	0.0000000	1.6592299	0.977	0.239	0.0000000
RPL7	0.0000000	-1.1671482	1.000	1.000	0.0000000
PLXNA4	0.0000000	1.3898766	0.955	0.239	0.0000000
PLEKHG1	0.0000000	2.3732135	0.955	0.239	0.0000000
LRMP	0.0000000	1.2343934	1.000	0.326	0.0000000
RIMKLA	0.0000000	0.9366240	0.955	0.239	0.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
ADAMTSL1	0.0000000	2.8293700	0.864	0.065	0.0000000
SYTL2	0.0000000	1.7384899	0.977	0.261	0.0000000
NR3C2	0.0000000	2.5209781	0.977	0.413	0.0000000
CCDC146	0.0000000	1.6365404	1.000	0.435	0.0000000
DOK5	0.0000000	1.7990537	0.886	0.065	0.0000000
THSD7A	0.0000000	2.4869458	0.932	0.174	0.0000000
PLEK2	0.0000000	2.2437994	1.000	0.500	0.0000000
PON2	0.0000000	1.1232197	1.000	0.500	0.0000000
DOCK2	0.0000000	1.8196237	0.841	0.043	0.0000000
CPEB4	0.0000000	1.3809870	1.000	0.500	0.0000000
STK32B	0.0000000	2.0609853	1.000	0.348	0.0000000
CLIP4	0.0000000	0.9570652	0.886	0.043	0.0000000
SARDH	0.0000000	0.7081074	0.841	0.043	0.0000000
TIGIT	0.0000000	0.3937183	0.955	0.130	0.0000000
LIPG	0.0000000	0.6026859	0.977	0.217	0.0000000
C20orf194	0.0000000	1.3817024	1.000	0.565	0.0000000
LRRC17	0.0000000	1.9268022	0.886	0.130	0.0000000
ADAP1	0.0000000	2.0157769	0.841	0.043	0.0000000
ASRGL1	0.0000000	-2.4576027	0.909	1.000	0.0000000
CNN1	0.0000000	0.7614740	0.909	0.152	0.0000000
HNF1A	0.0000000	0.8694735	1.000	0.326	0.0000000
LAD1	0.0000000	1.7165668	1.000	0.826	0.0000000
FAM13AOS	0.0000000	1.2583111	0.932	0.196	0.0000000
STMN1	0.0000000	-1.1713950	1.000	1.000	0.0000000
FBLN7	0.0000000	2.2489532	0.864	0.109	0.0000000
MOCOS	0.0000000	0.7892219	0.841	0.065	0.0000000
ADAMTS17	0.0000000	1.1966767	0.977	0.261	0.0000000
EBF1	0.0000000	0.7292584	0.955	0.217	0.0000000
USP2	0.0000000	1.5133659	1.000	0.500	0.0000000
MVP	0.0000000	1.5087068	1.000	0.804	0.0000000
MICALCL	0.0000000	2.1745257	0.977	0.370	0.0000000
GLIPR2	0.0000000	-2.1072428	0.659	0.978	0.0000000
CTSL1	0.0000000	-1.4118362	1.000	1.000	0.0000000
SEPW1	0.0000000	-1.6241404	1.000	1.000	0.0000000
IGSF10	0.0000000	1.4350682	0.977	0.565	0.0000000
BCAT1	0.0000000	-2.2355659	0.523	1.000	0.0000000
S100A6	0.0000000	-2.4462282	0.227	0.913	0.0000000
SOX13	0.0000000	0.9647821	1.000	0.696	0.0000000
INPP1	0.0000000	0.7157649	0.864	0.087	0.0000000
PLIN5	0.0000000	0.4262821	0.886	0.087	0.0000000
ENPP2	0.0000000	1.4879376	0.841	0.065	0.0000000
C14orf37	0.0000000	1.4148718	1.000	0.435	0.0000000
DSG2	0.0000000	-1.0864521	1.000	1.000	0.0000000
PGAM4	0.0000000	-0.5053326	0.545	0.978	0.0000000
D4S234E	0.0000000	1.4486240	1.000	0.587	0.0000000
WFDC2	0.0000000	1.4984103	1.000	0.609	0.0000000
C6orf132	0.0000000	-1.1900983	0.136	0.870	0.0000000
TIPARP	0.0000000	1.4516101	1.000	0.783	0.0000000
ANXA2	0.0000000	-1.7117422	0.818	1.000	0.0000000
C21orf63	0.0000000	1.1626314	0.977	0.326	0.0000000
PTGES	0.0000000	-2.5127172	0.341	0.935	0.0000000
PGM5	0.0000000	0.5568692	0.886	0.065	0.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
JAZF1	0.0000000	1.4394057	1.000	0.522	0.0000000
ETV5	0.0000000	1.1093701	1.000	0.500	0.0000000
C1orf59	0.0000000	1.2410815	1.000	0.957	0.0000000
ARHGAP6	0.0000000	1.3316681	0.773	0.000	0.0000000
ATAD3B	0.0000000	-1.8170790	1.000	1.000	0.0000000
MXD1	0.0000000	0.9507585	0.955	0.391	0.0000000
MPP2	0.0000000	0.8192628	1.000	0.304	0.0000000
PAMR1	0.0000000	0.7622399	0.932	0.130	0.0000000
GNG2	0.0000000	1.6425034	0.932	0.261	0.0000000
S100A10	0.0000000	-3.1242489	0.545	0.978	0.0000000
PLA2G4C	0.0000000	0.2881187	0.955	0.304	0.0000000
MIF	0.0000000	-1.4136492	1.000	1.000	0.0000000
PLEC	0.0000000	-0.5876595	0.273	0.913	0.0000000
FBXL7	0.0000000	2.6712464	0.795	0.043	0.0000000
CERKL	0.0000000	0.7523225	0.932	0.217	0.0000000
ANPEP	0.0000000	-2.3901568	0.159	0.870	0.0000000
ABCB4	0.0000000	2.1844774	0.818	0.087	0.0000000
SEMA5A	0.0000000	1.4882464	0.818	0.087	0.0000000
ADAMTS9	0.0000000	1.5320477	0.977	0.261	0.0000000
C2orf15	0.0000000	0.7505445	1.000	0.826	0.0000000
MAPK10	0.0000000	1.3649107	0.773	0.022	0.0000000
CRISPLD2	0.0000000	1.1999117	0.932	0.196	0.0000000
ANXA2P2	0.0000000	-0.3790308	0.750	1.000	0.0000000
NKX3-1	0.0000000	0.2677898	0.886	0.109	0.0000000
UQCRHL	0.0000000	-0.2601507	1.000	1.000	0.0000000
PI4KAP2	0.0000000	-1.2880329	0.977	1.000	0.0000000
A4GALT	0.0000000	-1.4004103	1.000	1.000	0.0000000
B4GALT6	0.0000000	0.6492175	0.886	0.152	0.0000000
KATNAL1	0.0000000	1.4269528	1.000	0.739	0.0000000
PION	0.0000000	1.1061820	0.955	0.239	0.0000000
C5orf45	0.0000000	1.0881029	1.000	0.609	0.0000000
KIAA0114	0.0000000	-0.9565410	1.000	1.000	0.0000000
RPSAP9	0.0000000	-0.3950181	1.000	1.000	0.0000000
TSPAN7	0.0000000	1.1076461	1.000	0.283	0.0000000
JAG1	0.0000000	1.2603949	1.000	0.435	0.0000000
DAAM2	0.0000000	0.9577001	0.795	0.065	0.0000000
DNAJC15	0.0000000	-1.6991115	1.000	1.000	0.0000000
GNA14	0.0000000	2.2401184	0.932	0.283	0.0000000
NTRK2	0.0000000	0.9938981	0.886	0.087	0.0000000
PDE9A	0.0000000	1.8157872	0.818	0.109	0.0000000
PCSK5	0.0000000	1.2895022	1.000	0.457	0.0000000
SHMT1	0.0000000	-1.3411881	0.841	1.000	0.0000000
C2orf74	0.0000000	-0.6391454	0.182	0.870	0.0000000
ABAT	0.0000000	0.5323583	0.932	0.217	0.0000000
PI4KAP1	0.0000000	-0.7233015	0.955	0.978	0.0000000
WDR76	0.0000000	0.7094006	1.000	0.957	0.0000000
MCTP2	0.0000000	1.5611308	0.841	0.130	0.0000000
ABTB2	0.0000000	1.6462273	0.977	0.609	0.0000000
LYN	0.0000000	-2.1614245	0.341	0.913	0.0000000
NAIP	0.0000000	0.6046114	0.977	0.761	0.0000000
psiTPTE22	0.0000000	-1.4169954	1.000	1.000	0.0000000
ESCO2	0.0000000	1.1709918	1.000	0.891	0.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
FAM19A5	0.0000000	1.8677701	0.818	0.109	0.0000000
ITGA11	0.0000000	0.2765441	0.795	0.022	0.0000000
QPRT	0.0000000	-2.0222083	0.568	0.978	0.0000000
KIF26B	0.0000000	2.1198566	0.795	0.087	0.0000000
ANXA5	0.0000000	-1.5487950	1.000	1.000	0.0000000
LAMP3	0.0000000	0.2801015	0.932	0.239	0.0000000
BICC1	0.0000000	1.9600507	0.750	0.022	0.0000000
MALAT1	0.0000000	-1.4953907	1.000	1.000	0.0000000
CDH2	0.0000000	1.0275217	1.000	0.326	0.0000000
IL16	0.0000000	0.6045551	0.841	0.087	0.0000000
FAM149A	0.0000000	1.3702293	0.818	0.130	0.0000000
FHIT	0.0000000	2.0720440	0.932	0.326	0.0000000
PLAGL1	0.0000000	0.6106521	0.841	0.130	0.0000000
SNPH	0.0000000	0.3012737	0.750	0.022	0.0000000
NTN1	0.0000000	1.9315856	0.773	0.065	0.0000000
ACAD11	0.0000000	1.6306257	0.909	0.283	0.0000000
IRF8	0.0000000	0.7692309	0.841	0.109	0.0000000
ZNF502	0.0000000	0.6928463	1.000	0.370	0.0000000
RADIL	0.0000000	1.8148002	0.955	0.304	0.0000000
RGS2	0.0000000	2.7237767	1.000	0.913	0.0000000
ITGA4	0.0000000	0.8792367	0.977	0.261	0.0000000
HN1	0.0000000	-1.4360880	1.000	1.000	0.0000000
ATP10D	0.0000000	0.7800145	0.841	0.087	0.0000000
TUBA4A	0.0000000	0.7406149	1.000	0.413	0.0000000
SPARC	0.0000000	-3.4297029	0.159	0.826	0.0000000
BMP6	0.0000000	0.4734452	1.000	0.957	0.0000000
GLIPR1	0.0000000	0.3327495	1.000	0.978	0.0000000
CHRNA7	0.0000000	1.0586351	1.000	0.478	0.0000000
PRIM1	0.0000000	-2.1039370	0.682	0.978	0.0000000
FYN	0.0000000	0.4048487	1.000	0.543	0.0000000
C3orf59	0.0000000	1.4850604	0.955	0.391	0.0000000
EEF1A1P9	0.0000000	-0.9170901	1.000	1.000	0.0000000
MAST4	0.0000000	1.1922525	1.000	0.413	0.0000000
PLCL1	0.0000000	0.9276809	0.932	0.239	0.0000000
ZCWPW1	0.0000000	1.0602693	0.977	0.457	0.0000000
C9orf140	0.0000000	-1.1229869	0.023	0.739	0.0000000
ST3GAL4	0.0000000	1.1994496	0.955	0.326	0.0000000
ZNF618	0.0000000	1.6306291	0.932	0.239	0.0000000
GATA3	0.0000000	-1.1140910	0.477	0.978	0.0000000
SIGLEC10	0.0000000	0.2822238	1.000	0.804	0.0000000
SQRDL	0.0000000	1.0548831	1.000	0.304	0.0000000
CREB5	0.0000000	2.0235071	0.795	0.109	0.0000000
GLS2	0.0000000	0.3112343	0.795	0.109	0.0000000
PABPC3	0.0000000	-0.3021941	1.000	1.000	0.0000000
RUNDC3B	0.0000000	1.8270063	0.773	0.087	0.0000000
CLIP3	0.0000000	0.3111558	0.864	0.152	0.0000000
RASGRP1	0.0000000	0.3842405	0.705	0.000	0.0000000
LRRC49	0.0000000	1.8598286	0.864	0.196	0.0000000
CA2	0.0000000	-0.4843419	0.205	0.870	0.0000000
ABLIM2	0.0000000	1.0544444	0.773	0.065	0.0000000
GNG12	0.0000000	1.7507344	1.000	0.674	0.0000000
FHOD3	0.0000000	1.7764831	0.909	0.217	0.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
SLC41A2	0.0000000	1.5460476	0.909	0.348	0.0000001
ITGA9	0.0000000	0.6755887	0.841	0.109	0.0000001
ATP8A1	0.0000000	0.8835261	0.955	0.196	0.0000001
SH3BP4	0.0000000	-1.7202046	0.705	0.935	0.0000001
TNIK	0.0000000	1.3777424	1.000	0.761	0.0000001
KIT	0.0000000	0.9579549	1.000	0.457	0.0000001
ABI3BP	0.0000000	1.3550934	0.773	0.065	0.0000001
C7orf10	0.0000000	2.0590190	0.977	0.457	0.0000001
C16orf74	0.0000000	1.0837614	0.977	0.457	0.0000001
SVEP1	0.0000000	0.8168769	0.795	0.087	0.0000001
PLAC8	0.0000000	-0.3354967	0.841	1.000	0.0000001
NDUFA3	0.0000000	-0.5311892	0.932	1.000	0.0000001
LOC374443	0.0000000	0.6317670	0.932	0.217	0.0000001
ADCY9	0.0000000	0.9995968	1.000	0.500	0.0000001
C20orf112	0.0000000	0.5637699	0.909	0.174	0.0000001
DAAM1	0.0000000	1.4685925	1.000	0.978	0.0000001
PLS1	0.0000000	1.4363076	0.977	0.435	0.0000001
DSC2	0.0000000	-1.1130090	0.159	0.870	0.0000001
PCLO	0.0000000	0.5670148	0.977	0.217	0.0000001
TMC7	0.0000000	-1.5730200	0.500	0.957	0.0000001
ADCY7	0.0000000	0.5433858	0.886	0.326	0.0000001
PLB1	0.0000000	0.5475836	0.886	0.152	0.0000001
MRVI1	0.0000000	0.9304879	0.818	0.174	0.0000001
PSAT1	0.0000000	-2.1552743	0.364	0.913	0.0000001
CCND2	0.0000000	0.8396229	1.000	0.326	0.0000001
PHACTR1	0.0000000	1.6180526	0.932	0.283	0.0000001
DDX58	0.0000000	0.6964304	0.932	0.370	0.0000001
TLE2	0.0000000	0.6752802	0.932	0.239	0.0000001
CDH3	0.0000000	0.9800161	1.000	0.652	0.0000001
RASGRF1	0.0000000	0.3239208	0.977	0.283	0.0000001
GOLM1	0.0000000	1.2592666	1.000	0.761	0.0000001
CLCN4	0.0000000	0.6494175	0.955	0.217	0.0000001
LRRC8C	0.0000000	0.4790664	0.841	0.130	0.0000002
FHL2	0.0000000	-2.9064622	0.091	0.761	0.0000002
INPP4B	0.0000000	1.2267641	0.818	0.087	0.0000002
FAM190A	0.0000000	1.2458925	0.795	0.043	0.0000002
AMOTL1	0.0000000	0.8361130	0.977	0.413	0.0000002
TSPAN12	0.0000000	0.3792005	1.000	0.304	0.0000002
PLEKHB1	0.0000000	0.4029576	1.000	0.348	0.0000002
ADD3	0.0000000	0.7414007	1.000	0.978	0.0000002
CTSC	0.0000000	-1.4381958	0.977	1.000	0.0000002
C1orf106	0.0000000	-0.9495183	0.227	0.804	0.0000002
KIAA1324L	0.0000000	1.0263357	1.000	0.783	0.0000002
C1orf210	0.0000000	0.3117505	1.000	0.696	0.0000002
C2orf88	0.0000000	1.2428395	0.864	0.152	0.0000002
SGCD	0.0000000	1.1424689	0.727	0.022	0.0000002
MTHFD1L	0.0000000	-2.3856960	0.705	0.978	0.0000002
AIM1	0.0000000	0.5852343	0.977	0.391	0.0000003
HS6ST1	0.0000000	-1.6027343	0.818	0.978	0.0000003
SEMA6A	0.0000000	-2.2153479	0.386	0.870	0.0000003
ZNF799	0.0000000	0.7619002	0.955	0.500	0.0000003
GJA1	0.0000000	-0.8002619	1.000	1.000	0.0000003

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
MYBL2	0.0000000	-1.2954334	1.000	1.000	0.0000003
SLC6A9	0.0000000	0.3616126	0.864	0.152	0.0000003
CRYBG3	0.0000000	0.8011353	1.000	0.587	0.0000003
KIF4A	0.0000000	1.1197869	1.000	0.957	0.0000003
NCRNA00182	0.0000000	-1.1291458	1.000	1.000	0.0000003
LRP6	0.0000000	0.8027027	1.000	0.913	0.0000004
DISP1	0.0000000	1.1809019	0.818	0.130	0.0000004
FBLN2	0.0000000	0.3544814	0.864	0.109	0.0000004
YPEL1	0.0000000	0.9248744	1.000	0.826	0.0000004
FAM161B	0.0000000	0.3810998	1.000	0.413	0.0000004
CDCA7L	0.0000000	1.3141468	0.886	0.348	0.0000004
ITPR1	0.0000000	1.3818447	0.886	0.239	0.0000005
ZNF280B	0.0000000	0.6577046	1.000	0.543	0.0000005
PTPRM	0.0000000	0.9718096	0.795	0.087	0.0000006
PTPRK	0.0000000	1.3206399	0.977	0.457	0.0000006
KAL1	0.0000000	0.3494970	0.750	0.065	0.0000006
PPAP2A	0.0000000	-2.0656916	0.955	1.000	0.0000006
KCNIP4	0.0000000	0.7929049	0.750	0.065	0.0000006
NCALD	0.0000000	1.8175678	0.864	0.261	0.0000007
SAMD12	0.0000000	0.4467106	0.795	0.174	0.0000007
RAB38	0.0000000	1.6839206	0.773	0.130	0.0000007
IQCD	0.0000000	0.4076733	0.886	0.239	0.0000007
GALC	0.0000000	0.4035489	0.909	0.196	0.0000008
EDN1	0.0000000	0.2579561	0.750	0.043	0.0000008
AFF3	0.0000000	0.9526527	0.818	0.130	0.0000008
F13A1	0.0000000	0.5854924	0.636	0.000	0.0000008
ZNF10	0.0000000	0.5021791	1.000	0.370	0.0000009
GPR98	0.0000000	0.7056300	0.932	0.152	0.0000009
RCAN2	0.0000000	1.0340196	0.659	0.022	0.0000009
NCAPH	0.0000000	0.9201562	1.000	0.913	0.0000010
PPP1R13B	0.0000000	1.0395522	1.000	0.696	0.0000011
DYNC2H1	0.0000000	1.2393985	0.909	0.370	0.0000011
SLC7A2	0.0000000	-2.9988259	0.909	1.000	0.0000011
SYNE2	0.0000000	0.8065743	1.000	0.978	0.0000011
PDE3A	0.0000000	0.8766439	0.750	0.109	0.0000012
RPL22L1	0.0000000	-0.9823927	1.000	1.000	0.0000013
ARHGAP32	0.0000000	1.0929269	1.000	0.674	0.0000013
SCML1	0.0000000	0.6641218	0.977	0.587	0.0000013
SYK	0.0000000	-1.0305268	0.386	0.870	0.0000013
RTKN	0.0000000	-1.6653630	0.159	0.783	0.0000013
PLEKHH1	0.0000000	-0.4120454	1.000	1.000	0.0000013
GBP2	0.0000000	2.0353929	0.682	0.043	0.0000013
BANK1	0.0000000	0.6479601	0.795	0.087	0.0000015
LRRC4	0.0000000	0.7603866	0.977	0.348	0.0000016
CHPT1	0.0000000	-1.8118872	0.864	0.978	0.0000017
HPGD	0.0000000	-2.2552975	0.136	0.739	0.0000017
EME1	0.0000000	-0.2697187	1.000	1.000	0.0000017
ROMO1	0.0000000	-0.4143593	0.909	0.978	0.0000018
GALNT10	0.0000000	-1.4918928	0.386	0.848	0.0000020
C10orf125	0.0000000	-0.5416123	0.045	0.674	0.0000020
PERP	0.0000000	-0.4645845	0.477	0.935	0.0000021
CDKN3	0.0000000	-1.5075143	0.864	1.000	0.0000022

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
FLNB	0.0000000	-0.5730157	0.886	1.000	0.0000022
EXPH5	0.0000000	-0.9225704	0.977	1.000	0.0000022
EML5	0.0000000	0.5846725	0.955	0.326	0.0000023
CPEB2	0.0000000	0.2873232	1.000	0.522	0.0000024
HIPK2	0.0000000	0.7539102	0.932	0.326	0.0000024
HMGA1	0.0000000	-0.5375781	1.000	1.000	0.0000025
ADM	0.0000000	-1.1248469	0.477	0.935	0.0000025
CSRP2	0.0000000	1.2382421	1.000	0.761	0.0000025
C6orf97	0.0000000	0.5033943	0.750	0.087	0.0000027
ARHGAP20	0.0000000	0.3341781	0.727	0.043	0.0000027
KIAA1407	0.0000000	0.6511348	0.886	0.261	0.0000028
ZNF304	0.0000000	0.3826644	1.000	0.674	0.0000029
DECR2	0.0000000	-0.6876001	0.795	0.957	0.0000029
SYNM	0.0000000	0.2829329	0.955	0.370	0.0000029
MAPRE3	0.0000000	0.4510239	0.705	0.065	0.0000030
CTGF	0.0000000	-0.5130098	0.091	0.739	0.0000030
ECE2	0.0000000	-1.0778430	0.591	0.957	0.0000031
SHC2	0.0000000	0.2732769	0.818	0.152	0.0000032
SLC1A3	0.0000000	-2.3018529	0.091	0.696	0.0000032
TMEM229B	0.0000000	0.3586154	0.864	0.196	0.0000032
LDLRAD3	0.0000000	1.3655932	0.886	0.261	0.0000033
SLC25A23	0.0000000	-0.8621569	1.000	0.957	0.0000033
PXK	0.0000000	1.8047048	0.955	0.543	0.0000034
SLC7A5	0.0000000	-0.2834986	0.932	0.957	0.0000037
CDKN1A	0.0000000	0.4517396	0.909	0.174	0.0000040
EEPD1	0.0000000	1.0653137	0.864	0.283	0.0000040
SORBS2	0.0000000	0.5210979	0.636	0.022	0.0000043
EMP2	0.0000000	-1.8458084	1.000	1.000	0.0000045
PSD3	0.0000000	1.3045961	1.000	0.652	0.0000047
CUEDC1	0.0000000	0.6917550	0.750	0.087	0.0000047
SLC38A1	0.0000000	-0.7582077	0.000	0.609	0.0000048
ZEB1	0.0000000	0.6711336	0.909	0.217	0.0000048
HSPA1A	0.0000000	0.2926873	1.000	0.870	0.0000050
PAFAH1B3	0.0000000	-0.6961258	0.909	0.957	0.0000050
DLGAP5	0.0000000	1.5354355	1.000	1.000	0.0000050
FCHO1	0.0000000	0.4994059	0.727	0.109	0.0000050
DHCR24	0.0000000	-2.0651393	0.909	0.935	0.0000052
RPS26	0.0000000	-0.7405762	1.000	1.000	0.0000052
MOSC2	0.0000000	0.3259126	0.636	0.043	0.0000054
SERPINB8	0.0000000	0.2562964	0.705	0.087	0.0000059
FLJ44635	0.0000000	-0.4031407	0.886	0.978	0.0000059
PVRL3	0.0000000	0.9012033	1.000	0.457	0.0000061
ZFP28	0.0000000	0.3352700	1.000	0.370	0.0000062
CD97	0.0000000	-0.9509575	0.591	0.870	0.0000067
C10orf58	0.0000000	-1.7514204	0.909	0.978	0.0000067
FILIP1	0.0000000	-2.6040604	0.386	0.891	0.0000069
CHST10	0.0000000	0.3251387	0.705	0.087	0.0000070
FAM81A	0.0000000	0.6099482	0.614	0.022	0.0000071
EXOC3L2	0.0000000	1.0511295	0.886	0.435	0.0000073
ZNF549	0.0000000	0.3365274	1.000	0.870	0.0000074
RAB15	0.0000000	-1.6860248	1.000	0.978	0.0000074
SNX25	0.0000000	1.0625343	1.000	0.500	0.0000077

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
TFRC	0.0000000	-1.7613689	1.000	0.978	0.0000078
LAMC1	0.0000000	-1.8574030	1.000	1.000	0.0000078
PRSS8	0.0000000	-1.1766940	0.114	0.696	0.0000078
SLA2	0.0000000	0.3046863	0.795	0.304	0.0000079
APBA2	0.0000000	0.9182016	0.750	0.152	0.0000083
LRRC6	0.0000000	0.3316641	0.909	0.217	0.0000085
PARD6G	0.0000000	0.7947862	1.000	0.935	0.0000086
RGNEF	0.0000000	0.7381342	0.818	0.152	0.0000088
KIAA0922	0.0000000	1.9323010	0.955	0.739	0.0000089
MT1E	0.0000000	0.3250639	1.000	0.630	0.0000093
PRDX2	0.0000000	-0.3932237	1.000	1.000	0.0000095
NMNAT3	0.0000000	0.6162807	0.705	0.087	0.0000098
GPR133	0.0000000	0.8846533	0.773	0.130	0.0000100
CCDC102B	0.0000000	0.8716528	0.682	0.043	0.0000112
KCNK1	0.0000000	-0.4691044	0.568	0.978	0.0000118
EPSTI1	0.0000000	2.0822289	1.000	0.717	0.0000121
C5orf34	0.0000000	0.8734811	0.886	0.500	0.0000124
OLFM1	0.0000000	0.2906691	0.909	0.152	0.0000128
FNIP2	0.0000000	1.2723366	1.000	0.739	0.0000128
ABCC1	0.0000000	0.8055347	0.841	0.283	0.0000132
HSPA1B	0.0000000	0.2940787	1.000	0.891	0.0000140
TTLL12	0.0000000	-0.8746757	0.955	0.978	0.0000148
S100A13	0.0000000	-2.8736966	0.614	0.935	0.0000151
FAM70B	0.0000000	0.4826836	0.750	0.130	0.0000152
POMZP3	0.0000000	0.8209333	1.000	0.674	0.0000158
IGSF9	0.0000000	0.6817558	0.841	0.348	0.0000166
ETV3	0.0000000	0.2982081	0.955	0.326	0.0000198
CTCFL	0.0000000	0.5560626	0.977	0.304	0.0000218
PID1	0.0000000	0.2917467	0.955	0.196	0.0000230
SLC12A8	0.0000000	1.4029895	0.773	0.283	0.0000237
CLDN4	0.0000000	-0.7649041	0.136	0.696	0.0000241
PRKCI	0.0000000	-1.1754891	1.000	1.000	0.0000251
FSD1L	0.0000000	0.3571643	0.818	0.152	0.0000252
TNS3	0.0000000	-2.5051688	0.295	0.783	0.0000255
ZNF425	0.0000000	0.2683032	0.818	0.217	0.0000263
PITPNC1	0.0000000	-2.4614043	0.909	0.978	0.0000263
UHRF1	0.0000000	2.2399890	1.000	0.935	0.0000264
EPB41L2	0.0000000	0.6943385	1.000	0.826	0.0000273
TMEM22	0.0000000	1.4314666	0.773	0.196	0.0000279
TRIM56	0.0000000	-0.2787337	0.000	0.565	0.0000282
CDKL5	0.0000000	1.0039393	0.909	0.348	0.0000283
C7orf50	0.0000000	-1.7405132	0.795	0.935	0.0000286
CHI3L2	0.0000000	-0.7751756	0.409	0.935	0.0000304
F3	0.0000000	-0.7512253	0.341	0.804	0.0000307
C2orf77	0.0000000	0.6128367	0.955	0.457	0.0000325
KRT19	0.0000000	-1.3313895	0.091	0.652	0.0000327
IL6ST	0.0000000	-0.5117557	0.909	0.957	0.0000333
FGD3	0.0000000	0.5561453	0.818	0.196	0.0000355
RTN1	0.0000000	0.5310105	0.545	0.000	0.0000366
PLAGL2	0.0000000	0.4617807	1.000	0.935	0.0000368
ACAA2	0.0000000	-1.6515641	1.000	1.000	0.0000368
UCP2	0.0000000	0.6949975	0.955	0.826	0.0000377

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
AOX1	0.0000000	0.5703419	0.909	0.348	0.0000380
CALD1	0.0000000	-3.3996221	0.159	0.696	0.0000395
FBXO43	0.0000000	0.4155714	0.727	0.174	0.0000397
ITGBL1	0.0000000	0.8280028	0.727	0.109	0.0000400
RTN4R	0.0000000	0.3415780	0.841	0.283	0.0000401
ATP9A	0.0000000	0.9228638	0.932	0.413	0.0000411
CDH13	0.0000000	1.2127039	0.591	0.022	0.0000434
TUBG2	0.0000000	0.6306697	0.977	0.935	0.0000455
MTUS1	0.0000000	1.0399580	1.000	0.848	0.0000463
SYTL4	0.0000000	0.6183500	0.773	0.239	0.0000481
ZFP36L2	0.0000000	-0.2622541	0.818	0.935	0.0000498
MAML2	0.0000000	0.4708314	0.591	0.022	0.0000516
PHKA1	0.0000000	-1.9903626	0.386	0.783	0.0000518
ARMC9	0.0000000	0.6853165	0.864	0.239	0.0000540
RNF180	0.0000000	0.2998513	0.682	0.087	0.0000593
HLA-F	0.0000000	-0.7286424	0.045	0.609	0.0000606
VSIG10	0.0000000	-0.6316341	0.795	0.957	0.0000629
GSTP1	0.0000000	-0.8801543	0.932	0.935	0.0000630
ABCB6	0.0000000	-0.4054685	0.568	0.891	0.0000644
BLNK	0.0000000	0.3507302	0.591	0.043	0.0000646
CTNNAL1	0.0000000	-1.8703063	0.955	0.935	0.0000647
CD276	0.0000000	-0.5461630	0.068	0.630	0.0000726
BAIAP2	0.0000000	0.8143021	1.000	0.978	0.0000746
PWWP2B	0.0000000	-0.5557064	0.023	0.565	0.0000773
CLDN3	0.0000000	-0.3525409	0.023	0.587	0.0000788
BOP1	0.0000000	-0.8626664	0.886	1.000	0.0000816
LGALS1	0.0000000	0.4594461	1.000	0.761	0.0000872
CMTM7	0.0000000	-1.7734516	0.045	0.587	0.0000883
BSPRY	0.0000000	-0.8593798	0.318	0.761	0.0000925
FTL	0.0000000	0.5493786	1.000	1.000	0.0000940
C19orf21	0.0000000	-0.6505094	0.295	0.826	0.0000959
SPON1	0.0000000	1.2169604	0.705	0.152	0.0000968
ZBTB37	0.0000000	0.4427539	1.000	0.413	0.0000969
SCN8A	0.0000000	0.4221282	0.795	0.196	0.0000984
KRTCAP3	0.0000000	-0.6058042	0.455	0.891	0.0001004
WWC1	0.0000000	-1.3698639	0.841	0.978	0.0001044
NFE2L3	0.0000000	-0.2836486	0.955	1.000	0.0001080
ABHD2	0.0000000	0.7102442	1.000	1.000	0.0001131
ABHD6	0.0000000	-0.9524766	0.409	0.826	0.0001147
TRPV4	0.0000000	0.3112631	0.750	0.152	0.0001255
ANK3	0.0000000	0.7369754	0.841	0.370	0.0001258
LASS6	0.0000000	0.9411872	0.909	0.500	0.0001343
MYH11	0.0000000	0.6356644	0.955	0.500	0.0001401
EIF3C	0.0000000	-0.8918529	1.000	1.000	0.0001422
GULP1	0.0000000	-2.2969904	0.159	0.674	0.0001457
MARCKS	0.0000000	-0.8633799	0.705	0.935	0.0001461
ESRP2	0.0000000	-0.5398300	0.932	0.957	0.0001484
PUSL1	0.0000000	-0.2971319	0.545	0.826	0.0001538
CSGALNACT1	0.0000000	1.4513036	0.705	0.217	0.0001553
ACSS3	0.0000000	0.5399205	0.614	0.065	0.0001588
TEAD1	0.0000000	-1.8750639	0.932	0.978	0.0001591
NUAK2	0.0000000	-0.3194034	1.000	1.000	0.0001630

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
DAB2	0.0000000	-2.1014579	0.477	0.978	0.0001635
PLS3	0.0000000	-1.5528166	0.477	0.891	0.0001649
C12orf75	0.0000001	0.4808842	0.750	0.152	0.0001782
KIF5C	0.0000001	0.4405633	0.909	0.283	0.0001975
ZNF827	0.0000001	0.3481597	0.795	0.174	0.0002081
CBWD3	0.0000001	-0.7720289	1.000	1.000	0.0002139
MAP9	0.0000001	0.6416588	1.000	0.565	0.0002170
LNPEP	0.0000001	0.3723516	0.841	0.261	0.0002194
MLLT3	0.0000001	0.6299860	0.864	0.326	0.0002381
SIPA1L2	0.0000001	0.8696331	1.000	0.565	0.0002485
LASS4	0.0000001	-1.5757438	0.591	0.870	0.0002521
LRRCC1	0.0000001	-0.9240192	0.500	0.913	0.0002552
C9orf93	0.0000001	0.4168823	0.864	0.348	0.0002600
MVD	0.0000001	-1.8787782	0.591	0.848	0.0002658
DBNDD2	0.0000001	-0.2878240	0.455	0.891	0.0002904
EVC2	0.0000001	0.5767469	0.727	0.130	0.0003171
KIF3C	0.0000001	0.5955646	0.977	0.543	0.0003297
SPAG16	0.0000001	1.1928280	0.932	0.522	0.0003331
TMEM27	0.0000001	0.4321870	0.818	0.239	0.0003340
CCDC85C	0.0000001	-0.9828936	0.977	0.957	0.0003345
LGR4	0.0000001	-1.6372887	0.773	0.913	0.0003462
ARHGAP23	0.0000001	-0.6273714	0.114	0.652	0.0003480
MGLL	0.0000001	-1.3239647	0.000	0.500	0.0003496
SLC16A2	0.0000001	-1.7838718	0.000	0.500	0.0003496
TROAP	0.0000001	0.7075892	1.000	0.978	0.0003499
SVIP	0.0000001	0.2705536	1.000	0.587	0.0003642
OSBP2	0.0000001	0.3952233	0.773	0.152	0.0004136
C15orf27	0.0000001	0.3425589	0.568	0.043	0.0004371
NT5C3L	0.0000001	-0.4637151	0.727	0.957	0.0004516
ZNF443	0.0000001	0.6750300	0.955	0.522	0.0004518
CCDC88C	0.0000001	0.8860292	0.955	0.630	0.0004752
SH2D3A	0.0000001	-0.2611639	0.205	0.674	0.0004754
SLC9A3R1	0.0000001	-1.2961920	1.000	0.978	0.0004766
AKAP6	0.0000001	0.5736913	0.727	0.152	0.0004925
HAS3	0.0000001	0.4583427	0.977	0.652	0.0004938
CD9	0.0000001	-1.0437245	1.000	1.000	0.0004980
SLC12A2	0.0000001	0.5583321	1.000	0.739	0.0005031
TRIB3	0.0000001	-0.6802490	0.068	0.587	0.0005123
GALNTL2	0.0000002	0.3215244	0.886	0.478	0.0005212
STYK1	0.0000002	0.2546047	0.614	0.065	0.0005687
DBN1	0.0000002	-0.8031655	0.545	0.870	0.0006819
RRAS2	0.0000002	-0.9751010	1.000	0.957	0.0007373
PRKX	0.0000002	-0.9739742	0.977	1.000	0.0007374
MARVELD2	0.0000002	-0.9149152	0.750	0.935	0.0007800
LYST	0.0000002	0.3202687	0.841	0.239	0.0008451
UBASH3B	0.0000002	-1.7692287	0.818	0.913	0.0008484
GNA11	0.0000003	0.7097538	1.000	1.000	0.0008764
PLIN2	0.0000003	-1.1214546	0.636	1.000	0.0008844
GALNT3	0.0000003	0.4758416	0.864	0.326	0.0008935
SLC19A2	0.0000003	0.4474756	0.909	0.587	0.0009018
ARNT2	0.0000003	0.3386791	0.523	0.022	0.0009217
ARHGEF12	0.0000003	0.4166151	1.000	0.870	0.0010366

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
ZNF788	0.0000003	0.7657318	1.000	0.957	0.0010860
MARCKSL1	0.0000003	-0.5282209	0.886	1.000	0.0011310
RAD54L2	0.0000003	0.5352131	1.000	0.978	0.0011829
GTF2H2B	0.0000004	-0.3919128	1.000	1.000	0.0012344
ARHGAP22	0.0000004	0.3032063	0.545	0.043	0.0014532
TTBK2	0.0000004	0.6483663	0.795	0.283	0.0015177
TACSTD2	0.0000004	-0.2896415	0.250	0.674	0.0015344
PDE7A	0.0000005	1.0166085	1.000	0.739	0.0016096
EFNB2	0.0000005	0.5696452	1.000	0.630	0.0016534
SIGIRR	0.0000005	-0.7369790	0.795	0.913	0.0016648
C6orf108	0.0000005	-0.4495516	0.477	0.804	0.0017587
MAN1A1	0.0000005	0.7035409	0.977	0.391	0.0017698
CKB	0.0000005	-0.5858969	0.955	1.000	0.0018058
ZNF165	0.0000005	-1.0132651	0.500	0.783	0.0018758
LETM2	0.0000006	0.2982797	0.773	0.261	0.0019376
CBWD6	0.0000006	-0.5583202	1.000	1.000	0.0019639
FAM65B	0.0000006	0.7745285	0.682	0.152	0.0021721
IRAK2	0.0000006	0.3772860	0.682	0.217	0.0021935
XPR1	0.0000006	0.4183543	1.000	0.957	0.0022259
KCTD15	0.0000007	-0.3861739	0.636	0.826	0.0023350
MT1G	0.0000007	-0.2993515	1.000	0.870	0.0024105
CMTM4	0.0000007	0.8615652	1.000	0.957	0.0024191
SPIRE1	0.0000007	0.6790811	0.795	0.348	0.0024705
TSPAN13	0.0000007	-1.4311722	0.864	0.957	0.0024998
CPPED1	0.0000007	-1.5218339	0.909	0.978	0.0025166
FAM115A	0.0000007	0.8694408	0.909	0.630	0.0025324
ELOVL6	0.0000008	-1.4887586	1.000	1.000	0.0026287
LDB2	0.0000008	0.5975245	0.432	0.000	0.0027085
FXYD5	0.0000008	-0.3824483	0.023	0.478	0.0027687
CEP290	0.0000008	-0.9536488	0.864	0.891	0.0027908
PVT1	0.0000008	-1.3979786	0.500	0.848	0.0028210
C15orf33	0.0000009	0.6792054	0.773	0.348	0.0029304
SRGAP1	0.0000009	0.3751629	0.977	0.609	0.0031186
SNX24	0.0000010	-0.8975512	0.955	1.000	0.0033662
IRF4	0.0000010	0.2595947	0.614	0.130	0.0034223
SH2D4A	0.0000011	1.0712027	1.000	0.957	0.0036538
NFATC2	0.0000011	0.4543062	0.500	0.043	0.0038415
TMEM154	0.0000011	0.5581043	0.773	0.261	0.0039175
MICALL1	0.0000011	-0.7228887	0.864	0.957	0.0039317
SLC2A3	0.0000012	-0.9769813	0.727	1.000	0.0041797
ANKRD6	0.0000012	0.2550252	0.977	0.674	0.0042699
LIMS3-LOC440895	0.0000013	-0.3220856	0.682	0.891	0.0043329
GRAP2	0.0000013	0.3735856	0.523	0.043	0.0044372
MARK1	0.0000013	-1.1799096	0.432	0.739	0.0044447
TSTA3	0.0000013	-0.4825817	0.773	0.913	0.0044578
LPHN2	0.0000013	-2.6222091	0.295	0.696	0.0045382
SHROOM3	0.0000013	-1.5329418	0.864	0.891	0.0045643
SERPINE2	0.0000013	0.5029744	1.000	0.609	0.0045920
RAB3IP	0.0000014	-0.7449904	0.909	0.978	0.0046565
BUB1B	0.0000014	0.9612398	1.000	0.957	0.0046654
C6orf115	0.0000014	-1.5140861	0.705	0.870	0.0047012
SULF2	0.0000014	0.3880174	0.909	0.413	0.0047940

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
TACC3	0.0000015	1.0051568	1.000	1.000	0.0052678
PRR11	0.0000016	-0.8708761	1.000	1.000	0.0054846
ZNF331	0.0000016	-0.9942462	0.659	0.935	0.0055122
TUBB6	0.0000019	-0.7976244	0.841	1.000	0.0064055
ZNF596	0.0000019	0.3373285	0.932	0.348	0.0065132
S100A14	0.0000020	-1.1124850	0.250	0.630	0.0068825
ATP2C2	0.0000021	0.6180313	0.886	0.478	0.0072899
AURKA	0.0000022	1.2177067	1.000	1.000	0.0075555
PALM2	0.0000023	0.3405406	0.545	0.087	0.0078115
NCKAP1	0.0000023	-0.8702900	1.000	1.000	0.0078620
INPP5J	0.0000026	0.3552199	0.955	0.391	0.0088983
SESN3	0.0000026	0.6122523	1.000	0.543	0.0089596
BDNFOS	0.0000028	0.3047444	0.773	0.304	0.0094733
SERPINB1	0.0000029	-1.3716648	0.295	0.696	0.0097952
PDPR	0.0000029	0.5281232	1.000	0.674	0.0098352
CHCHD6	0.0000029	0.3052339	1.000	0.696	0.0099331
ARRB1	0.0000029	-1.2379621	0.409	0.891	0.0099857
CKS2	0.0000030	-0.6739444	1.000	1.000	0.0103667
RHOU	0.0000031	-2.6584074	0.364	0.674	0.0106097
COL23A1	0.0000032	-0.8937847	0.682	0.174	0.0109434
GCNT2	0.0000032	-1.0380836	0.114	0.543	0.0110178
PXMP4	0.0000033	-0.2606470	1.000	1.000	0.0112127
PRKD1	0.0000033	0.4075724	0.591	0.109	0.0112673
CACHD1	0.0000035	-1.6546211	0.295	0.717	0.0120776
TNFRSF1B	0.0000036	0.3061520	0.750	0.435	0.0124700
STOX1	0.0000040	0.4201824	0.682	0.196	0.0138696
SSBP2	0.0000041	0.5418392	0.886	0.413	0.0139114
FAM53A	0.0000041	0.2611876	0.591	0.109	0.0141796
IPCEF1	0.0000043	0.3835926	0.636	0.217	0.0148244
GPRC5C	0.0000043	-1.0124136	0.159	0.587	0.0148579
ERCC6L	0.0000045	0.5575663	1.000	0.739	0.0155044
CCDC3	0.0000046	-0.3114449	0.818	0.217	0.0157982
LIMA1	0.0000046	1.3773583	1.000	0.978	0.0159103
NPM3	0.0000046	0.3379043	1.000	1.000	0.0159103
GATA2	0.0000046	-1.7616511	0.432	0.761	0.0159433
TOM1L1	0.0000047	0.5856251	0.955	0.696	0.0161645
TANC2	0.0000051	0.5113157	0.909	0.413	0.0174130
SH3TC1	0.0000052	-0.7257360	0.068	0.478	0.0180148
ST6GALNAC3	0.0000053	-0.7396654	0.659	0.130	0.0181997
RNF157	0.0000053	0.2715768	1.000	0.783	0.0182866
RPLP0P2	0.0000056	-0.4711643	1.000	1.000	0.0192821
RPL23AP82	0.0000056	-0.8822101	1.000	1.000	0.0192821
TMEM64	0.0000057	-0.3545281	0.682	0.804	0.0195026
PTRF	0.0000057	-0.4982785	0.409	0.739	0.0196139
DIAPH2	0.0000059	0.3081427	0.955	0.674	0.0201195
SAMD5	0.0000060	-0.9768677	0.091	0.500	0.0206494
SPAG5	0.0000061	-0.5829838	1.000	0.978	0.0208139
TPD52	0.0000062	0.5586456	0.977	0.891	0.0211495
EPS8L2	0.0000062	-0.6067522	0.136	0.543	0.0213302
ACOT7	0.0000065	-1.3828432	0.955	0.957	0.0224421
RNF213	0.0000066	0.2855956	0.909	0.391	0.0227384
AUTS2	0.0000068	0.6873022	0.977	0.500	0.0235090

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
TMTC2	0.0000070	0.3777867	0.818	0.239	0.0240312
NPHP1	0.0000082	0.4929608	0.864	0.391	0.0280909
CPXM2	0.0000087	0.4364486	0.455	0.043	0.0298665
DPY19L1	0.0000092	-0.8691245	0.318	0.696	0.0314396
MYCN	0.0000093	-0.6107259	0.591	0.978	0.0320479
EDARADD	0.0000094	-0.4987980	0.932	0.978	0.0321197
CDCP1	0.0000094	-0.4948578	0.114	0.522	0.0322910
NDFIP2	0.0000095	-0.6812258	0.977	1.000	0.0327540
ALDH5A1	0.0000097	0.2895039	0.977	0.717	0.0333382
RPP25	0.0000098	-0.3379294	0.659	1.000	0.0336679
OSBPL1A	0.0000099	0.7847369	0.955	0.739	0.0339681
GPR89C	0.0000099	-0.9018997	1.000	1.000	0.0340015
KCNC4	0.0000102	0.3593223	1.000	0.478	0.0350321
MYO9A	0.0000103	0.3507049	1.000	0.978	0.0352942
HSD17B11	0.0000105	-1.0612162	0.386	0.761	0.0360437
EFNA1	0.0000117	-1.2563467	0.386	0.739	0.0401231
RNF152	0.0000120	0.5393660	0.614	0.130	0.0410683
NDC80	0.0000124	-0.7006195	0.932	1.000	0.0424795
SOLH	0.0000124	-0.2827897	0.886	0.891	0.0427018
SEPP1	0.0000125	-0.4798255	0.205	0.652	0.0429756
SEMA6D	0.0000126	-2.8261643	0.068	0.457	0.0433532
KIF2C	0.0000128	0.9286348	1.000	0.935	0.0440781
DNMT3B	0.0000132	-1.9356216	0.864	0.957	0.0454354
RHOBTB3	0.0000133	0.3830000	1.000	0.891	0.0456741
SERPINB9	0.0000149	-1.0281112	1.000	1.000	0.0510816
PIR	0.0000157	-1.3931598	0.318	0.630	0.0538675
REEP1	0.0000157	-2.6027958	0.455	0.696	0.0539310
WASF1	0.0000160	0.7165414	1.000	0.870	0.0548061
EIF2C2	0.0000160	0.4464418	1.000	0.978	0.0549605
ATP6V1C2	0.0000160	-1.2289012	1.000	0.978	0.0549605
GPR89B	0.0000172	-0.6651245	0.955	0.935	0.0590250
ZNF320	0.0000175	-0.4380392	0.932	0.935	0.0600372
BICD2	0.0000179	-0.6114936	1.000	0.957	0.0613046
TUBA1A	0.0000179	-0.5687819	1.000	1.000	0.0613094
DAB2IP	0.0000182	0.4754445	0.886	0.587	0.0623177
MICAL2	0.0000186	0.5181218	0.841	0.478	0.0637123
SIAE	0.0000198	-0.8803026	0.318	0.674	0.0680358
TPD52L1	0.0000203	-1.7503716	0.091	0.478	0.0697517
POLE2	0.0000245	-1.4307429	0.727	0.935	0.0841956
MPP6	0.0000306	-0.6160918	1.000	1.000	0.1050151
KCNS3	0.0000306	-0.2564592	0.659	0.196	0.1051689
NUDT7	0.0000310	0.2916282	0.864	0.457	0.1063378
PTPN21	0.0000312	0.6447320	1.000	0.761	0.1070135
SERPINH1	0.0000316	-0.5659551	0.114	0.500	0.1084988
CCNT1	0.0000325	1.0143339	0.932	0.565	0.1114954
MBOAT1	0.0000340	-0.5326534	1.000	1.000	0.1167524
CCDC82	0.0000353	0.7481012	1.000	0.696	0.1211022
MICAL3	0.0000365	0.3155485	1.000	1.000	0.1252583
MGC72080	0.0000377	0.3492432	1.000	0.870	0.1293949
BLVRB	0.0000379	-1.1304716	0.545	0.848	0.1300509
CENPI	0.0000388	0.4556867	0.909	0.587	0.1331140
KHDRBS3	0.0000391	-1.5471796	1.000	1.000	0.1343505

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
MYO1B	0.0000405	-0.8728630	1.000	0.978	0.1391281
SEMA4B	0.0000406	0.3865369	1.000	0.696	0.1393564
TESK2	0.0000432	1.0177135	1.000	0.674	0.1482962
QDPR	0.0000434	0.3977133	1.000	0.957	0.1491605
FLT1	0.0000461	0.3217166	0.727	0.348	0.1580921
CCNB2	0.0000466	0.5091900	1.000	1.000	0.1598998
FAM169A	0.0000475	0.4785589	0.977	0.717	0.1630064
GJC1	0.0000481	0.3011823	1.000	0.891	0.1652972
GRTP1	0.0000482	0.5341030	1.000	0.913	0.1654158
SDK1	0.0000490	0.5373576	0.591	0.130	0.1682194
CTSD	0.0000490	-0.8260880	0.977	0.935	0.1683015
SNHG5	0.0000499	-0.5480782	1.000	1.000	0.1713571
NCRNA00152	0.0000500	-1.0574693	0.136	0.522	0.1716828
GRB10	0.0000517	-0.4719904	1.000	0.978	0.1773735
ERO1L	0.0000535	-0.7222069	0.955	0.978	0.1835377
CDCA8	0.0000535	0.7810021	1.000	1.000	0.1835898
C11orf83	0.0000573	-0.2518513	0.932	1.000	0.1965914
MITF	0.0000582	0.8533107	0.841	0.587	0.1998260
CEP152	0.0000591	0.6401729	0.977	0.761	0.2029020
DAPK1	0.0000600	-1.0935233	0.455	0.674	0.2059929
RIN2	0.0000623	-1.2250049	0.182	0.522	0.2140321
DGCR6	0.0000634	-0.2797044	0.955	0.957	0.2177408
CDYL2	0.0000681	0.3179990	0.614	0.174	0.2337588
PHGDH	0.0000702	-2.1939833	0.250	0.609	0.2409053
DLC1	0.0000724	-1.1251926	0.932	0.913	0.2486594
CENPF	0.0000727	-0.3020470	0.932	1.000	0.2495469
KCTD3	0.0000777	-0.8358596	1.000	0.913	0.2668879
MECOM	0.0000787	1.4720345	0.545	0.196	0.2701129
PDE10A	0.0000812	0.2997771	0.295	0.000	0.2786371
STEAP1	0.0000817	-0.4012217	0.455	0.761	0.2803493
MLF1	0.0000829	0.3692131	1.000	0.674	0.2844735
HMHA1	0.0000898	0.4325303	0.932	0.783	0.3082963
CCDC125	0.0000918	-0.3812560	0.477	0.783	0.3149893
ZNF540	0.0001014	0.2836014	0.682	0.326	0.3480403
HIST2H2BF	0.0001127	0.6474381	1.000	0.696	0.3869199
MCM4	0.0001200	-0.4459022	1.000	0.978	0.4118997
SLC6A8	0.0001217	-0.4869385	0.727	1.000	0.4178983
ZNF286B	0.0001238	-0.2517915	0.955	0.935	0.4251271
FAM111B	0.0001239	0.2715392	0.727	0.370	0.4253195
UGCG	0.0001319	-2.5013872	0.909	0.935	0.4529148
OGFRL1	0.0001347	-0.3729524	0.136	0.500	0.4625630
TIAM2	0.0001372	0.3917044	0.864	0.391	0.4711643
LAMB1	0.0001413	-1.0829659	1.000	1.000	0.4852358
SLC47A1	0.0001434	-0.3127786	0.364	0.609	0.4922052
CEP55	0.0001503	0.6059327	1.000	0.848	0.5160616
ZNF395	0.0001580	0.6036928	0.977	0.891	0.5425217
ENPEP	0.0001635	-2.3089827	0.364	0.587	0.5612124
GYPC	0.0001637	-1.5519767	0.000	0.283	0.5619942
C6orf204	0.0001646	1.2404942	1.000	0.652	0.5650873
FAM110B	0.0001772	-0.9095295	0.136	0.500	0.6081775
RHOC	0.0001773	-1.2136331	0.977	1.000	0.6087658
SMAD7	0.0001774	-0.2655703	0.136	0.457	0.6091429

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
CC2D2A	0.0001834	-0.3256688	0.636	0.891	0.6297323
DPP4	0.0001933	-0.5073020	0.045	0.370	0.6636437
NPAS2	0.0001945	0.3071010	0.682	0.283	0.6676747
PRNP	0.0001945	-0.3823408	0.477	0.848	0.6677054
MAP4K1	0.0001991	-0.3440991	1.000	0.478	0.6836293
TSPAN1	0.0002007	-0.4698365	0.023	0.326	0.6889238
FAM89A	0.0002065	1.0220600	0.795	0.391	0.7088280
SH3BP5	0.0002077	0.5154191	0.932	0.739	0.7131219
ACOT11	0.0002129	-0.4632902	0.636	1.000	0.7309371
PRTFDC1	0.0002161	-0.5905820	0.114	0.478	0.7420307
KANK2	0.0002180	0.3557896	0.955	0.674	0.7484625
FADS2	0.0002233	-0.6267545	0.091	0.413	0.7664547
PYGL	0.0002239	-1.0874910	0.182	0.500	0.7685462
RBP7	0.0002264	-1.9944357	0.432	0.761	0.7772740
MAN2A1	0.0002332	-0.9108195	0.886	0.870	0.8007233
CTSL2	0.0002517	-0.5976782	1.000	1.000	0.8641228
AGPAT2	0.0002573	-0.8375809	0.864	0.913	0.8831663
ECT2	0.0002598	0.5118859	1.000	0.978	0.8917523
SNCAIP	0.0002622	-0.2559640	0.523	0.109	0.9002879
TNFRSF21	0.0002742	-0.8049820	0.364	0.674	0.9412106
REPS2	0.0002778	-0.2639998	1.000	0.543	0.9535781
MNS1	0.0002961	0.2512992	0.977	0.478	1.0000000
NUF2	0.0002990	0.8552705	0.977	0.978	1.0000000
GBP4	0.0003037	-0.5546770	1.000	1.000	1.0000000
SLC39A6	0.0003435	0.3682383	1.000	0.891	1.0000000
HMMR	0.0003438	-0.4667089	1.000	0.957	1.0000000
ITM2C	0.0003546	0.3279600	1.000	0.978	1.0000000
GCLM	0.0003546	-0.9692286	1.000	1.000	1.0000000
AGAP6	0.0003562	-0.3835859	0.614	0.804	1.0000000
CDC25C	0.0003624	0.4548536	1.000	0.783	1.0000000
STK17B	0.0003889	0.8893913	1.000	0.957	1.0000000
FAM160A1	0.0003893	0.2612018	0.932	0.478	1.0000000
CAMK2D	0.0003974	-1.8468690	0.159	0.457	1.0000000
TMPRSS13	0.0004075	-0.4229804	0.136	0.435	1.0000000
XRCC2	0.0004134	-0.5430477	1.000	0.957	1.0000000
RHOB	0.0004466	-0.8133626	0.705	0.913	1.0000000
PLXDC2	0.0004542	-0.8135178	0.523	0.130	1.0000000
ROR2	0.0004544	0.9104013	0.295	0.022	1.0000000
OTUD7B	0.0005906	0.3225549	0.773	0.587	1.0000000
EFNA5	0.0005907	0.2692817	0.705	0.587	1.0000000
PTPN14	0.0005936	-0.7632314	1.000	0.978	1.0000000
TCF7	0.0006109	0.4646596	0.955	0.935	1.0000000
ZNF426	0.0006289	0.3265359	1.000	0.870	1.0000000
JUP	0.0006339	-1.9891107	0.909	0.783	1.0000000
MOBKL2B	0.0006492	-1.8251804	0.818	0.761	1.0000000
C17orf53	0.0006726	0.2784847	0.977	0.804	1.0000000
F2R	0.0006883	-0.4311669	1.000	0.935	1.0000000
GSTA4	0.0007088	-0.4247754	0.318	0.630	1.0000000
RET	0.0007147	-0.3916622	0.136	0.435	1.0000000
PDLIM1	0.0007518	-0.2669063	1.000	0.957	1.0000000
GIPC1	0.0007519	-0.4923093	0.977	1.000	1.0000000
LARP6	0.0007541	-0.4441410	0.250	0.587	1.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
ALOX5	0.0007640	-0.2570250	0.023	0.283	1.0000000
HMGN5	0.0007672	-0.9509225	0.341	0.630	1.0000000
NPIPL3	0.0007742	-0.2865395	1.000	1.000	1.0000000
SYDE2	0.0008109	-0.4402250	0.477	0.674	1.0000000
MAN1C1	0.0008346	-1.3660262	0.750	0.283	1.0000000
IL1RN	0.0008403	0.3437349	0.341	0.065	1.0000000
LHFP	0.0008421	-0.9807433	0.318	0.565	1.0000000
GATA6	0.0008443	-0.4249470	0.500	1.000	1.0000000
FAM126A	0.0008449	-0.5221639	1.000	0.978	1.0000000
SLC7A7	0.0008449	-1.0561590	1.000	1.000	1.0000000
PGBD1	0.0008587	-0.2894021	0.250	0.587	1.0000000
CCDC122	0.0008698	-0.5484050	1.000	1.000	1.0000000
ZNF134	0.0008755	0.3211406	1.000	0.696	1.0000000
LACTB2	0.0009535	-0.6742617	0.432	0.652	1.0000000
BATF3	0.0009866	-0.9791438	0.773	0.826	1.0000000
C3orf67	0.0010918	-0.2673554	0.864	0.413	1.0000000
HIST1H2BK	0.0011218	0.5174263	1.000	0.826	1.0000000
INSR	0.0011885	-0.6480308	0.795	0.804	1.0000000
PPFIBP1	0.0011918	-0.7316079	0.977	0.957	1.0000000
SAMHD1	0.0012194	0.3758618	0.977	0.826	1.0000000
IQCK	0.0012447	0.2615073	1.000	0.739	1.0000000
STIL	0.0012593	1.0242269	1.000	0.870	1.0000000
GCH1	0.0012601	0.5277579	1.000	0.891	1.0000000
ACRC	0.0012758	0.8464133	0.455	0.152	1.0000000
LEPR	0.0012973	-0.3565100	1.000	1.000	1.0000000
PBX1	0.0013239	0.3247948	0.909	0.543	1.0000000
ALDH2	0.0013597	-2.0561664	0.364	0.565	1.0000000
AFAP1	0.0013670	0.3033257	1.000	0.826	1.0000000
PPARG	0.0013901	-0.6849979	0.318	0.565	1.0000000
LRIG3	0.0014076	-0.7989664	0.977	0.870	1.0000000
RNF43	0.0014306	-0.2671866	0.023	0.261	1.0000000
TANC1	0.0015131	0.2584763	1.000	0.543	1.0000000
MAPRE2	0.0015131	0.2571826	1.000	0.543	1.0000000
KANK1	0.0015233	-1.3570145	0.659	0.761	1.0000000
NET1	0.0015342	0.3454610	1.000	1.000	1.0000000
GNB4	0.0016216	0.2526310	1.000	1.000	1.0000000
ANXA6	0.0017465	-1.1264791	0.614	0.674	1.0000000
TEAD2	0.0017665	-0.4037843	0.750	0.913	1.0000000
CCL5	0.0019648	-0.3732747	1.000	1.000	1.0000000
GPC3	0.0019882	-0.3067696	0.705	0.326	1.0000000
PLD2	0.0020728	-0.3942074	0.977	0.913	1.0000000
C7orf68	0.0021314	-0.2877493	1.000	1.000	1.0000000
REST	0.0021314	-0.3786607	0.977	1.000	1.0000000
DHCR7	0.0021787	-1.1965229	0.909	0.891	1.0000000
C14orf106	0.0021898	-0.3425953	1.000	0.978	1.0000000
SLC25A33	0.0021898	-0.4179649	1.000	1.000	1.0000000
BICD1	0.0022129	-1.3719416	0.591	0.696	1.0000000
LIMCH1	0.0022197	-1.1865148	0.636	0.217	1.0000000
FBLN1	0.0022742	-1.1982928	0.727	0.739	1.0000000
NFIL3	0.0023654	-0.4093804	0.955	0.870	1.0000000
PKMYT1	0.0024377	-0.2897679	1.000	0.935	1.0000000
TSC22D3	0.0024765	0.4652626	0.341	0.087	1.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
SPP1	0.0025651	-0.3707203	0.045	0.283	1.0000000
RASSF2	0.0025704	-0.6194018	0.727	0.717	1.0000000
AURKB	0.0026410	-0.5371967	1.000	1.000	1.0000000
PGM2L1	0.0027115	-0.7153006	1.000	0.935	1.0000000
MYL6B	0.0027440	-0.4604163	0.818	0.891	1.0000000
SPTLC3	0.0027692	-1.3519222	0.091	0.326	1.0000000
NINJ2	0.0027719	-1.2724788	0.023	0.239	1.0000000
MCM8	0.0027842	-0.3144426	1.000	0.935	1.0000000
CENPJ	0.0027842	-0.5602508	1.000	0.935	1.0000000
PTGR1	0.0027857	-2.5546003	0.750	0.696	1.0000000
MYO1E	0.0028233	0.3159383	0.955	0.652	1.0000000
GSTO2	0.0028273	-0.3118104	0.182	0.435	1.0000000
SLC20A2	0.0028418	-1.2087719	0.614	0.739	1.0000000
TMEM63A	0.0030558	-0.3323191	0.705	0.239	1.0000000
ATAD5	0.0030924	-0.7027717	1.000	0.913	1.0000000
CENPK	0.0031751	0.3482775	0.977	0.957	1.0000000
PDE4D	0.0031940	-0.6119820	0.636	0.261	1.0000000
RBPMS2	0.0033456	-0.3395241	1.000	1.000	1.0000000
VAMP1	0.0033972	0.2831287	0.795	0.457	1.0000000
MYO5C	0.0034815	-0.6138407	0.614	0.696	1.0000000
PTK2	0.0035236	-0.7969233	1.000	0.957	1.0000000
C21orf91	0.0035933	0.7711140	1.000	0.783	1.0000000
ZNF682	0.0035995	0.3659288	1.000	0.804	1.0000000
SCARA3	0.0039062	-0.6129121	0.045	0.261	1.0000000
FBXO17	0.0040503	-0.4004597	0.523	0.652	1.0000000
RFC3	0.0043262	-0.3035332	1.000	1.000	1.0000000
RARRES1	0.0044655	-0.6651658	0.205	0.413	1.0000000
GPD1L	0.0046616	-0.8942990	0.955	0.913	1.0000000
NEXN	0.0050080	-0.3370095	0.136	0.370	1.0000000
GABARAPL1	0.0051605	-0.8662837	1.000	0.978	1.0000000
ZNF506	0.0052907	0.3068997	1.000	0.957	1.0000000
TRAIP	0.0053032	0.3170107	0.977	0.761	1.0000000
MPDZ	0.0055782	-0.9431545	0.750	0.739	1.0000000
EVL	0.0056020	-0.2559733	0.886	0.500	1.0000000
ST3GAL6	0.0056071	-0.8640068	0.455	0.565	1.0000000
PLK1S1	0.0056800	0.2983333	0.977	0.717	1.0000000
SORBS1	0.0061199	-0.8607192	0.955	0.870	1.0000000
C4orf34	0.0062900	0.4010981	1.000	1.000	1.0000000
SCD5	0.0065838	-0.3673859	0.818	0.804	1.0000000
TRIM6	0.0065973	0.3693577	0.955	0.913	1.0000000
PFKM	0.0071763	-0.4928820	0.659	0.783	1.0000000
PCDH1	0.0072637	-2.6116240	0.591	0.652	1.0000000
EFEMP1	0.0080945	-0.3653633	0.023	0.196	1.0000000
RRAD	0.0081749	-0.3784942	0.159	0.370	1.0000000
PLCD3	0.0082032	-0.5546828	1.000	0.913	1.0000000
NINL	0.0082930	-1.0967311	0.477	0.587	1.0000000
TPM1	0.0084036	-0.9561138	0.977	1.000	1.0000000
PELI2	0.0084994	-0.4674713	0.795	0.391	1.0000000
B4GALNT3	0.0086960	-0.2593364	0.227	0.457	1.0000000
FGD4	0.0090216	0.2809053	1.000	0.935	1.0000000
KIF11	0.0090216	-0.3302762	0.977	0.957	1.0000000
GPR19	0.0094396	-0.5439609	0.636	0.283	1.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
SETBP1	0.0095170	-0.6889494	0.159	0.370	1.0000000
SLC12A7	0.0104684	-0.4430109	0.727	0.761	1.0000000
CKAP2L	0.0116267	0.5823731	1.000	0.826	1.0000000
C11orf67	0.0118241	-0.6110796	0.750	0.891	1.0000000
MLF1IP	0.0122016	0.2696351	1.000	0.978	1.0000000
PTPN22	0.0122540	0.7983488	0.364	0.174	1.0000000
SCRN1	0.0127557	-0.4200877	0.523	0.217	1.0000000
MAP3K13	0.0130028	0.5870852	0.545	0.283	1.0000000
ZNF595	0.0130593	0.6611308	1.000	0.913	1.0000000
NRP1	0.0133985	0.3601851	0.182	0.022	1.0000000
WDR66	0.0136591	-0.5994931	0.977	0.913	1.0000000
EHHADH	0.0139829	-0.4353940	0.295	0.478	1.0000000
SGCE	0.0140522	-0.2801129	0.477	0.174	1.0000000
PALM2-AKAP2	0.0144558	-0.8323079	0.977	0.978	1.0000000
QKI	0.0156287	-0.5511033	1.000	1.000	1.0000000
SLCO2A1	0.0158534	-0.2836668	0.591	0.261	1.0000000
FHDC1	0.0158621	-0.4142092	0.136	0.326	1.0000000
FAM113B	0.0162157	-0.9705090	0.273	0.478	1.0000000
IL28RA	0.0163356	-0.2998545	1.000	1.000	1.0000000
DUSP1	0.0165379	-0.8033412	0.364	0.565	1.0000000
NT5DC3	0.0170705	0.3897495	1.000	0.978	1.0000000
STAT1	0.0174228	-0.4093460	0.864	0.978	1.0000000
ARHGAP28	0.0180561	-0.2574069	0.023	0.174	1.0000000
TJP1	0.0182272	-0.4757578	1.000	1.000	1.0000000
EPB41L3	0.0182832	-0.9640020	0.750	0.783	1.0000000
SNTB1	0.0189757	-1.1597692	0.136	0.304	1.0000000
TACC1	0.0207479	-0.3439809	1.000	1.000	1.0000000
HIST1H2BD	0.0209729	0.3842166	0.818	0.478	1.0000000
WWP1	0.0211910	-0.8535129	1.000	0.913	1.0000000
SNHG1	0.0211964	-0.2694855	1.000	1.000	1.0000000
RDH10	0.0216532	0.3579207	1.000	1.000	1.0000000
RANBP17	0.0223227	-0.3035408	0.682	0.304	1.0000000
EPB41L1	0.0227094	-0.7186203	0.682	0.674	1.0000000
ADCK5	0.0232339	-0.4541637	0.500	0.630	1.0000000
MYST4	0.0240676	-0.3368811	1.000	0.957	1.0000000
NLGN4X	0.0242766	-0.4525993	0.750	0.391	1.0000000
GLS	0.0258853	0.6332715	0.955	0.739	1.0000000
DENND1B	0.0259842	-1.2964135	0.000	0.109	1.0000000
TOP2A	0.0278398	-0.2948234	1.000	1.000	1.0000000
LYZ	0.0284182	-0.4516444	1.000	1.000	1.0000000
C12orf35	0.0296060	-0.2788178	1.000	1.000	1.0000000
DDAH1	0.0300848	-0.3136379	0.636	0.304	1.0000000
ANKRD26	0.0302131	-0.4179197	1.000	0.935	1.0000000
TRERF1	0.0304080	-0.8181610	0.591	0.674	1.0000000
EFHD1	0.0319520	-1.6173660	0.932	0.717	1.0000000
ST3GAL1	0.0324108	-1.0697426	0.977	0.891	1.0000000
CD86	0.0325459	-0.2652351	0.091	0.261	1.0000000
KIAA0040	0.0331322	-0.3485532	0.636	0.674	1.0000000
C10orf72	0.0341057	-0.3836601	1.000	1.000	1.0000000
FMNL2	0.0341859	0.3464536	0.841	0.783	1.0000000
PLXNA1	0.0357773	-0.3807803	0.841	0.826	1.0000000
CDC25A	0.0369304	-0.2564324	1.000	1.000	1.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
C11orf82	0.0383712	0.9298875	0.977	0.870	1.0000000
PRICKLE1	0.0393196	-0.6484960	0.705	0.370	1.0000000
VCAN	0.0410795	-1.2146564	0.318	0.435	1.0000000
ZDHHC11	0.0415809	-0.3004342	0.250	0.391	1.0000000
TMEM56	0.0420405	-0.7761861	0.773	0.783	1.0000000
ZBTB10	0.0430774	0.2540966	1.000	0.804	1.0000000
RPL39	0.0431806	-0.7463451	1.000	1.000	1.0000000
ECE1	0.0448451	-0.6146204	0.955	0.913	1.0000000
ZSCAN18	0.0464878	-0.3431402	0.886	0.478	1.0000000
GPR126	0.0473221	-0.3026235	0.886	0.500	1.0000000
C1orf172	0.0479182	-0.2967402	0.795	0.870	1.0000000
PKIG	0.0483851	-1.2090555	0.614	0.674	1.0000000
NBPF11	0.0493613	-0.3621654	1.000	0.978	1.0000000
E2F8	0.0526670	-0.3192137	0.795	0.870	1.0000000
BCL11A	0.0531558	-0.4607611	0.432	0.543	1.0000000
HOMER1	0.0531603	-0.7222158	0.909	0.935	1.0000000
ASAH1	0.0531956	-1.1607022	0.977	0.913	1.0000000
SLC16A9	0.0542521	-1.0975689	0.341	0.435	1.0000000
MAGI3	0.0544534	-1.3669775	0.795	0.674	1.0000000
HOOK1	0.0557006	-0.6934402	0.909	0.761	1.0000000
C3orf52	0.0562832	-0.6461822	0.659	0.696	1.0000000
ASS1	0.0569443	-0.8139229	1.000	0.717	1.0000000
MAP7	0.0583818	-0.4101124	1.000	0.957	1.0000000
FOS	0.0594607	0.2655845	1.000	0.935	1.0000000
ACADSB	0.0605593	-0.4920312	1.000	0.935	1.0000000
KIF23	0.0605635	0.4493120	1.000	0.978	1.0000000
MERTK	0.0616746	-0.7761915	0.977	0.957	1.0000000
CSF2RA	0.0628101	-0.2820069	1.000	0.957	1.0000000
KIAA1324	0.0628112	-0.6969612	1.000	1.000	1.0000000
ANO1	0.0629561	-0.3407566	0.682	0.326	1.0000000
DEPDC1B	0.0639224	0.4375106	1.000	0.870	1.0000000
NR4A1	0.0655805	-0.4339126	0.364	0.457	1.0000000
RALGAPA2	0.0685336	-1.5381465	0.682	0.565	1.0000000
SFXN2	0.0685785	-0.4428917	0.500	0.609	1.0000000
ARNTL2	0.0698726	-0.8249586	0.545	0.565	1.0000000
CENPA	0.0699669	0.4271619	1.000	0.935	1.0000000
KIAA1598	0.0712276	-0.4008697	1.000	1.000	1.0000000
STON2	0.0717972	-0.5051085	0.432	0.196	1.0000000
EFNA4	0.0756692	-0.4434435	0.932	0.891	1.0000000
ALDH4A1	0.0761289	-0.4012705	0.500	0.522	1.0000000
EFR3B	0.0788863	-0.4205651	0.886	0.870	1.0000000
ZBTB7C	0.0820879	-0.6651441	0.659	0.348	1.0000000
PMEPA1	0.0866632	-0.5904120	0.045	0.152	1.0000000
ZNF486	0.0877656	-0.2674263	0.955	0.935	1.0000000
PECAM1	0.0916254	-0.5701079	0.886	0.587	1.0000000
C11orf52	0.0933657	-0.2760258	0.250	0.348	1.0000000
SLC4A8	0.0936746	-0.8926333	0.659	0.609	1.0000000
MAP3K5	0.0986638	-0.4110290	0.750	0.500	1.0000000
ZNF518A	0.1004399	-0.2726466	1.000	0.891	1.0000000
FSTL1	0.1015101	-0.4006210	0.182	0.326	1.0000000
GOLGA8A	0.1078536	-0.3395856	0.705	0.696	1.0000000
FAM84B	0.1082138	-0.2662517	0.977	0.978	1.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
PARVA	0.1089296	-0.4728316	0.955	0.848	1.0000000
KPNA2	0.1091045	0.5458806	1.000	1.000	1.0000000
GPR161	0.1102696	-0.7675476	0.364	0.457	1.0000000
CDH11	0.1121284	-2.7049894	0.136	0.261	1.0000000
LRRC1	0.1136228	-0.3820250	0.977	0.935	1.0000000
TMEM99	0.1143683	-0.3306841	0.682	0.761	1.0000000
SASH1	0.1170809	-0.6924138	0.864	0.761	1.0000000
ANGPT1	0.1187649	-1.2306751	0.659	0.565	1.0000000
C1orf63	0.1201464	1.2650923	0.955	0.891	1.0000000
CXCL12	0.1210830	-0.6085503	0.114	0.239	1.0000000
GK	0.1237039	-0.3883836	0.409	0.457	1.0000000
ABLIM1	0.1285840	-0.8257677	0.795	0.500	1.0000000
STC2	0.1299974	-0.3491274	0.568	0.522	1.0000000
TCN2	0.1321623	0.4545993	0.636	0.457	1.0000000
STAG3L3	0.1419954	0.4308988	0.909	0.761	1.0000000
CYP1B1	0.1436094	-1.1944212	0.250	0.326	1.0000000
ZNF420	0.1448434	-0.3474486	0.614	0.435	1.0000000
SLC16A10	0.1492683	-1.7404734	0.727	0.696	1.0000000
FA2H	0.1536812	-0.7631858	0.614	0.565	1.0000000
DNAJC6	0.1583673	-1.6784448	0.614	0.522	1.0000000
C4orf21	0.1586024	-0.5195994	0.932	0.826	1.0000000
DSCC1	0.1589799	-0.5333131	1.000	1.000	1.0000000
STAG3L2	0.1604148	0.3933563	0.932	0.739	1.0000000
CAV2	0.1610508	-0.9515387	0.614	0.565	1.0000000
MEG3	0.1624819	-0.4169389	0.318	0.174	1.0000000
PDGFC	0.1643396	-0.3321064	0.068	0.152	1.0000000
SH3BGRL	0.1647945	0.3550615	0.364	0.239	1.0000000
PCDH17	0.1649110	-0.5740201	0.136	0.239	1.0000000
GRAMD3	0.1652280	-1.2082746	0.432	0.435	1.0000000
IFI16	0.1751724	-1.1624560	0.182	0.283	1.0000000
FANCE	0.1775172	-0.2537484	0.977	0.848	1.0000000
RAI14	0.1785750	-0.7465330	0.932	0.826	1.0000000
MYO1D	0.1787985	-0.3032957	0.682	0.413	1.0000000
MYO5B	0.1788185	-0.5212670	1.000	0.826	1.0000000
SLC16A6	0.1904210	0.4788090	0.523	0.457	1.0000000
BAMBI	0.1969074	-0.4732617	0.886	0.783	1.0000000
ANKRD50	0.2018168	0.3915820	0.864	0.739	1.0000000
HERC5	0.2140569	-0.2632993	0.955	0.696	1.0000000
ITPR2	0.2149304	-0.2694743	0.409	0.239	1.0000000
TBC1D16	0.2255434	-0.7860839	0.455	0.457	1.0000000
SLC7A8	0.2275024	-0.7422245	1.000	0.891	1.0000000
TSPAN33	0.2290835	-0.4313795	0.432	0.239	1.0000000
TMEM117	0.2338195	-1.4289714	0.045	0.109	1.0000000
C12orf48	0.2434496	-0.3089865	0.955	0.957	1.0000000
ID2	0.2434613	-0.4445531	1.000	0.935	1.0000000
HIP1	0.2434690	-0.8578403	1.000	0.978	1.0000000
MORC4	0.2445208	-1.1237501	0.886	0.696	1.0000000
PCDH7	0.2480497	0.3022786	0.136	0.065	1.0000000
STON1	0.2500528	-0.2998865	0.432	0.478	1.0000000
SGK1	0.2500548	0.3454695	1.000	1.000	1.0000000
ITGA5	0.2536232	-0.5953110	0.523	0.522	1.0000000
SUSD1	0.2590839	-0.5581090	0.295	0.391	1.0000000

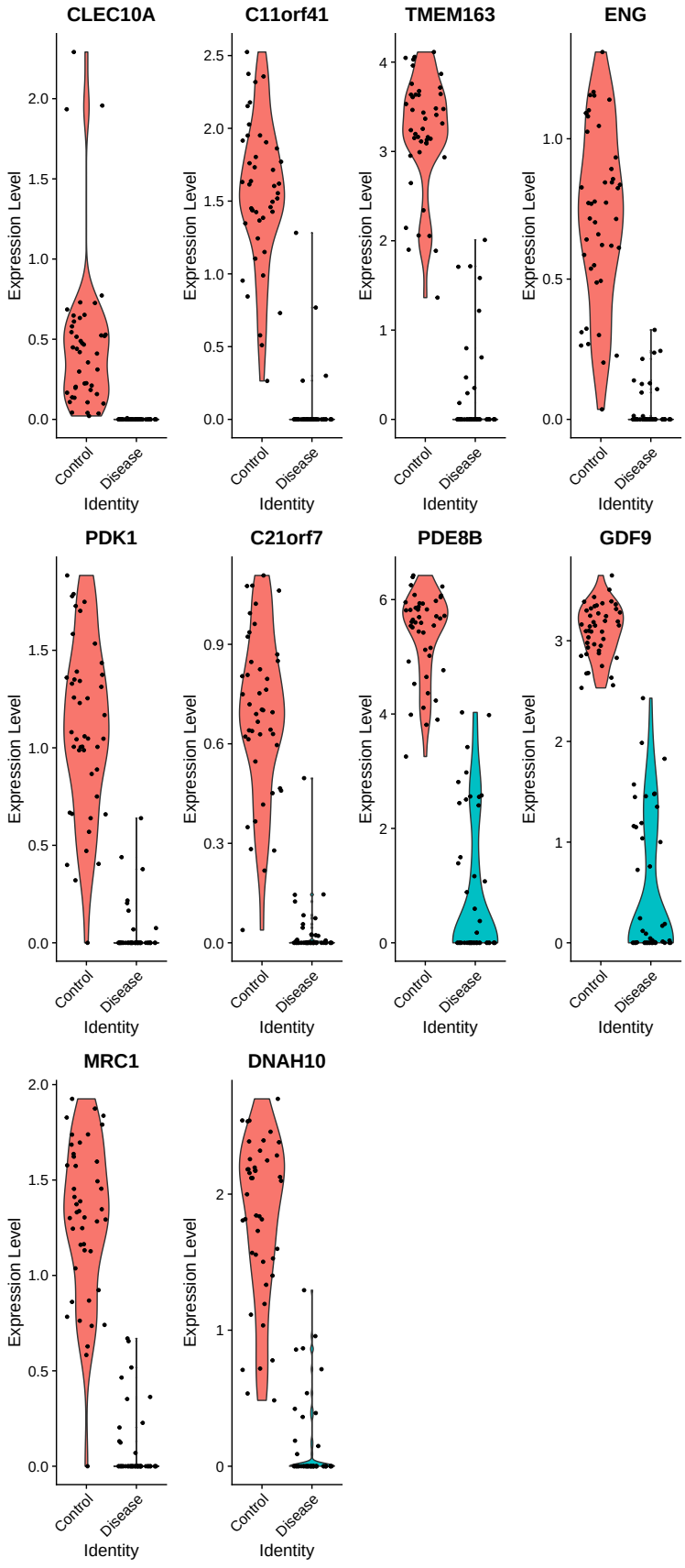
	p_val	avg_logFC	pct.1	pct.2	p_val_adj
ATP10A	0.2597057	0.3139579	0.409	0.304	1.0000000
FBXO32	0.2615423	-0.3665967	0.818	0.522	1.0000000
PBK	0.2626960	-0.3683611	0.795	0.761	1.0000000
C8orf42	0.2694989	-0.7051277	0.727	0.739	1.0000000
C8orf84	0.2712162	-0.3313593	0.705	0.609	1.0000000
BIK	0.2745739	-0.9625995	0.795	0.739	1.0000000
OPHN1	0.2776291	-0.3069068	0.977	0.957	1.0000000
APBB1	0.2807773	-0.4908462	0.591	0.565	1.0000000
CCNE1	0.2884956	0.6272489	1.000	1.000	1.0000000
RASGEF1A	0.2905519	-0.6358152	0.864	0.761	1.0000000
GSTT2	0.2942161	-0.2813340	0.295	0.196	1.0000000
C12orf24	0.2950140	-0.2909599	0.659	0.609	1.0000000
GBP1	0.2952995	-0.4784508	0.136	0.065	1.0000000
KITLG	0.2962755	0.4233821	0.500	0.413	1.0000000
ZNF702P	0.2964179	-0.3857107	0.659	0.565	1.0000000
C1orf38	0.3002008	-0.2801480	0.409	0.413	1.0000000
GOLGA8B	0.3041365	-0.3441692	0.795	0.739	1.0000000
MYC	0.3101535	0.3178721	0.682	1.000	1.0000000
AGPAT9	0.3186679	-0.3226309	1.000	0.826	1.0000000
GPNMB	0.3307166	-0.3513027	0.727	0.413	1.0000000
TRIB1	0.3329332	-0.2935392	0.682	0.739	1.0000000
GPCPD1	0.3347615	-0.3572551	1.000	0.978	1.0000000
SLC36A4	0.3347655	-0.4089434	0.250	0.283	1.0000000
ZNF415	0.3361627	-0.2760982	0.773	0.783	1.0000000
PEX11A	0.3456834	-0.2607037	0.864	0.783	1.0000000
KIAA0802	0.3560002	-0.4231039	0.795	0.478	1.0000000
NETO2	0.3637330	-0.3315691	1.000	0.848	1.0000000
RAP1GAP2	0.3735192	-0.3743397	0.727	0.543	1.0000000
INADL	0.3811307	-0.4568377	1.000	0.913	1.0000000
C1orf113	0.3852987	-0.2718002	0.432	0.478	1.0000000
PAQR8	0.3869320	-0.4213990	0.205	0.239	1.0000000
SLC25A4	0.3878679	-0.3289878	0.636	0.565	1.0000000
CCDC138	0.3970641	-0.3630327	0.909	0.696	1.0000000
FGF2	0.4384338	-0.4576783	0.432	0.370	1.0000000
GDPD5	0.4415434	-0.4619892	0.727	0.500	1.0000000
ZNF675	0.4455320	-0.3460764	1.000	0.870	1.0000000
MYO5A	0.4502703	-0.2876996	1.000	0.826	1.0000000
DACT1	0.4507961	-0.2947110	0.455	0.413	1.0000000
CCRN4L	0.4552841	0.4030398	1.000	0.957	1.0000000
LAYN	0.4619304	-0.2545824	0.341	0.370	1.0000000
ACAT1	0.4700311	-0.2954804	1.000	0.935	1.0000000
TNFRSF8	0.4702109	-0.8582492	0.182	0.217	1.0000000
RTKN2	0.4716914	-0.3285125	0.932	0.761	1.0000000
PECI	0.4721926	-0.3557794	0.795	0.739	1.0000000
FLRT2	0.4745923	-0.4339481	0.205	0.130	1.0000000
CTSH	0.4842317	-0.5865161	0.864	0.826	1.0000000
PHLPP1	0.4850440	-0.2871483	1.000	0.935	1.0000000
C18orf1	0.5064567	-0.4867430	0.182	0.217	1.0000000
OAF	0.5083360	-0.4741486	0.727	0.500	1.0000000
C7orf31	0.5170744	-0.2693786	0.818	0.652	1.0000000
APBB1IP	0.5198781	-0.3753235	0.091	0.130	1.0000000
SGEF	0.5315722	-0.3197411	0.977	0.913	1.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
SMAD9	0.5470877	-0.4036535	0.659	0.478	1.0000000
EAF2	0.5563128	-0.4500838	0.477	0.478	1.0000000
NAV1	0.5577895	-0.6927691	0.477	0.435	1.0000000
TNFAIP8	0.5631626	-0.2812320	0.750	0.543	1.0000000
PPP1R16A	0.5753861	-0.2787740	0.682	0.565	1.0000000
KHDC1	0.5810137	0.3366038	0.750	0.804	1.0000000
CCDC109B	0.5849976	-1.1399252	0.864	0.804	1.0000000
YPEL2	0.5857776	0.3297672	1.000	0.848	1.0000000
DENND2A	0.5910233	-0.4611109	0.409	0.326	1.0000000
RAD54L	0.5914220	0.3052667	1.000	0.935	1.0000000
C3orf14	0.5939686	-0.3332771	0.932	0.848	1.0000000
TMEM101	0.6131040	-0.2601536	0.977	0.696	1.0000000
ZNF100	0.6135056	0.2568811	0.909	0.826	1.0000000
NUSAP1	0.6196058	0.4020656	1.000	1.000	1.0000000
C11orf75	0.6225559	-0.2984229	0.614	0.587	1.0000000
C5orf36	0.6367883	-0.6173608	1.000	1.000	1.0000000
OAT	0.6425601	-0.4573766	1.000	1.000	1.0000000
BRCA1	0.6483400	-0.2676968	1.000	0.913	1.0000000
HPSE	0.6507495	-0.6407056	0.386	0.326	1.0000000
DRAM1	0.6896641	-0.4377068	0.795	0.674	1.0000000
CCDC30	0.7009924	-0.5082808	0.932	0.783	1.0000000
UBB	0.7014192	-0.4151180	1.000	1.000	1.0000000
DNAH14	0.7153225	-0.8281422	0.818	0.565	1.0000000
CAB39L	0.7210059	0.4294261	0.841	0.717	1.0000000
SLC39A8	0.7271978	-0.4281679	0.091	0.109	1.0000000
AVPI1	0.7313877	-0.3654026	0.955	0.826	1.0000000
CDC14B	0.7323065	-0.3249845	0.659	0.543	1.0000000
NCEH1	0.7375188	-0.3445557	0.977	0.826	1.0000000
SERINC5	0.7376427	-0.3918890	1.000	0.957	1.0000000
KIAA1467	0.7382910	-0.4278767	0.750	0.717	1.0000000
RILPL1	0.7391238	-0.3175830	0.568	0.370	1.0000000
SGPP2	0.7497711	-0.4860961	0.455	0.391	1.0000000
APP	0.7497982	-0.7208140	1.000	0.848	1.0000000
NRBP2	0.7504981	-0.9888088	0.727	0.565	1.0000000
PRKAR1B	0.7693656	-1.0269633	0.727	0.565	1.0000000
CCNA2	0.7992960	0.3869162	1.000	1.000	1.0000000
RASSF4	0.8126968	-0.5513600	0.273	0.239	1.0000000
ITGAM	0.8138430	-0.4418677	0.250	0.239	1.0000000
MAP7D3	0.8180581	-0.2575051	1.000	1.000	1.0000000
TMEM220	0.8260202	-0.4600665	0.318	0.239	1.0000000
OPTN	0.8305674	-0.3160509	1.000	0.826	1.0000000
CABLES1	0.8365376	-0.3209866	0.659	0.478	1.0000000
MPHOSPH9	0.8493329	-0.4237745	0.955	0.761	1.0000000
EPHA1	0.8528222	-0.2611100	0.500	0.500	1.0000000
KIAA1217	0.8574035	-2.1188907	0.250	0.217	1.0000000
TPST1	0.8580338	0.6043806	0.568	0.652	1.0000000
MPP1	0.8679590	-0.5674842	0.886	0.696	1.0000000
STARD4	0.8766795	-1.4726206	0.500	0.391	1.0000000
GCLC	0.9003187	-0.3105717	0.909	0.826	1.0000000
SCARB1	0.9340093	-0.4599054	0.523	0.435	1.0000000
DOCK1	0.9645726	-0.4481244	0.955	0.848	1.0000000
ADAMTS6	0.9693769	-0.3517148	0.159	0.152	1.0000000

	p_val	avg_logFC	pct.1	pct.2	p_val_adj
ZNF704	0.9966404	-0.6414213	0.659	0.478	1.0000000

```
#DT::datatable(cts_de_genes, extensions = c('FixedColumns','Buttons'),
#               options = list(
#                 pageLength = 5,
#                 scrollX = TRUE,
#                 scrollCollapse = TRUE,
#                 dom = 'Bfrtip',
#                 buttons = c('copy', 'csv', 'excel')
#               ))
```

Violin plot for top 10 DEGs



Functional enrichment analysis for DEGs

GO Biological Process

```
# This select genes of adj.p.value < 0.05, sometimes people use different threshold, like adding log2fo

enriched_combined <- enrichr(rownames(cts_de_genes[which(cts_de_genes$p_val_adj < 0.05 & abs(cts_de_gene
```

```
## Uploading data to Enrichr... Done.
##   Querying GO_Molecular_Function_2018... Done.
##   Querying GO_Cellular_Component_2018... Done.
##   Querying GO_Biological_Process_2018... Done.
##   Querying KEGG_2019_Human... Done.
## Parsing results... Done.
```

```
kable(head(enriched_combined$GO_Biological_Process_2018,n=20)[,c(-3,-5,-6,-7)])
```

Term	Overlap	Adjusted.P.value	Combined.Score	Genes
membrane raft assembly (GO:0001765)	3/6	0.0367183	822.36560	ANXA2;EM
membrane raft organization (GO:0031579)	3/10	0.1078483	419.64442	ANXA2;EM
membrane assembly (GO:0071709)	3/23	0.9907331	134.93264	ANXA2;EM
amino acid import across plasma membrane (GO:0089718)	2/7	1.0000000	271.96295	SLC1A3;SL
regulation of endothelial cell migration (GO:0010594)	4/69	1.0000000	52.08753	SPARC;PTI
positive regulation of cell-matrix adhesion (GO:0001954)	3/33	1.0000000	80.50138	PTK2B;EM
regulation of sequestering of calcium ion (GO:0051282)	2/9	1.0000000	195.18295	UBASH3B;I
Cdc42 protein signal transduction (GO:0032488)	2/9	1.0000000	195.18295	RHOU;NTN
Rho protein signal transduction (GO:0007266)	4/72	1.0000000	48.70299	RTKN;RHO
cholesterol biosynthetic process (GO:0006695)	3/35	1.0000000	73.85980	ACAA2;DH
secondary alcohol biosynthetic process (GO:1902653)	3/36	1.0000000	70.86179	ACAA2;DH
sterol biosynthetic process (GO:0016126)	3/40	1.0000000	60.61073	ACAA2;DH
vesicle budding from membrane (GO:0006900)	2/12	1.0000000	132.68425	ANXA2;S10
prostanoid metabolic process (GO:0006692)	2/12	1.0000000	132.68425	HPGD;PTG
nucleotide metabolic process (GO:0009117)	2/13	1.0000000	119.00904	PDE8B;FH
cellular response to acid chemical (GO:0071229)	4/91	1.0000000	33.34696	LYN;ABCB
L-alpha-amino acid transmembrane transport (GO:1902475)	2/15	1.0000000	97.81109	SLC1A3;SL
Ras protein signal transduction (GO:0007265)	6/223	1.0000000	19.37798	RTKN;RAB
positive regulation of cell-substrate adhesion (GO:0010811)	3/52	1.0000000	40.67555	PTK2B;EM
regulation of sprouting angiogenesis (GO:1903670)	2/19	1.0000000	70.36431	SEMA6A;A

```
## output top 20 enriched terms
#DT::datatable(head(enriched_combined$GO_Biological_Process_2018,n=20)[,c(-3,-5,-6,-7)], extensions = c
#              options = list(
#                pageLength = 5,
#                scrollX = TRUE,
#                scrollCollapse = TRUE,
#                dom = 'Bfrtip',
#                buttons = c('copy', 'csv', 'excel')
#              ))
```

GO Cellular Component

```
kable(head(enriched_combined$GO_Cellular_Component_2018,n=20)[,c(-3,-5,-6,-7)])
```

Term	Overlap	Adjusted.P.value	Combined.Score	Genes
actin cytoskeleton (GO:0015629)	8/294	0.5931489	25.028831	LAD1;CALD
focal adhesion (GO:0005925)	8/356	0.9625108	16.995574	FBLN7;AKA
perinuclear region of cytoplasm (GO:0048471)	8/378	0.9135826	14.967925	LYN;TFRC;
pigment granule (GO:0048770)	2/21	1.0000000	61.069717	RAB38;SYT
melanosome (GO:0042470)	2/21	0.8816241	61.069717	RAB38;SYT
membrane raft (GO:0045121)	4/119	0.8035784	21.135574	LYN;ANXA2
cytoskeleton (GO:0005856)	9/520	0.8350038	10.420019	LAD1;CALD
serine/threonine protein kinase complex (GO:1902554)	2/25	0.7725355	47.543941	DAB2;PHKA
alpha DNA polymerase:primase complex (GO:0005658)	1/6	1.0000000	73.143198	PRIM1
clathrin vesicle coat (GO:0030125)	1/6	1.0000000	73.143198	NCALD
HFE-transferrin receptor complex (GO:1990712)	1/8	1.0000000	49.986469	TFRC
clathrin coat of trans-Golgi network vesicle (GO:0030130)	1/8	1.0000000	49.986469	NCALD
apical dendrite (GO:0097440)	1/8	1.0000000	49.986469	PTK2B
SCF ubiquitin ligase complex (GO:0019005)	2/54	1.0000000	14.667201	ABTB2;FBX
NMDA selective glutamate receptor complex (GO:0017146)	1/9	1.0000000	42.669594	PTK2B
nuclear matrix (GO:0016363)	2/59	1.0000000	12.691086	SPARC;UHF
fibrillar center (GO:0001650)	3/131	1.0000000	8.509127	DAB2;TXNI
polymeric cytoskeletal fiber (GO:0099513)	4/221	1.0000000	6.483701	KRT18;KIF2
spindle pole centrosome (GO:0031616)	1/11	1.0000000	32.467308	DLGAP5
secretory granule lumen (GO:0034774)	5/317	1.0000000	5.549493	SPARC;ANX

```
#DT::datatable(head(enriched_combined$GO_Cellular_Component_2018,n=20)[,c(-3,-5,-6,-7)], extensions = c
#               options = list(
#                 pageLength = 5,
#                 scrollX = TRUE,
#                 scrollCollapse = TRUE,
#                 dom = 'Bfrtip',
#                 buttons = c('copy', 'csv', 'excel')
#               ))
```

GO Molecular Function

```
kable(head(enriched_combined$GO_Molecular_Function_2018,n=20)[,c(-3,-5,-6,-7)])
```

Term	Overlap	Adjusted.P.value	Combined.Score	G
phospholipase inhibitor activity (GO:0004859)	2/8	1.000000	228.142858	A
cyclic-nucleotide phosphodiesterase activity (GO:0004112)	2/10	1.000000	169.597477	P
tropomyosin binding (GO:0005523)	2/14	1.000000	107.543403	C
transaminase activity (GO:0008483)	2/14	1.000000	107.543403	P
calcium ion binding (GO:0005509)	7/284	1.000000	18.454783	S
calcium-dependent phospholipid binding (GO:0005544)	3/47	0.901937	47.516290	A
cadherin binding involved in cell-cell adhesion (GO:0098641)	2/19	1.000000	70.364312	K

Term	Overlap	Adjusted.P.value	Combined.Score	G
3',5'-cyclic-nucleotide phosphodiesterase activity (GO:0004114)	2/20	1.000000	65.448022	P
protein binding involved in cell-cell adhesion (GO:0098632)	2/21	1.000000	61.069717	K
core promoter proximal region DNA binding (GO:0001159)	2/22	1.000000	57.149674	U
carboxylic acid transmembrane transporter activity (GO:0046943)	3/64	1.000000	29.327706	S
GTPase regulator activity (GO:0030695)	6/275	1.000000	12.775555	R
metal ion binding (GO:0046872)	8/442	1.000000	10.582974	S
calmodulin-dependent protein kinase activity (GO:0004683)	2/27	1.000000	42.503233	P
protein homodimerization activity (GO:0042803)	10/664	1.000000	7.982032	T
non-membrane spanning protein tyrosine kinase activity (GO:0004715)	2/43	1.000000	21.065193	L
arginine transmembrane transporter activity (GO:0015181)	1/6	1.000000	73.143198	S
L-lysine transmembrane transporter activity (GO:0015189)	1/6	1.000000	73.143198	S
prostaglandin E receptor activity (GO:0004957)	1/6	1.000000	73.143198	H
L-ornithine transmembrane transporter activity (GO:0000064)	1/6	1.000000	73.143198	S

```
#DT::datatable(head(enriched_combined$GO_Molecular_Function_2018,n=20)[,c(-3,-5,-6,-7)], extensions = c
#               options = list(
#                 pageLength = 5,
#                 scrollX = TRUE,
#                 scrollCollapse = TRUE,
#                 dom = 'Bfrtip',
#                 buttons = c('copy', 'csv', 'excel')
#               ))
```

KEGG pathway

```
kable(head(enriched_combined$KEGG_2019_Mouse,n=20)[,c(-3,-5,-6,-7)])
```

|| || || ||

```
#DT::datatable(head(enriched_combined$KEGG_2019_Mouse,n=20)[,c(-3,-5,-6,-7)], extensions = c('FixedColu
#               options = list(
#                 pageLength = 5,
#                 scrollX = TRUE,
#                 scrollCollapse = TRUE,
#                 dom = 'Bfrtip',
#                 buttons = c('copy', 'csv', 'excel')
#               ))
```

Session Infomation

```
sessionInfo()
```

```
## R version 4.0.0 (2020-04-24)
## Platform: x86_64-w64-mingw32/x64 (64-bit)
## Running under: Windows 10 x64 (build 18363)
##
```

```
## Matrix products: default
##
## locale:
## [1] LC_COLLATE=Chinese (Simplified)_China.936
## [2] LC_CTYPE=Chinese (Simplified)_China.936
## [3] LC_MONETARY=Chinese (Simplified)_China.936
## [4] LC_NUMERIC=C
## [5] LC_TIME=Chinese (Simplified)_China.936
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
## [1] knitr_1.28   DT_0.13      enrichR_2.1  Seurat_3.1.5
##
## loaded via a namespace (and not attached):
##  [1] nlme_3.1-147        tsne_0.1-3          RcppAnnoy_0.0.16
##  [4] RColorBrewer_1.1-2  httr_1.4.1          sctransform_0.2.1
##  [7] tools_4.0.0         R6_2.4.1            irlba_2.3.3
## [10] KernSmooth_2.23-17  uwot_0.1.8          lazyeval_0.2.2
## [13] colorspace_1.4-1    withr_2.2.0         npsurv_0.4-0.1
## [16] tidyselect_1.0.0    gridExtra_2.3       curl_4.3
## [19] compiler_4.0.0      plotly_4.9.2.1      labeling_0.3
## [22] scales_1.1.1        lmtest_0.9-37       ggridges_0.5.2
## [25] pbapply_1.4-2       rappdirs_0.3.1      stringr_1.4.0
## [28] digest_0.6.25       rmarkdown_2.1       pkgconfig_2.0.3
## [31] htmltools_0.4.0     highr_0.8           limma_3.44.1
## [34] htmlwidgets_1.5.1   rlang_0.4.6         farver_2.0.3
## [37] zoo_1.8-8           jsonlite_1.6.1      ica_1.0-2
## [40] dplyr_0.8.5         magrittr_1.5        patchwork_1.0.0
## [43] Matrix_1.2-18       Rcpp_1.0.4.6        munsell_0.5.0
## [46] ape_5.3             reticulate_1.15     lifecycle_0.2.0
## [49] stringi_1.4.6       yaml_2.2.1          MASS_7.3-51.6
## [52] Rtsne_0.15          plyr_1.8.6          grid_4.0.0
## [55] parallel_4.0.0      listenv_0.8.0       ggrepel_0.8.2
## [58] crayon_1.3.4        lattice_0.20-41     cowplot_1.0.0
## [61] splines_4.0.0       pillar_1.4.4        igraph_1.2.5
## [64] rjson_0.2.20        future.apply_1.5.0  reshape2_1.4.4
## [67] codetools_0.2-16    leiden_0.3.3        glue_1.4.0
## [70] evaluate_0.14       lsei_1.2-0.1        data.table_1.12.8
## [73] png_0.1-7           vctrs_0.3.1         gtable_0.3.0
## [76] RANN_2.6.1          purrr_0.3.4         tidyr_1.0.3
## [79] future_1.17.0       assertthat_0.2.1    ggplot2_3.3.0
## [82] xfun_0.13           rsvd_1.0.3          RSpectra_0.16-0
## [85] survival_3.1-12     viridisLite_0.3.0   tibble_3.0.1
## [88] cluster_2.1.0       globals_0.12.5      fitdistrplus_1.0-14
## [91] ellipsis_0.3.0      ROCR_1.0-11
```