

# Differential Expression Analysis for bulk RNA-seq data

## CTRL(C03) vs AD in Vehicle condition

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## 1. Read the count data

In this section, we will read the clean count data from the `synaptosomes_bulkRNA` folder. We will read the data and merge them into a single table. The final table will be stored in `../dataresults/bulkRNA_counts_clean.csv`.

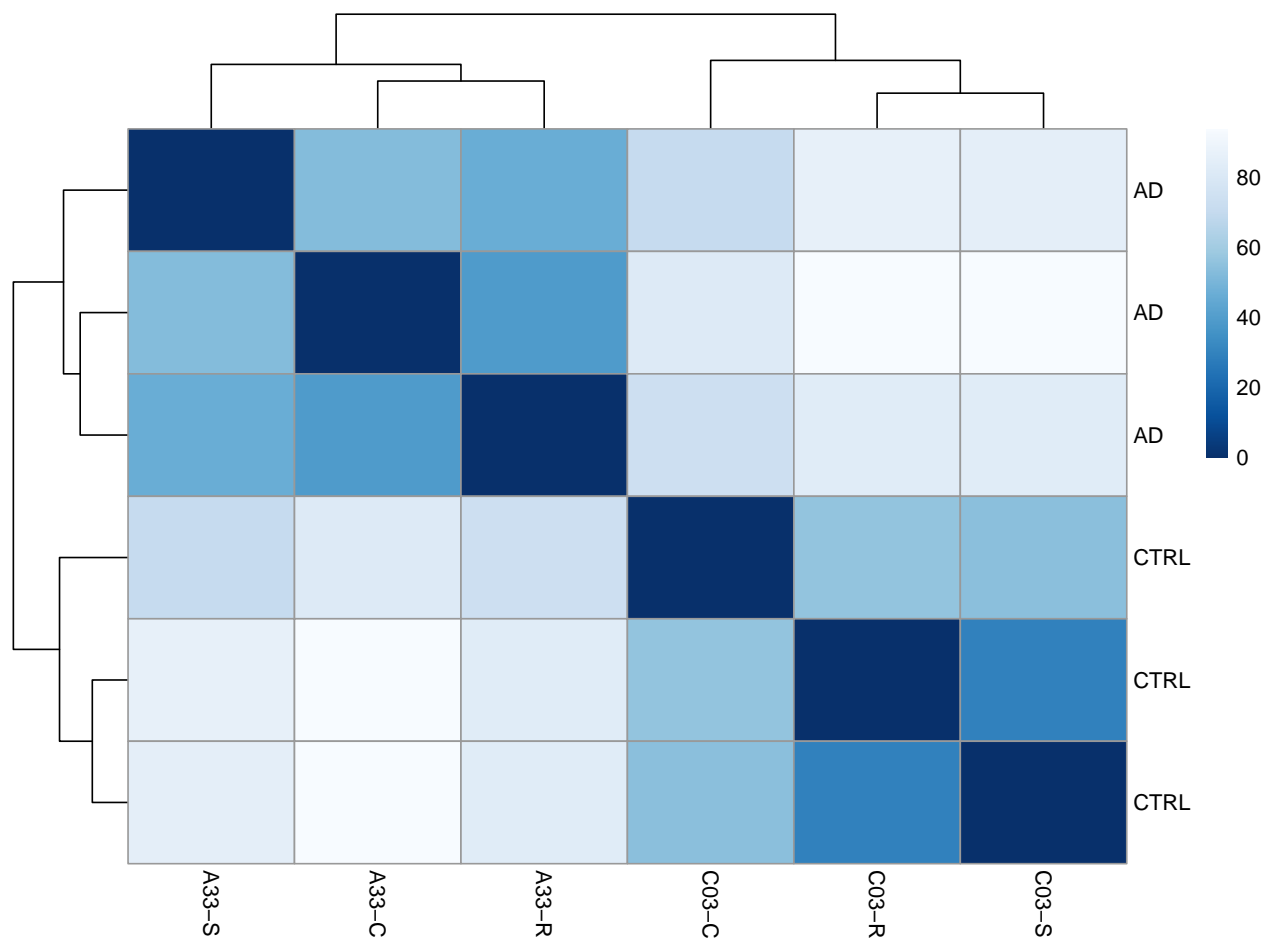
## 2. Differential expression analysis

In this section, we will perform differential expression analysis using DESeq2. We will compare the 22q vs Control in the vehicle condition. The results will be stored in `results/DEG-V_10/DESeq2_results.csv`.

```
## [1] "DEG analysis is done"
```

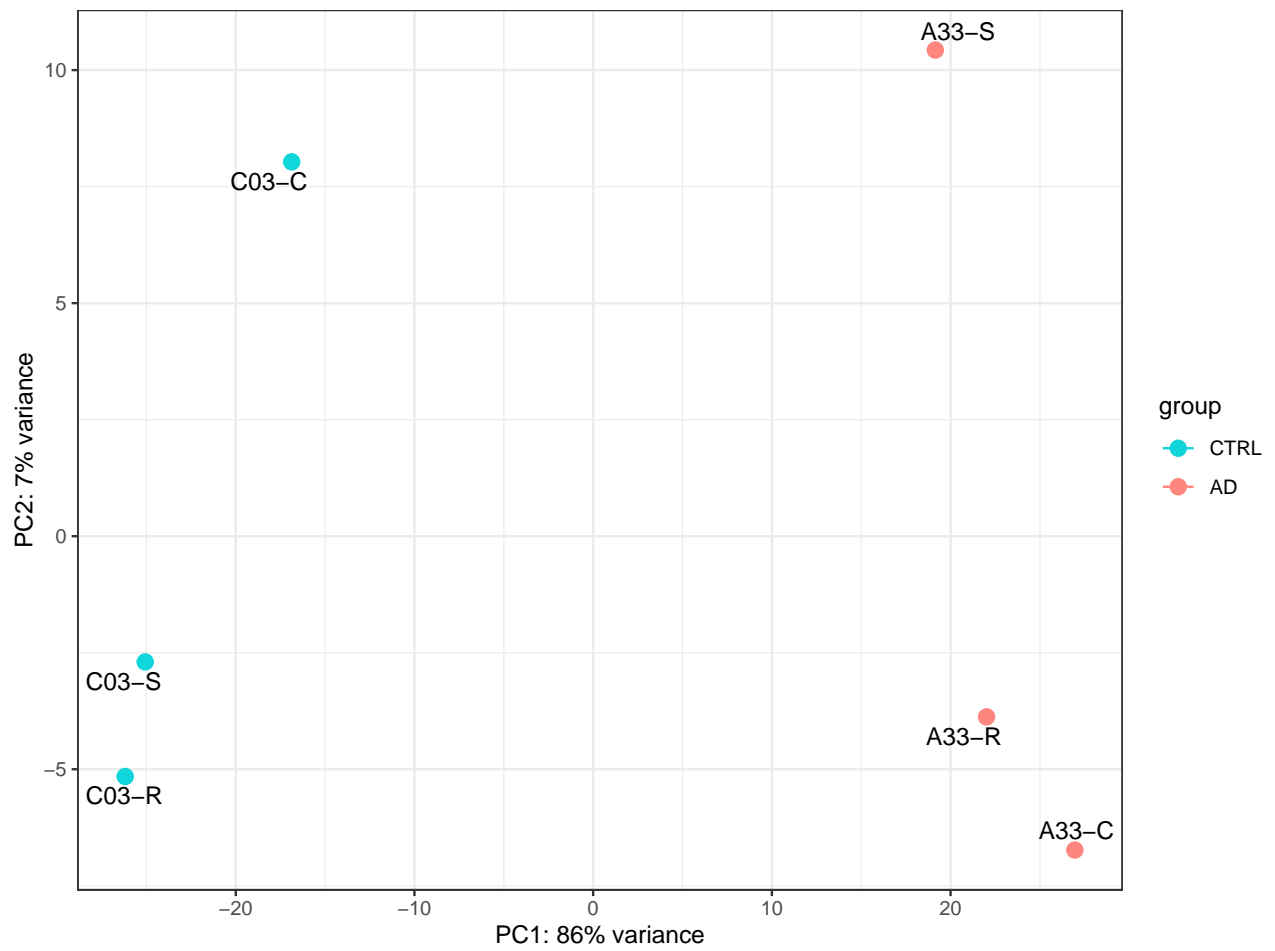
### 3. Visualization for reuslt

#### (1) Sample information



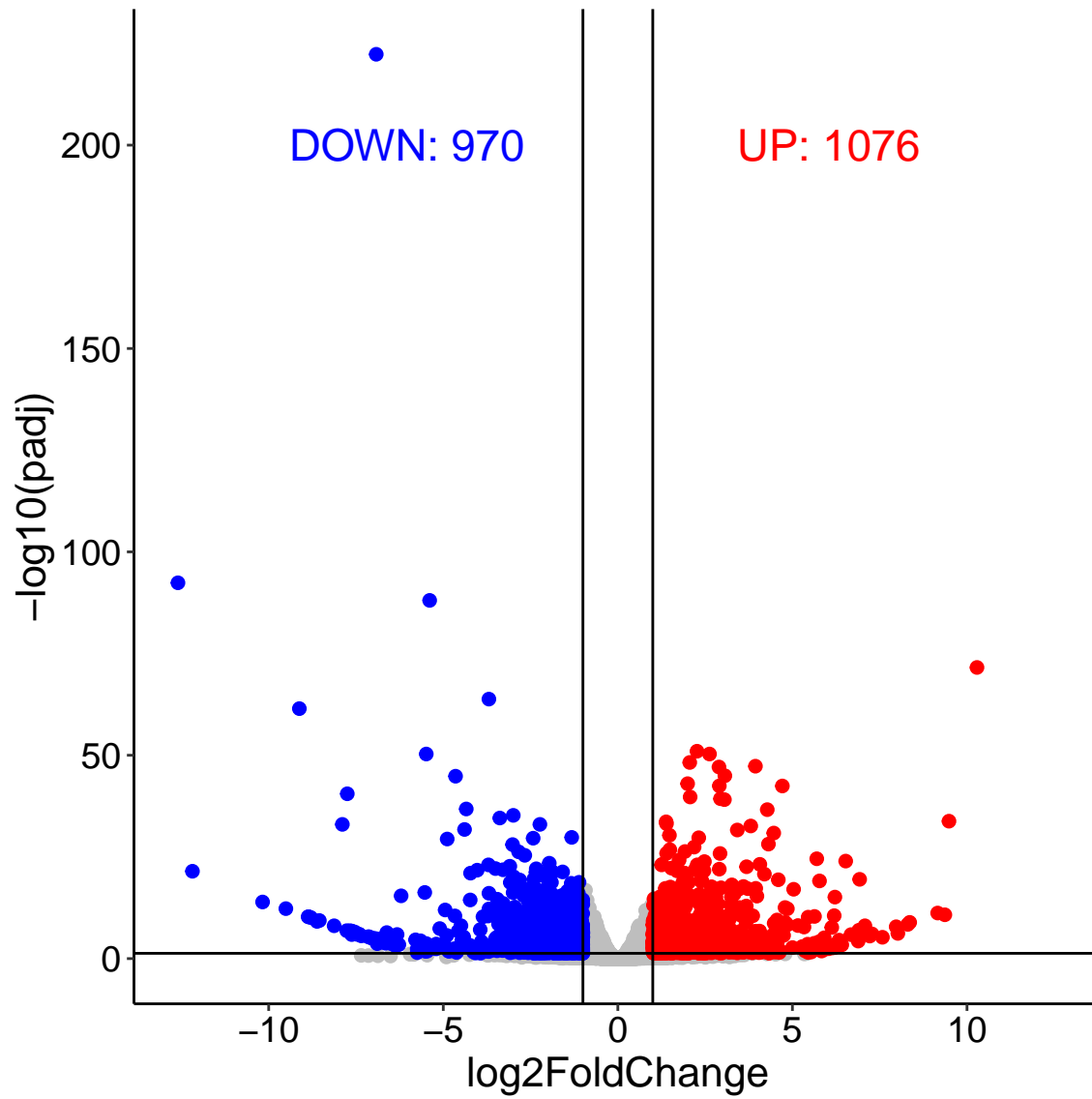
```
## [1] "Sample distance heatmap is done"
```

```
## [1] "PCA plot is done"
```

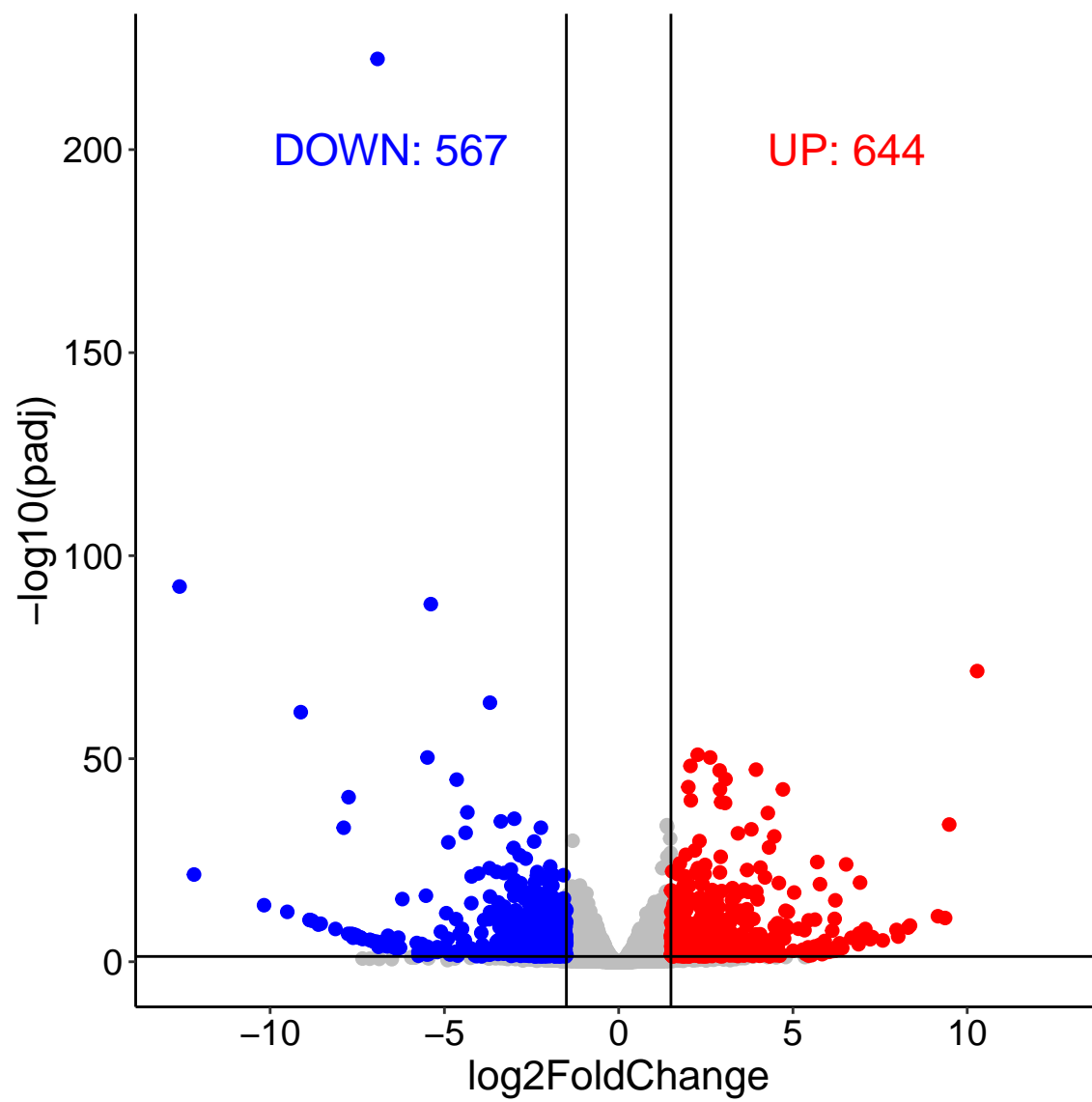


## (2) DEG visualization - Volcano plot and Heatmap

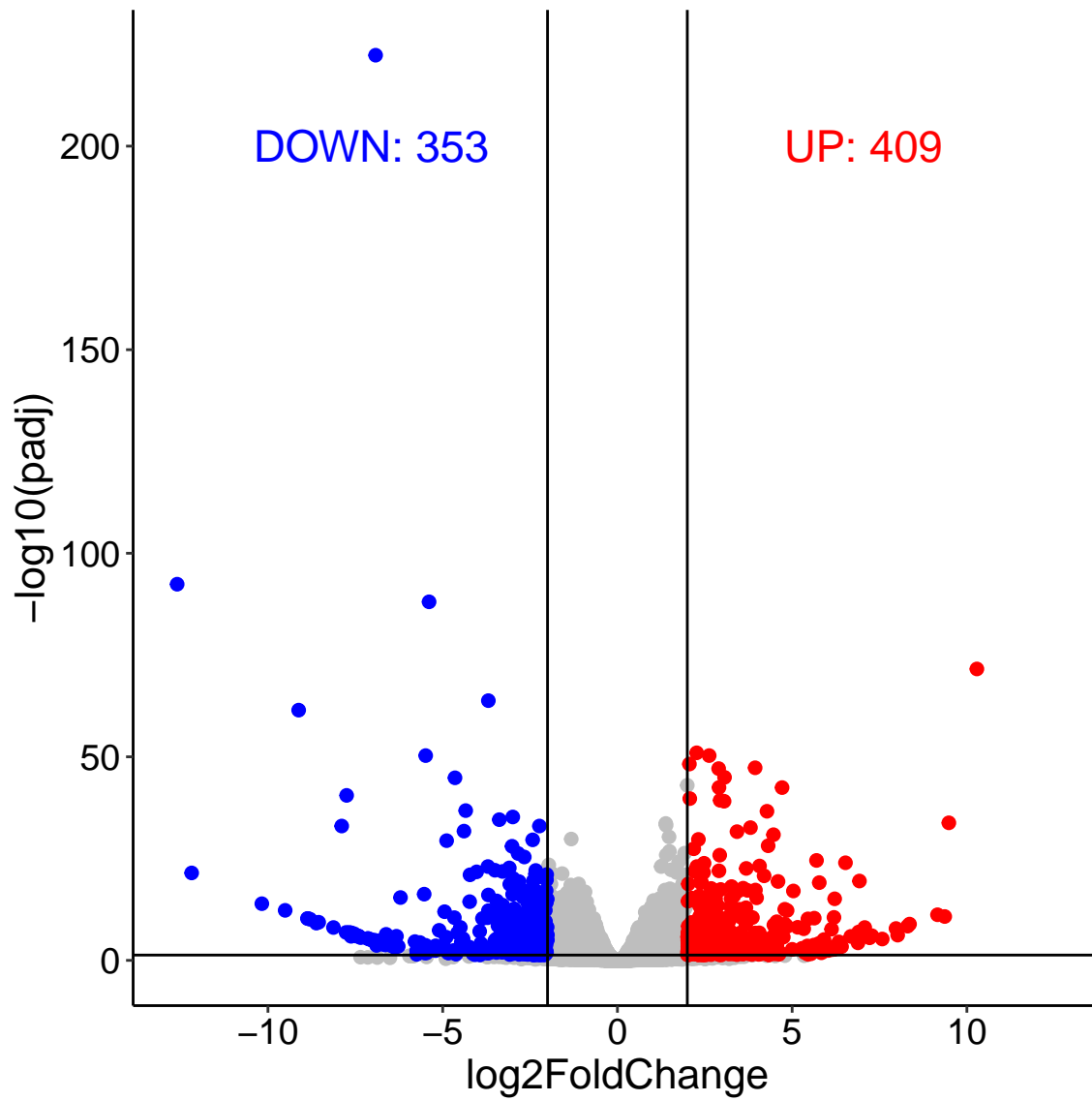
```
## [1] "Volcano plot for 02_volcano_plot_log2fc_1"
```



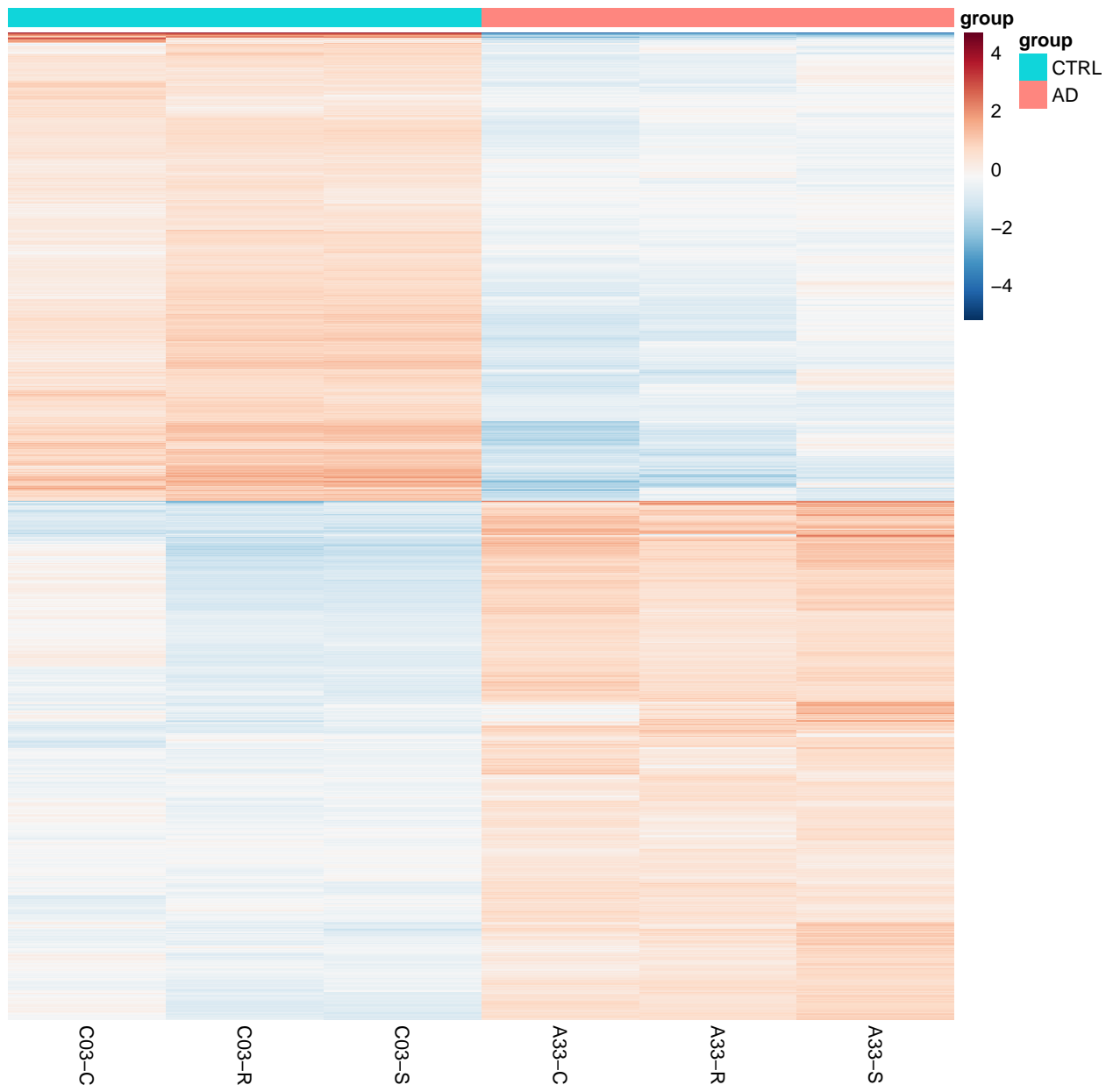
```
## [1] "Volcano plot for 03_volcano_plot_log2fc_1.5"
```



```
## [1] "Volcano plot for 03_volcano_plot_log2fc_2"
```

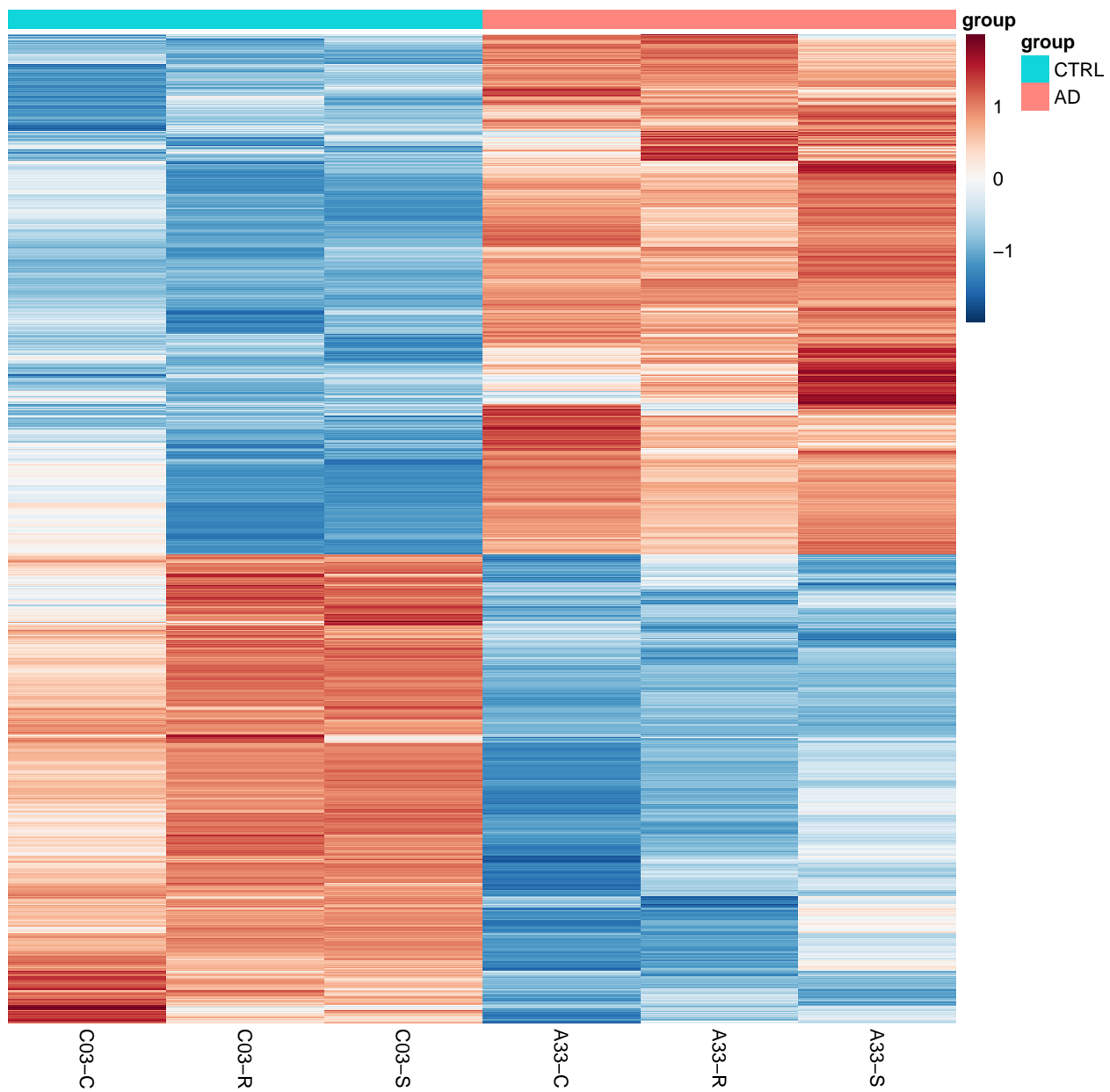


```
## [1] "Heatmap for 02_heatmap_log2fc_1 "
```

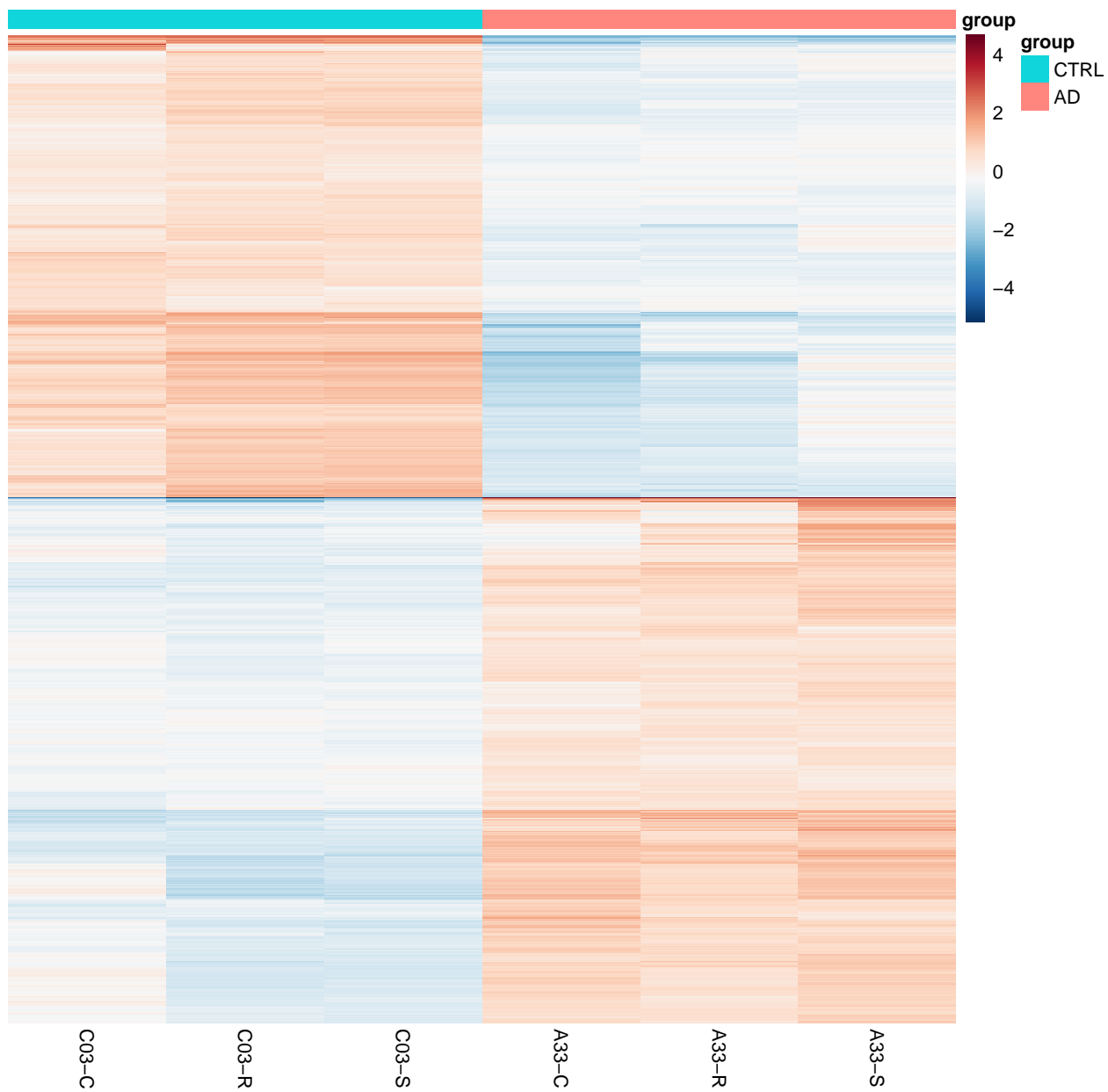


## [1] "Heatmap for 02\_heatmap\_log2fc\_1\_row "

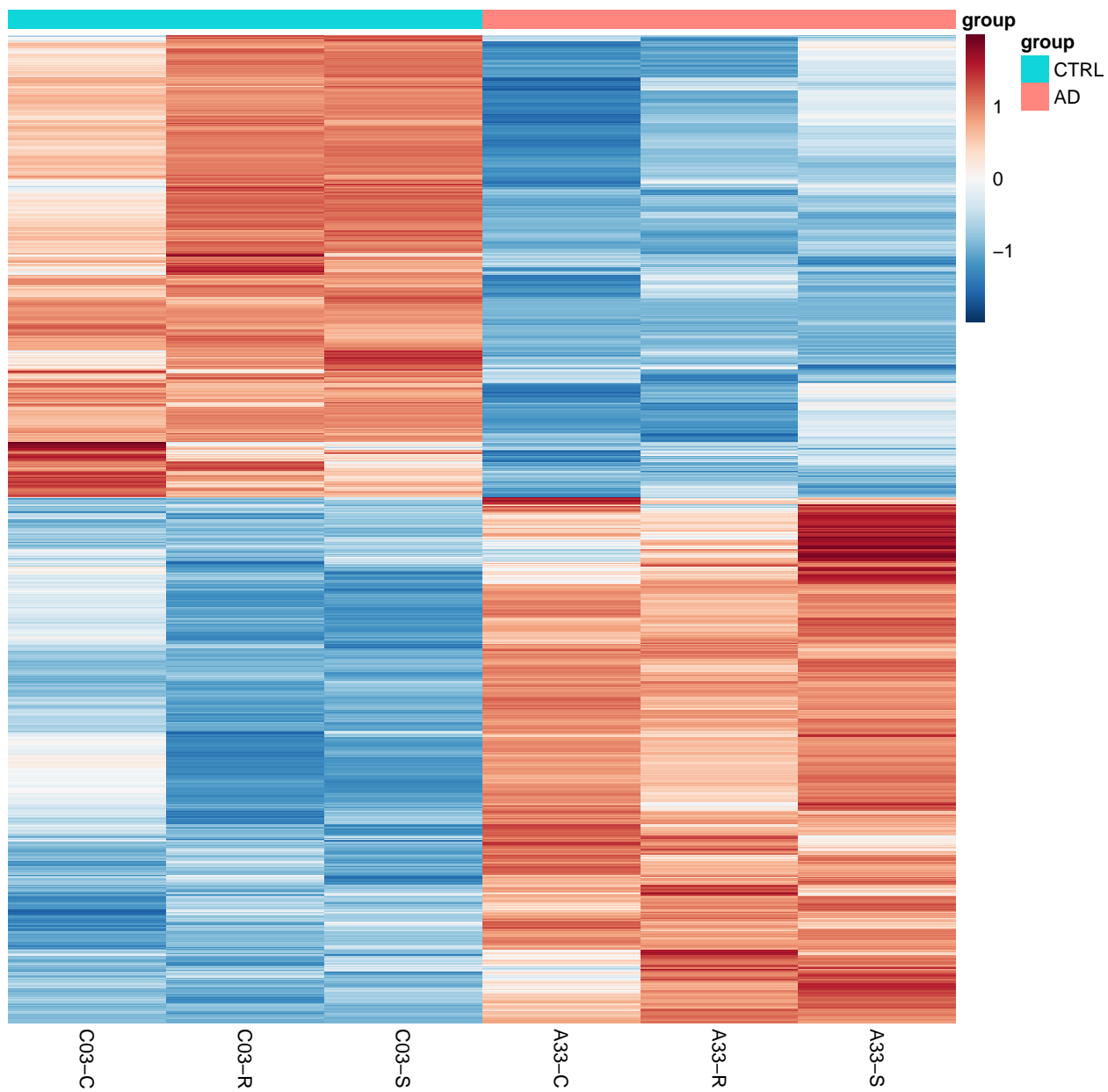




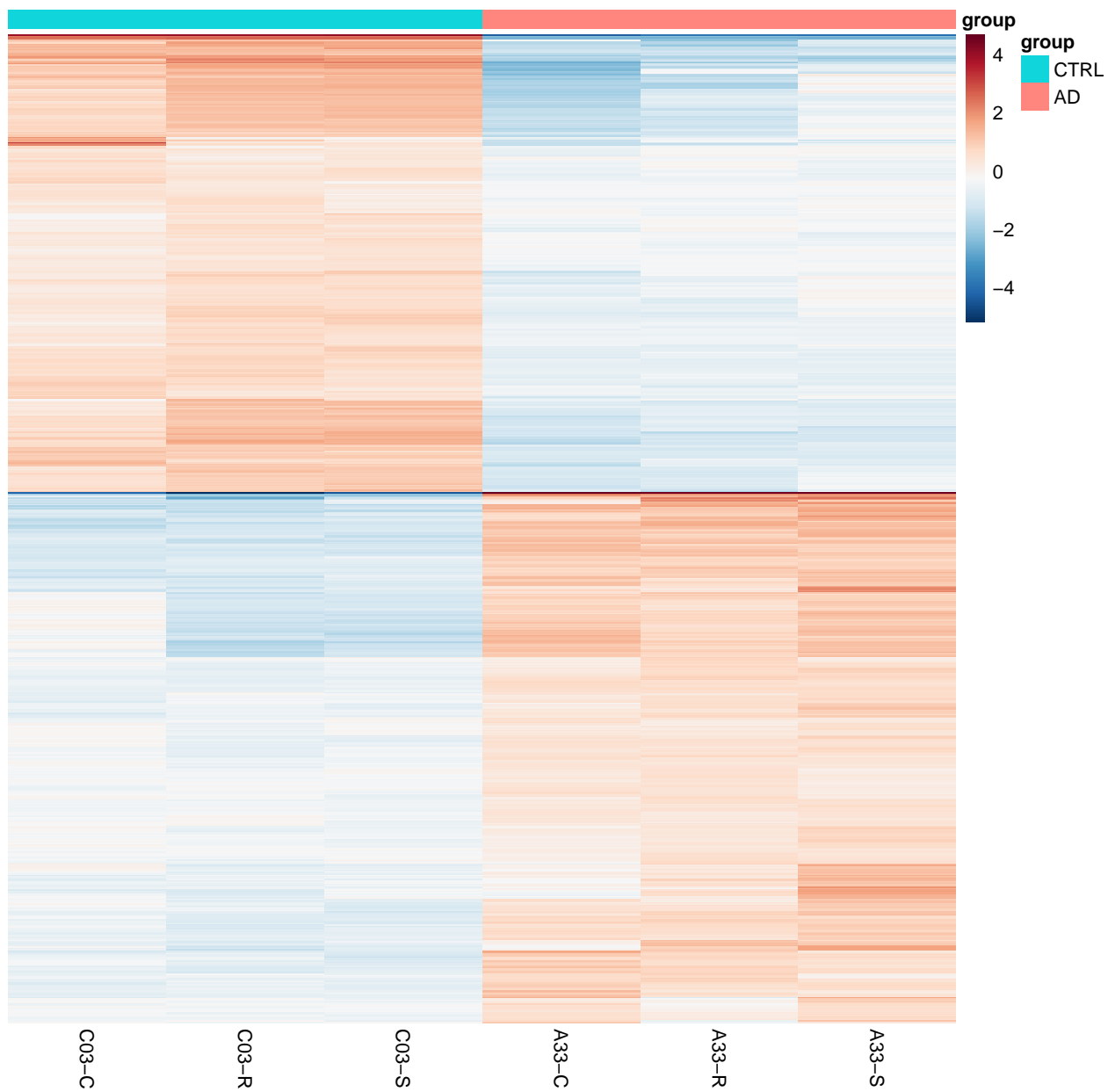
## [1] "Heatmap for 03\_heatmap\_log2fc\_1.5 "



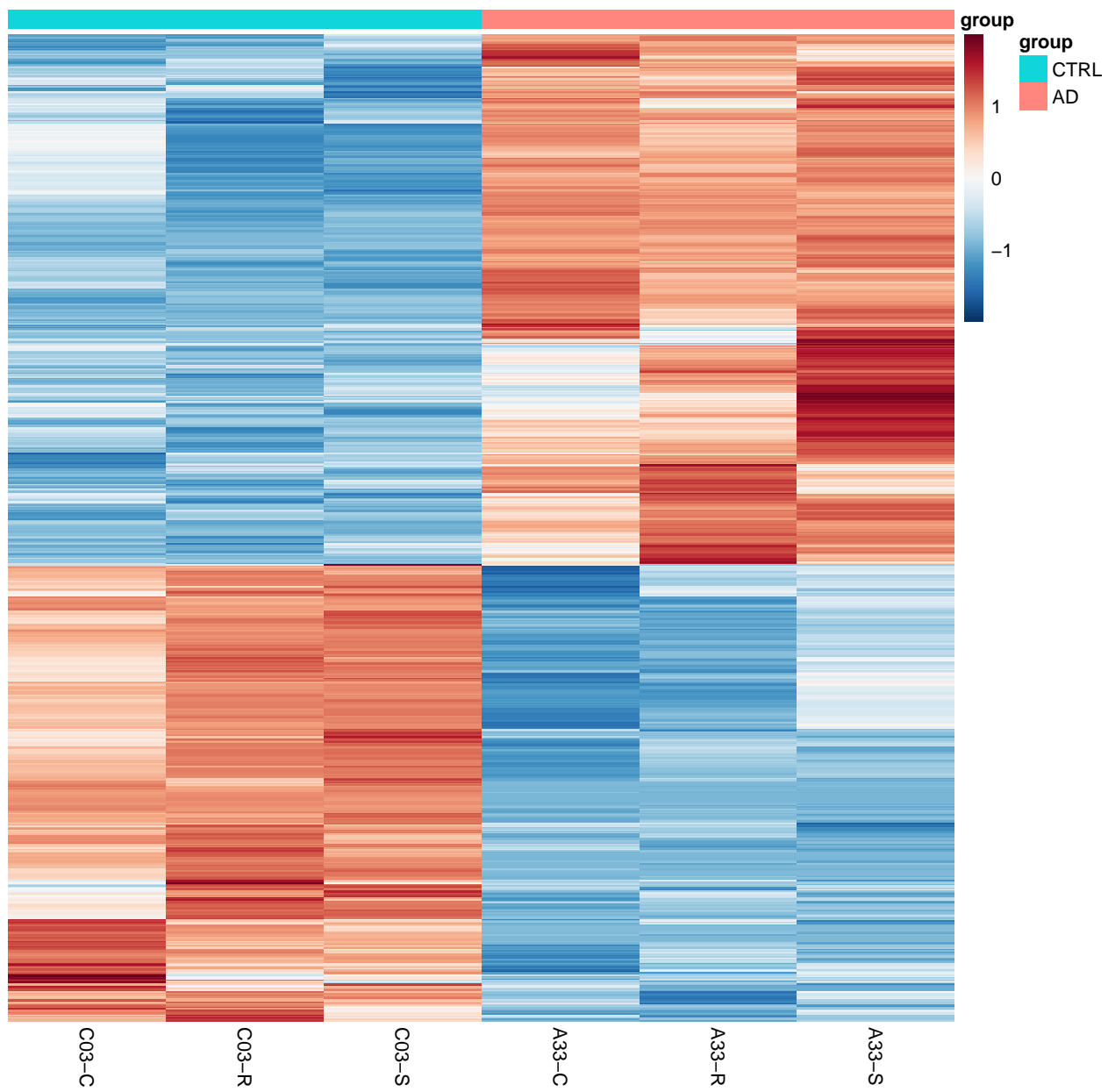
```
## [1] "Heatmap for 03_heatmap_log2fc_1.5_row "
```



## [1] "Heatmap for 03\_heatmap\_log2fc\_2 "



```
## [1] "Heatmap for 03_heatmap_log2fc_2_row "
```



## 4. GSVA analysis

```
## No annotation package name available in the input data object.  
## Attempting to directly match identifiers in data to gene sets.  
## Estimating GSVA scores for 10530 gene sets.  
## Estimating ECDFs with Gaussian kernels  
## |
```

Mitochondrial RNA 3 end processing

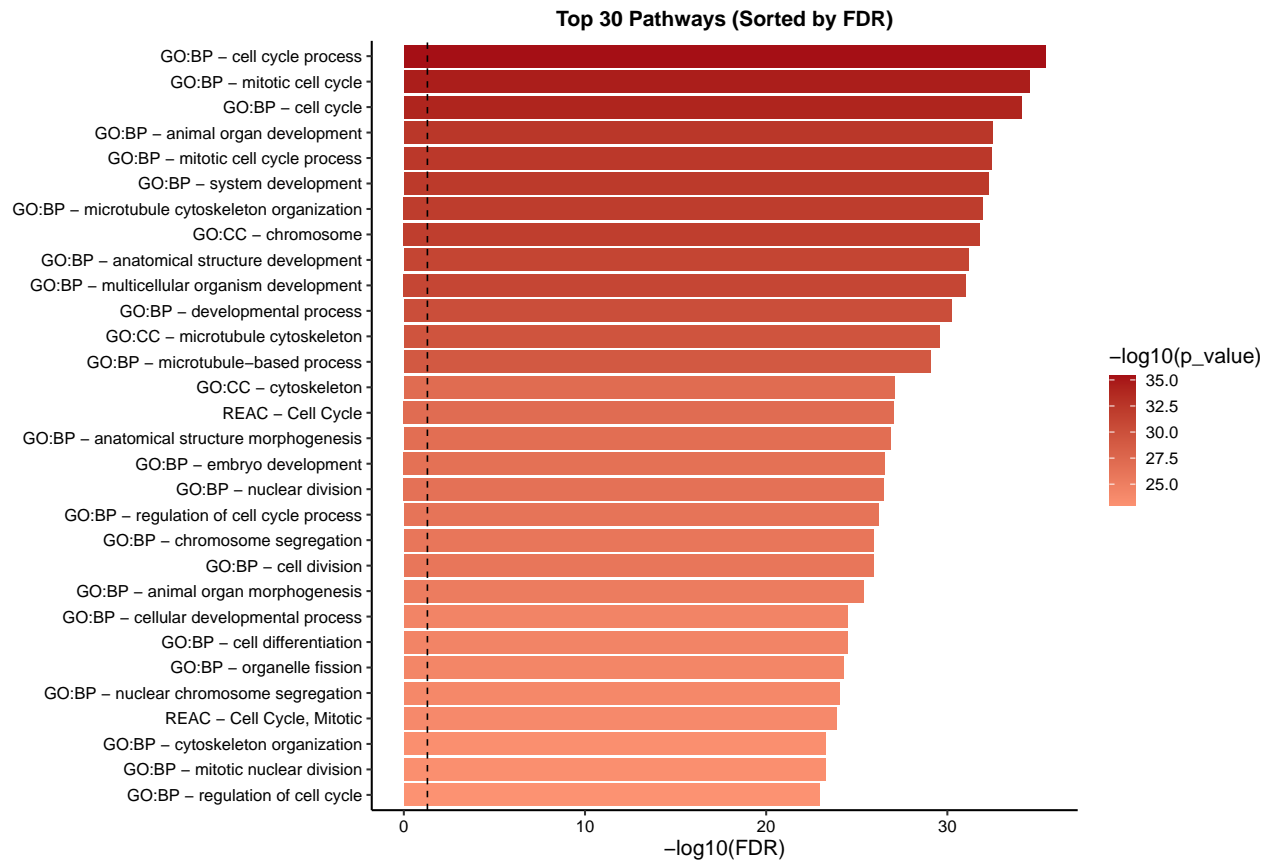
Mitochondrial RNA processing

GSVA Score

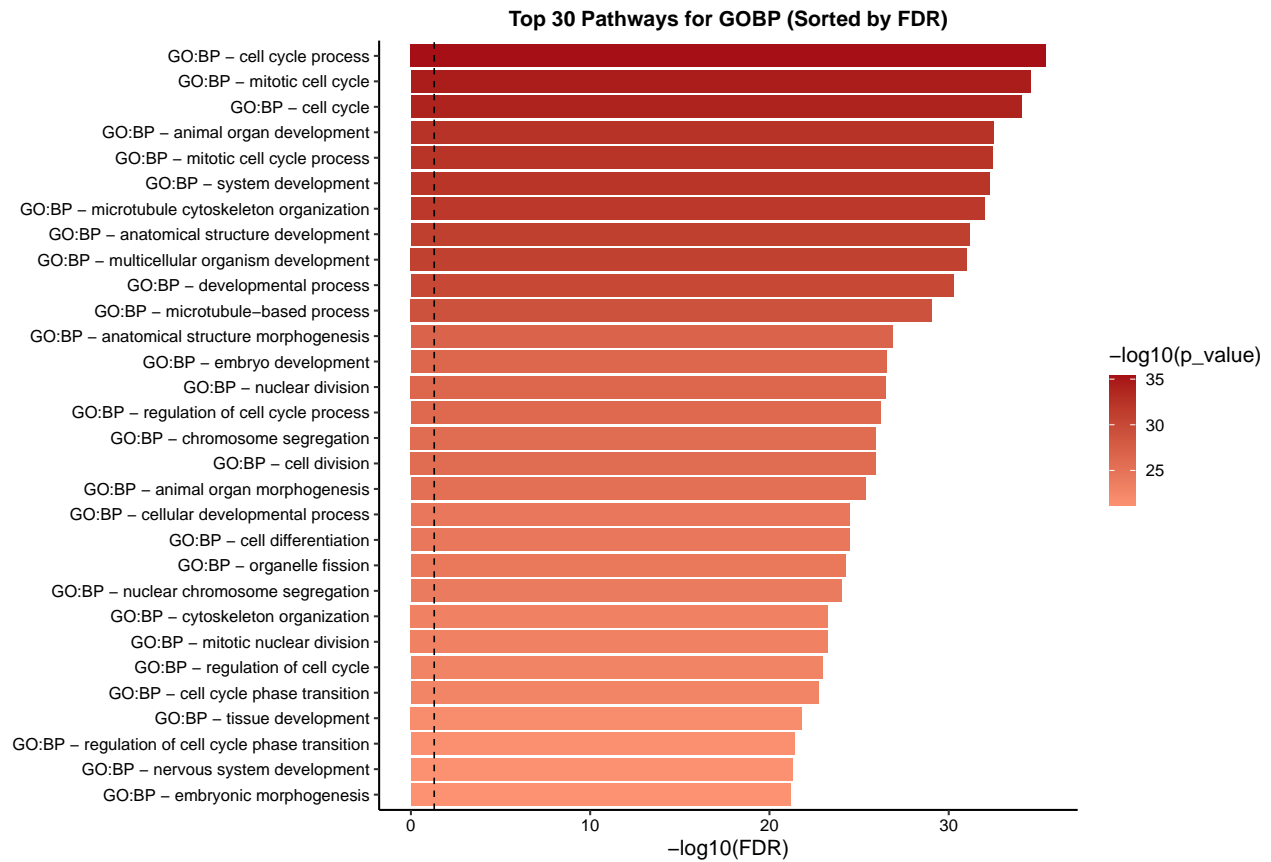
GSVA Score

## 5. Pathway Enrichment Analysis

```
## [1] "Enrichment analysis for 01-DEG_1.0_up "
```

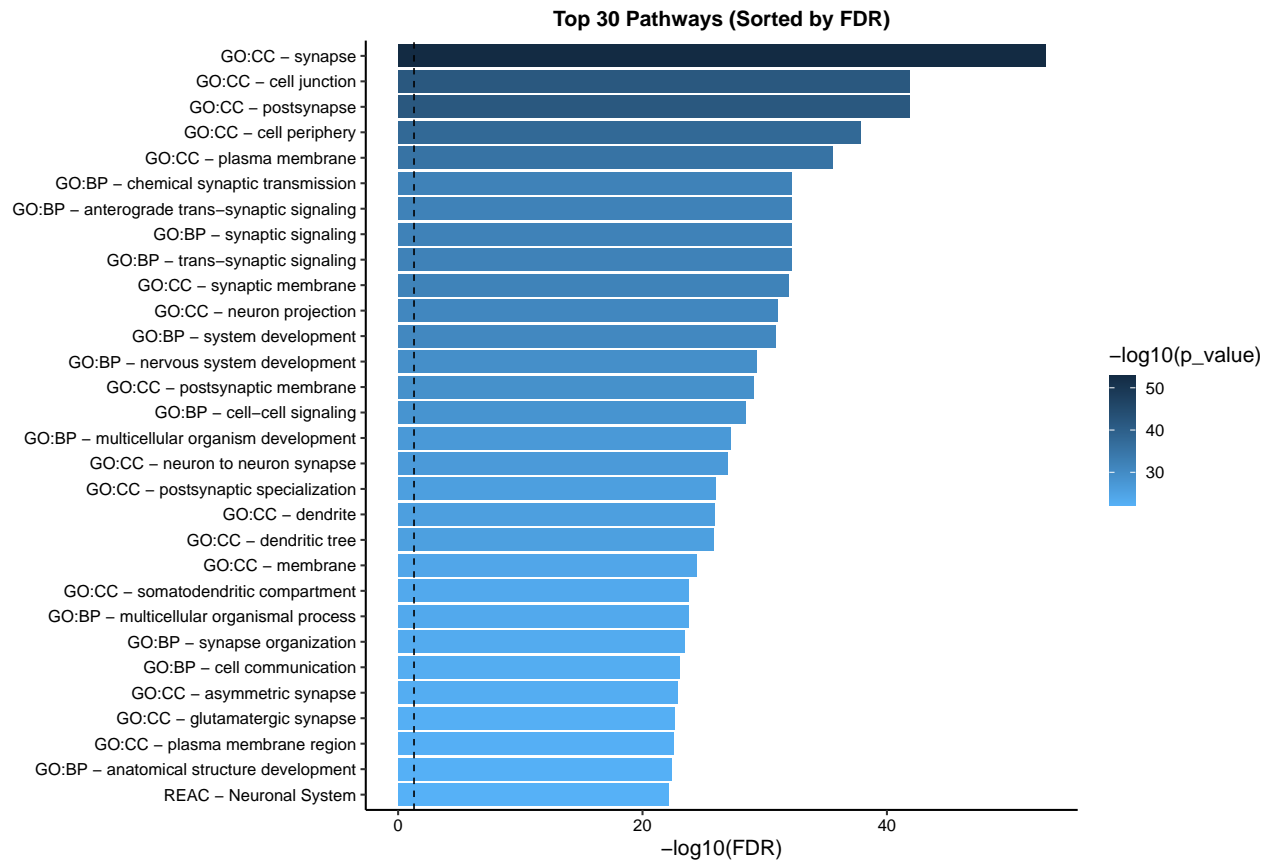


```
## [1] "Enrichment analysis for GOBP 01-DEG_1.0_up "
```

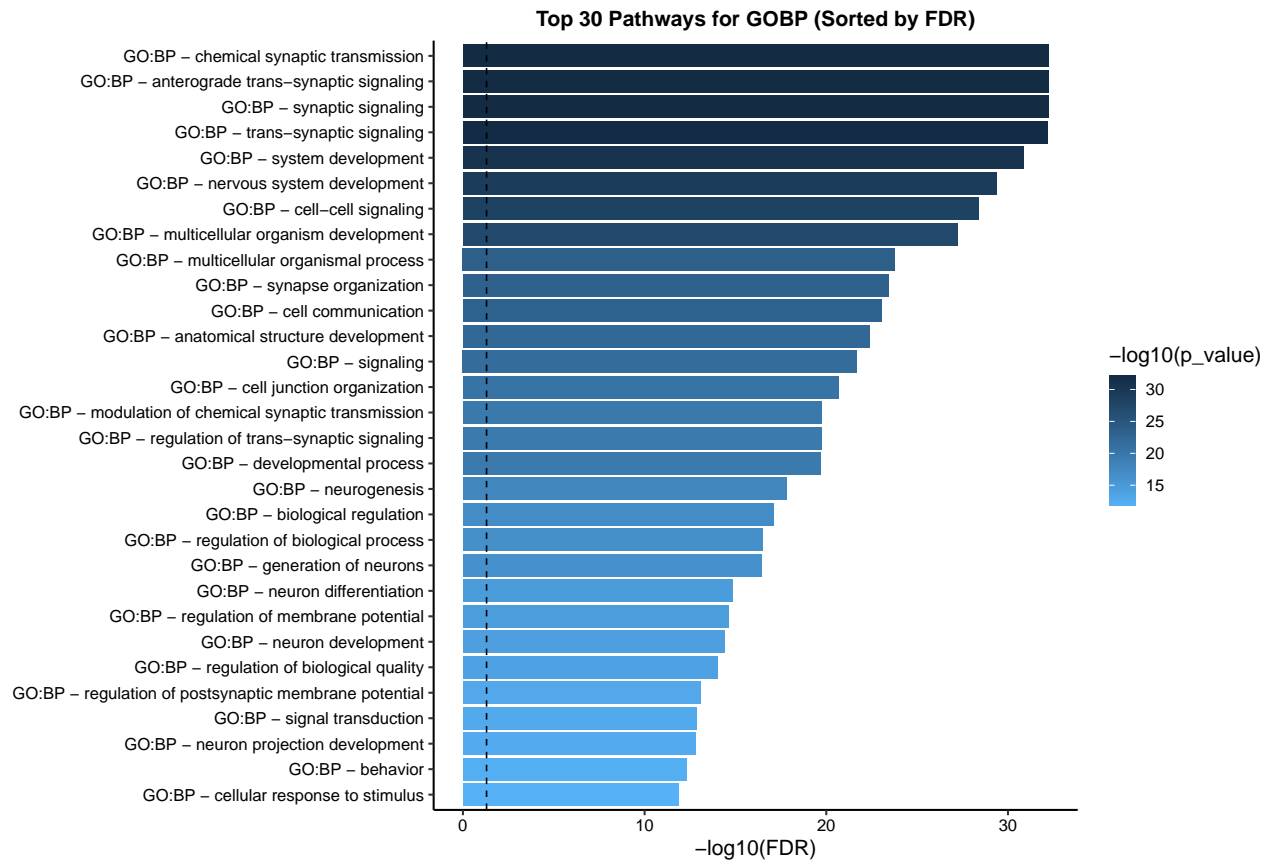


```
## [1] "Enrichment analysis for 01-DEG_1.0_down "
```

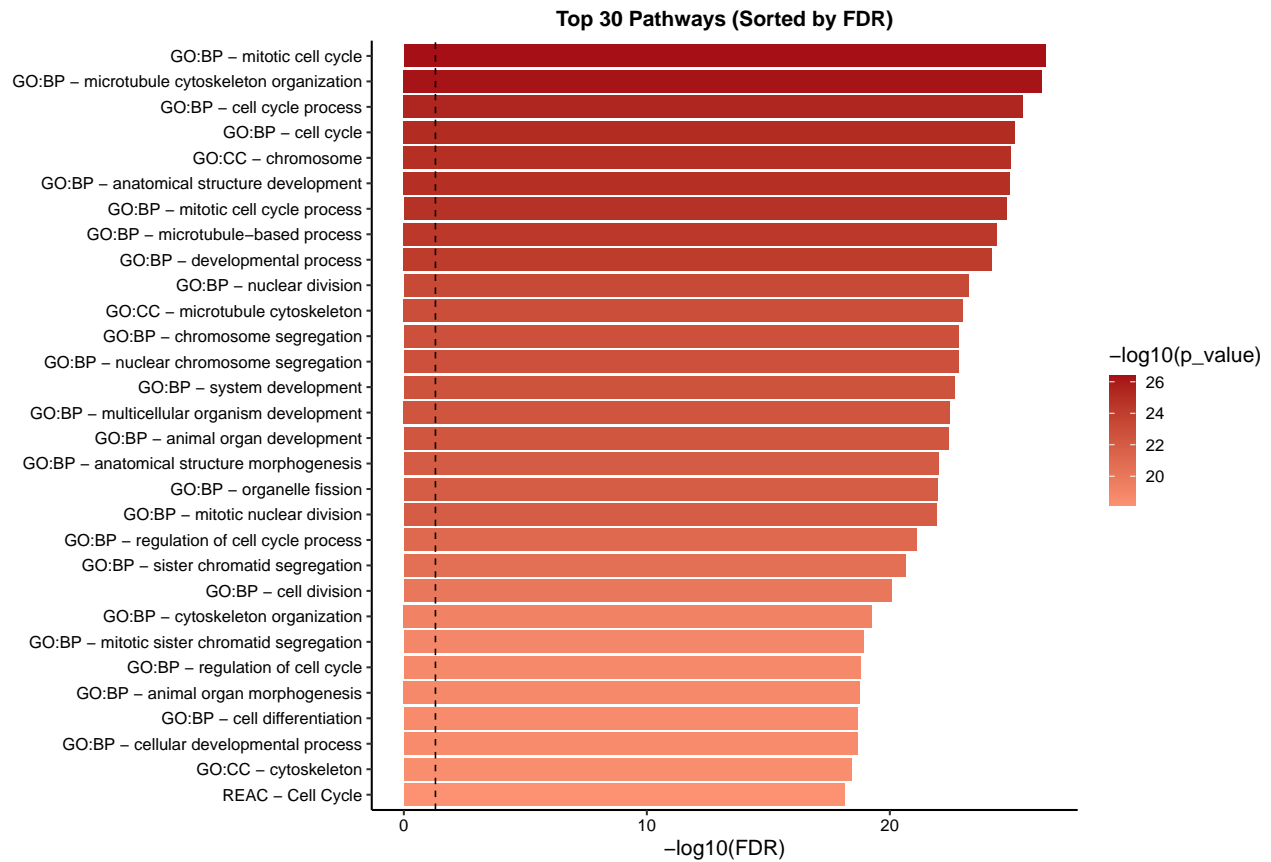




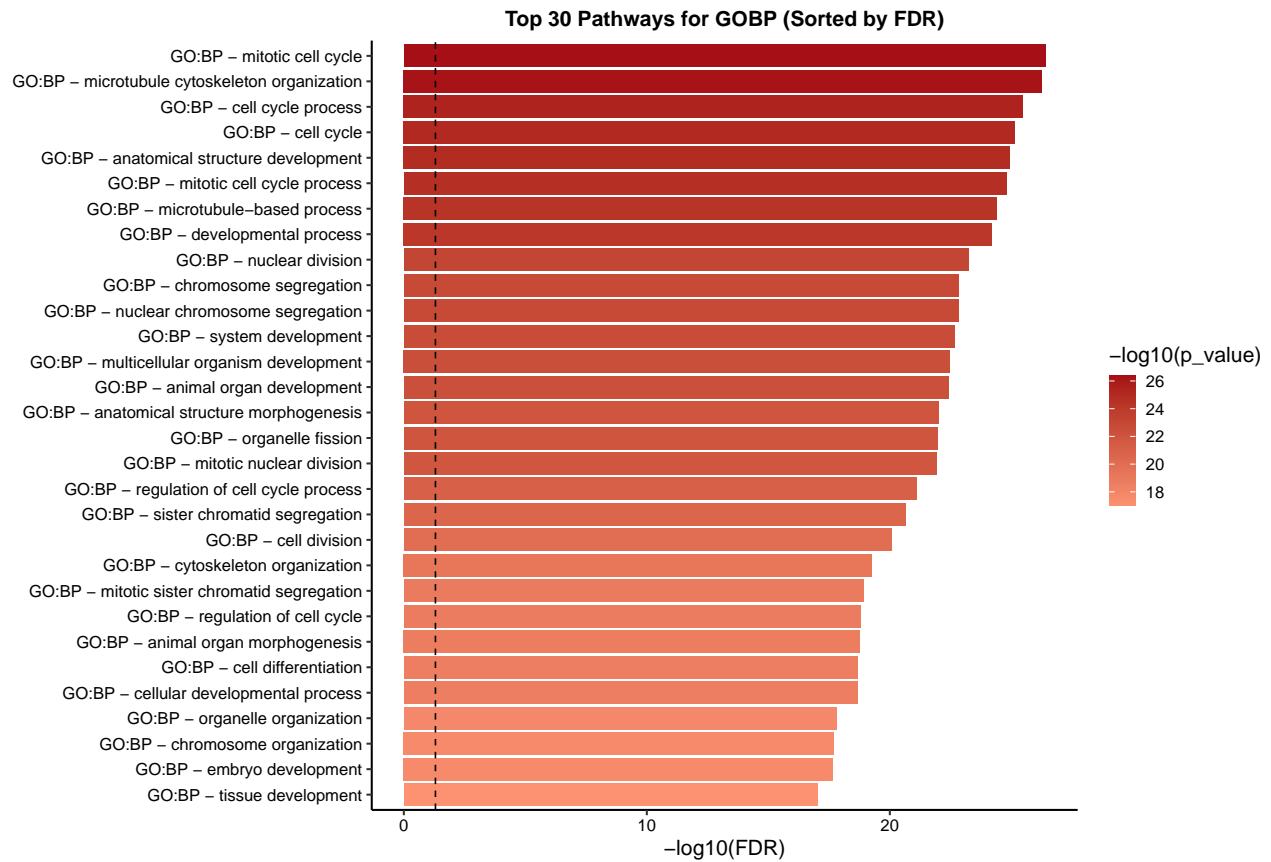
```
## [1] "Enrichment analysis for GOBP 01-DEG_1.0_down "
```



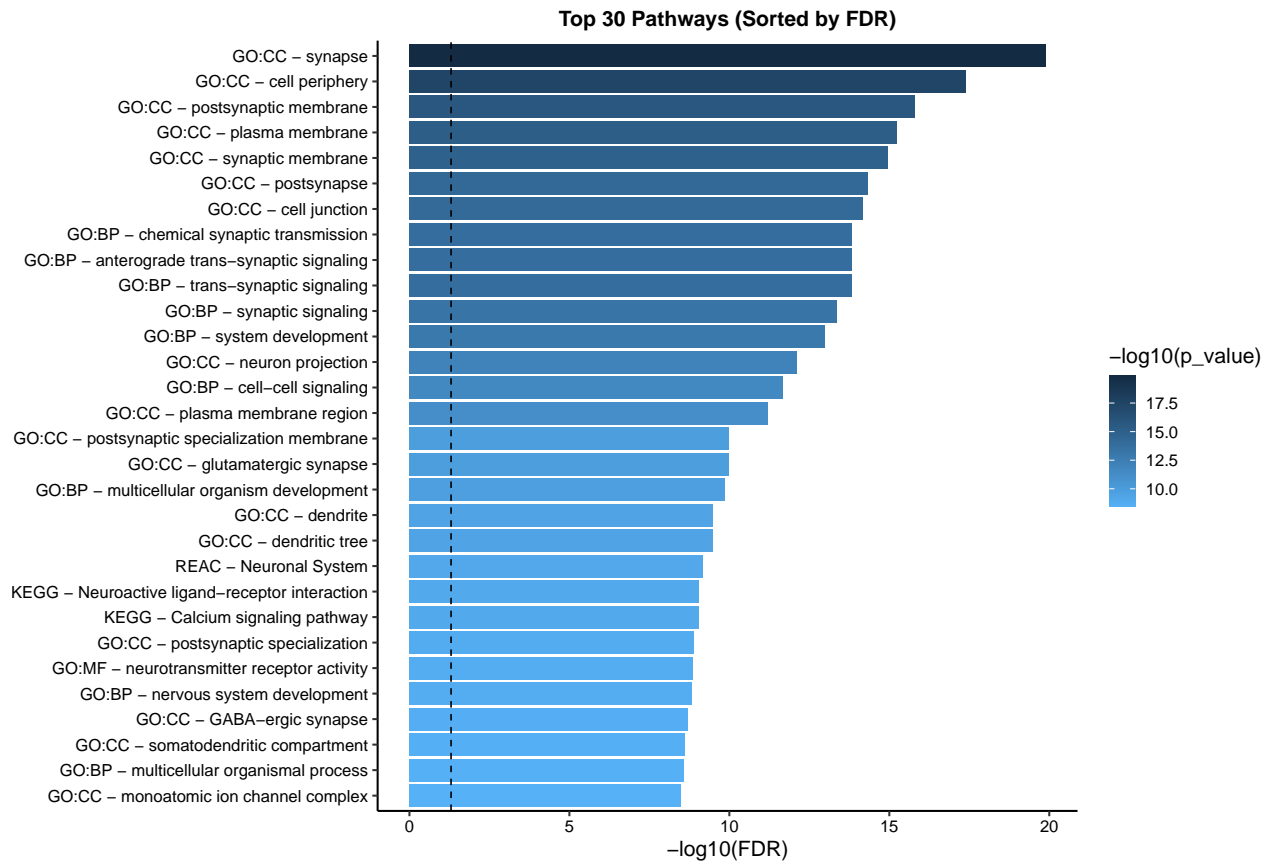
```
## [1] "Enrichment analysis for 02-DEG_1.5_up "
```



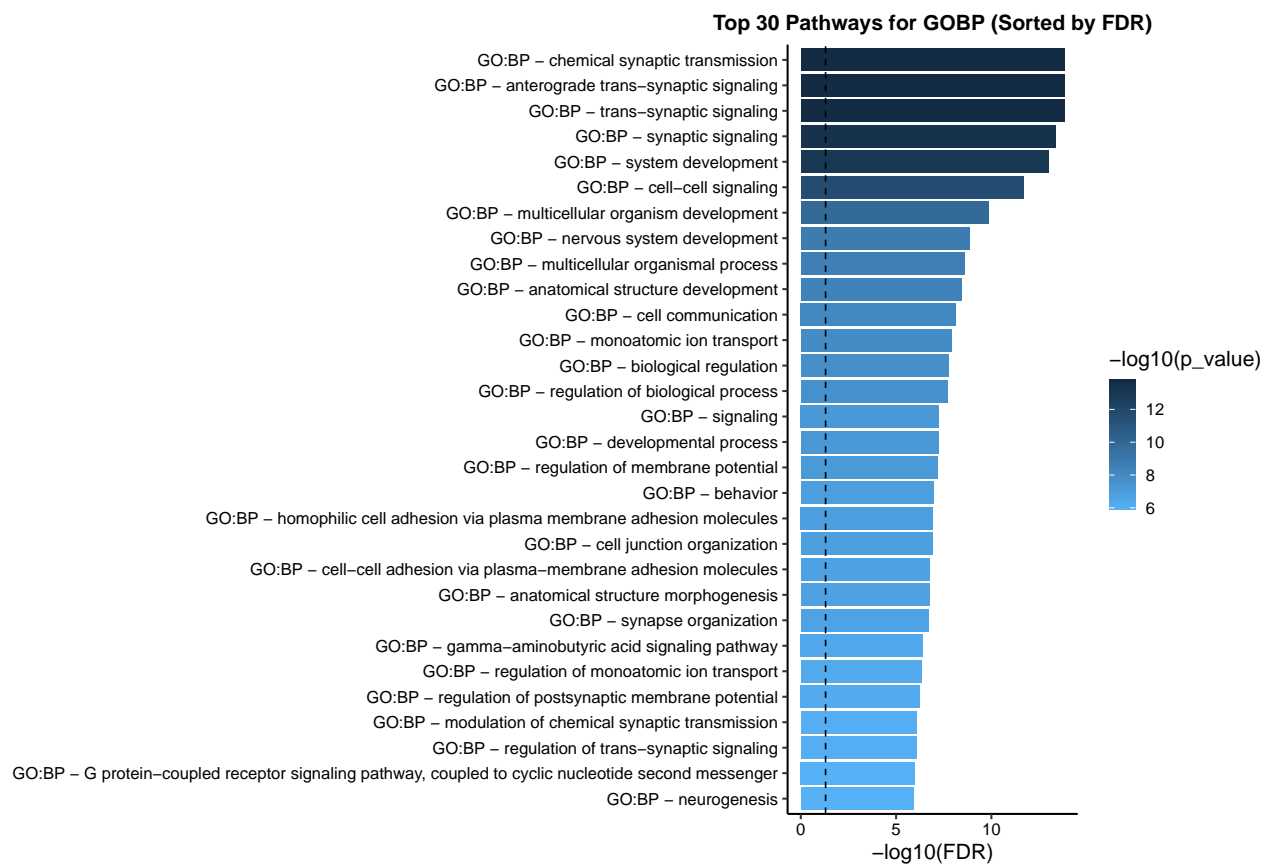
```
## [1] "Enrichment analysis for GOBP 02-DEG_1.5_up "
```



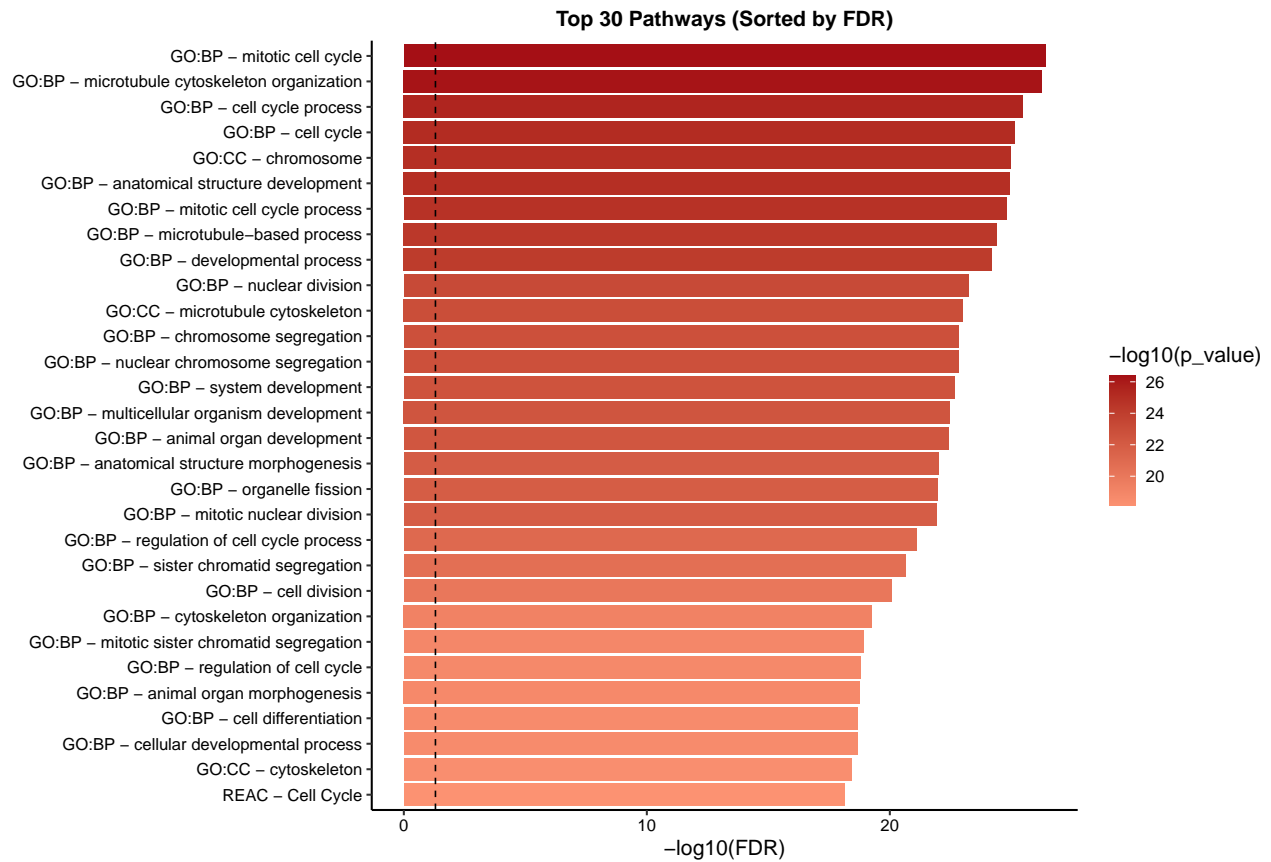
```
## [1] "Enrichment analysis for 02-DEG_1.5_down "
```



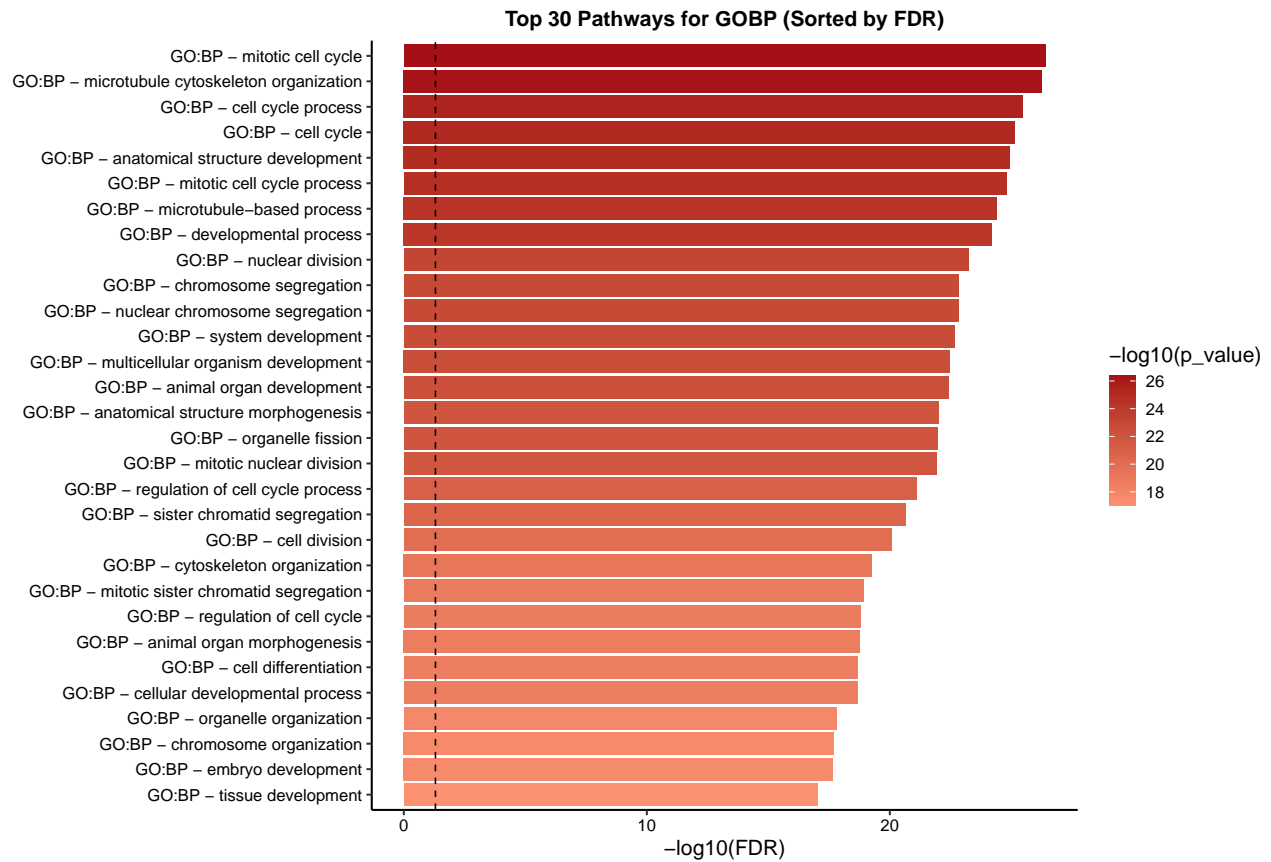
```
## [1] "Enrichment analysis for GOBP 02-DEG_1.5_down "
```



```
## [1] "Enrichment analysis for 03-DEG_2_up "
```

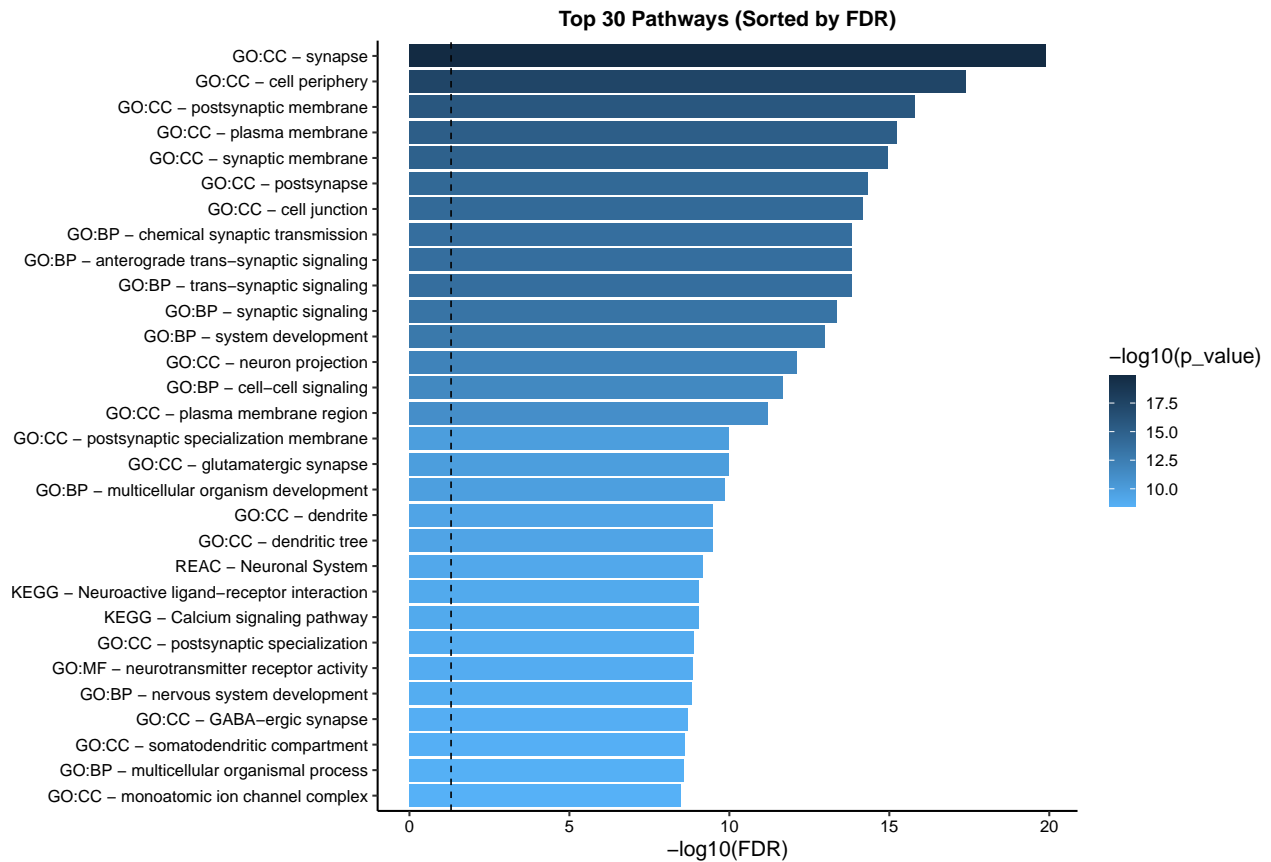


```
## [1] "Enrichment analysis for GOBP 03-DEG_2_up "
```

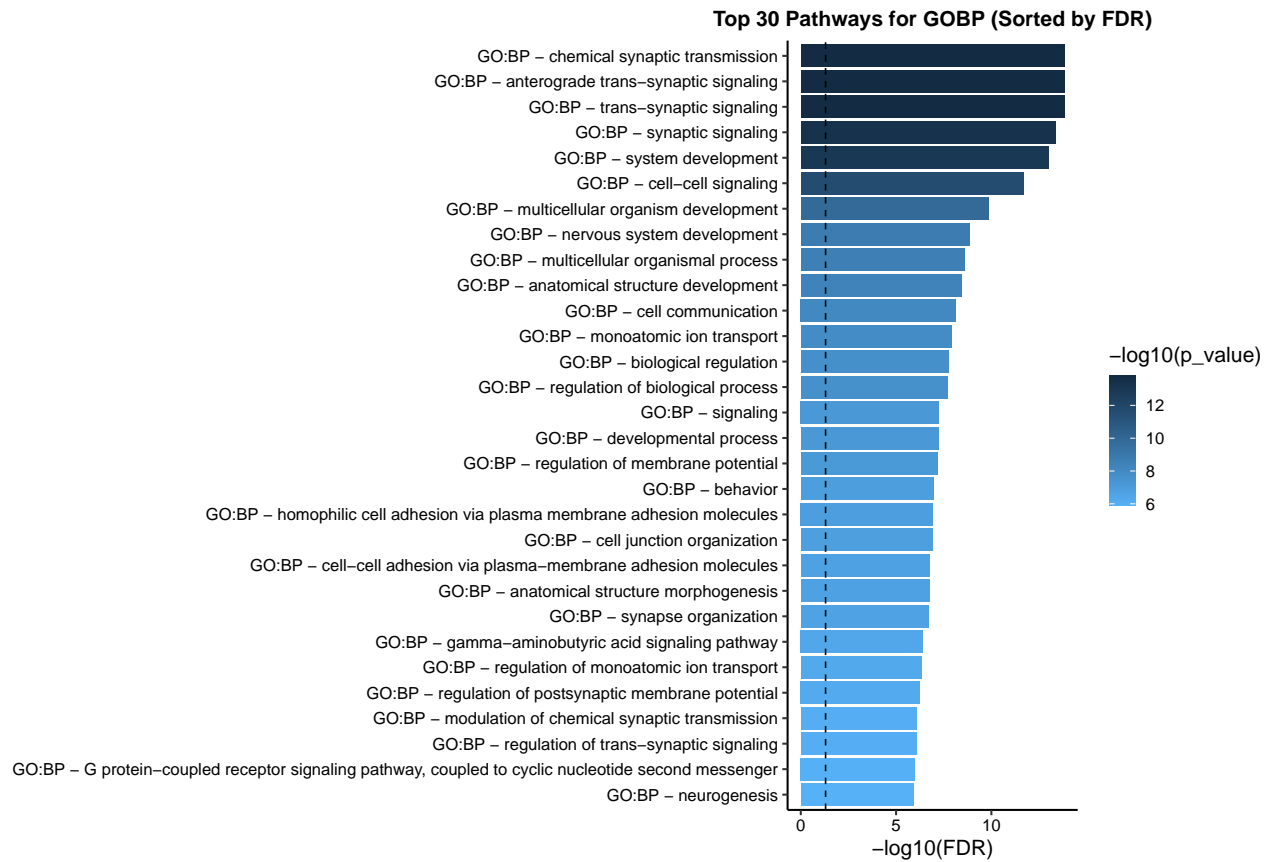


```
## [1] "Enrichment analysis for 03-DEG_2_down "
```





```
## [1] "Enrichment analysis for GOBP 03-DEG_2_down "
```



## Session information

```
## R version 4.4.0 (2024-04-24)
## Platform: aarch64-apple-darwin20
## Running under: macOS 15.4
##
## Matrix products: default
## BLAS:   /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRblas.0.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRlapack.dylib; LAPACK v
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: America/New_York
## tzcode source: internal
##
## attached base packages:
## [1] parallel stats4 stats graphics grDevices utils datasets
## [8] methods base
##
## other attached packages:
## [1] GSEABase_1.66.0 graph_1.82.0
## [3] annotate_1.82.0 XML_3.99-0.18
## [5] extrafont_0.19 ggsignif_0.6.4
## [7] patchwork_1.3.0 decoupleR_2.10.0
## [9] GSVA_1.52.3 BiocParallel_1.38.0
## [11] edgeR_4.2.2 limma_3.60.6
## [13] GenomicFeatures_1.56.0 biomaRt_2.60.1
## [15] gprofiler2_0.2.3 RColorBrewer_1.1-3
## [17] data.table_1.17.0 org.Hs.eg.db_3.19.1
## [19] AnnotationDbi_1.66.0 clusterProfiler_4.12.6
## [21] ggfortify_0.4.17 pheatmap_1.0.12
## [23] EnhancedVolcano_1.22.0 ggrepel_0.9.6
## [25] apeglm_1.26.1 DESeq2_1.44.0
## [27] SummarizedExperiment_1.34.0 Biobase_2.64.0
## [29] MatrixGenerics_1.16.0 matrixStats_1.5.0
## [31] reshape2_1.4.4 Matrix_1.7-3
## [33] Signac_1.14.0 Seurat_5.2.1
## [35] SeuratObject_5.0.2 sp_2.2-0
## [37] rtracklayer_1.64.0 GenomicRanges_1.56.2
## [39] GenomeInfoDb_1.40.1 IRanges_2.38.1
## [41] S4Vectors_0.42.1 BiocGenerics_0.50.0
## [43] knitr_1.50 lubridate_1.9.4
## [45] forcats_1.0.0 stringr_1.5.1
## [47] dplyr_1.1.4 purrr_1.0.4
## [49] readr_2.1.5 tidyr_1.3.1
## [51] tibble_3.2.1 ggplot2_3.5.2
## [53] tidyverse_2.0.0
##
## loaded via a namespace (and not attached):
## [1] SpatialExperiment_1.14.0 R.methodsS3_1.8.2
## [3] progress_1.2.3 goftest_1.2-3
## [5] HDF5Array_1.32.1 Biostrings_2.72.1
## [7] vctrs_0.6.5 spatstat.random_3.3-3
```

## [9] digest_0.6.37	png_0.1-8
## [11] deldir_2.0-4	parallelly_1.43.0
## [13] magick_2.8.6	MASS_7.3-65
## [15] httpuv_1.6.16	qvalue_2.36.0
## [17] withr_3.0.2	xfun_0.52
## [19] ggfun_0.1.8	survival_3.8-3
## [21] memoise_2.0.1	gson_0.1.0
## [23] systemfonts_1.2.2	ragg_1.4.0
## [25] tidytree_0.4.6	zoo_1.8-14
## [27] pbapply_1.7-2	R.oo_1.27.0
## [29] prettyunits_1.2.0	KEGGREST_1.44.1
## [31] promises_1.3.2	httr_1.4.7
## [33] restfulr_0.0.15	rhdf5filters_1.16.0
## [35] globals_0.17.0	fitdistrplus_1.2-2
## [37] rhdf5_2.48.0	rstudioapi_0.17.1
## [39] UCSC.utils_1.0.0	miniUI_0.1.2
## [41] generics_0.1.3	DOSE_3.30.5
## [43] curl_6.2.2	zlibbioc_1.50.0
## [45] ScaledMatrix_1.12.0	ggraph_2.2.1
## [47] polyclip_1.10-7	GenomeInfoDbData_1.2.12
## [49] SparseArray_1.4.8	xtable_1.8-4
## [51] evaluate_1.0.3	S4Arrays_1.4.1
## [53] BiocFileCache_2.12.0	hms_1.1.3
## [55] irlba_2.3.5.1	colorspace_2.1-1
## [57] filelock_1.0.3	ROCR_1.0-11
## [59] reticulate_1.42.0	spatstat.data_3.1-6
## [61] magrittr_2.0.3	lmtest_0.9-40
## [63] later_1.4.2	viridis_0.6.5
## [65] ggtree_3.12.0	lattice_0.22-7
## [67] spatstat.geom_3.3-6	future.apply_1.11.3
## [69] scattermore_1.2	shadowtext_0.1.4
## [71] cowplot_1.1.3	RcppAnnoy_0.0.22
## [73] pillar_1.10.2	nlme_3.1-168
## [75] compiler_4.4.0	beachmat_2.20.0
## [77] RSpectra_0.16-2	stringi_1.8.7
## [79] tensor_1.5	GenomicAlignments_1.40.0
## [81] plyr_1.8.9	crayon_1.5.3
## [83] abind_1.4-8	BiocIO_1.14.0
## [85] gridGraphics_0.5-1	emdbbook_1.3.13
## [87] locfit_1.5-9.12	graphlayouts_1.2.2
## [89] bit_4.6.0	fastmatch_1.1-6
## [91] textshaping_1.0.0	codetools_0.2-20
## [93] BiocSingular_1.20.0	plotly_4.10.4
## [95] mime_0.13	splines_4.4.0
## [97] Rcpp_1.0.14	fastDummies_1.7.5
## [99] sparseMatrixStats_1.16.0	dbplyr_2.5.0
## [101] Rttf2pt1_1.3.12	blob_1.2.4
## [103] here_1.0.1	fs_1.6.6
## [105] listenv_0.9.1	ggplotify_0.1.2
## [107] statmod_1.5.0	tzdb_0.5.0
## [109] tweenr_2.0.3	pkgconfig_2.0.3
## [111] tools_4.4.0	cachem_1.1.0
## [113] RSQLite_2.3.9	viridisLite_0.4.2
## [115] DBI_1.2.3	numDeriv_2016.8-1.1

## [117] fastmap_1.2.0	rmarkdown_2.29
## [119] scales_1.3.0	grid_4.4.0
## [121] ica_1.0-3	Rsamtools_2.20.0
## [123] coda_0.19-4.1	dotCall64_1.2
## [125] RANN_2.6.2	farver_2.1.2
## [127] tidygraph_1.3.1	scatterpie_0.2.4
## [129] yaml_2.3.10	cli_3.6.4
## [131] lifecycle_1.0.4	uwot_0.2.3
## [133] mvtnorm_1.3-3	timechange_0.3.0
## [135] gtable_0.3.6	rjson_0.2.23
## [137] gggridges_0.5.6	progressr_0.15.1
## [139] ape_5.8-1	jsonlite_2.0.0
## [141] RcppHNSW_0.6.0	bitops_1.0-9
## [143] bit64_4.6.0-1	Rtsne_0.17
## [145] yulab.utils_0.2.0	spatstat.utils_3.1-3
## [147] bdsmatrix_1.3-7	GOSemSim_2.30.2
## [149] spatstat.univar_3.1-2	R.utils_2.13.0
## [151] lazyeval_0.2.2	shiny_1.10.0
## [153] htmltools_0.5.8.1	enrichplot_1.24.4
## [155] GO.db_3.19.1	sctransform_0.4.1
## [157] rappdirs_0.3.3	tinytex_0.57
## [159] glue_1.8.0	spam_2.11-1
## [161] httr2_1.1.2	XVector_0.44.0
## [163] RCurl_1.98-1.17	rprojroot_2.0.4
## [165] treeio_1.28.0	gridExtra_2.3
## [167] extrafontdb_1.0	igraph_2.1.4
## [169] R6_2.6.1	SingleCellExperiment_1.26.0
## [171] labeling_0.4.3	RcppRoll_0.3.1
## [173] cluster_2.1.8.1	bbmle_1.0.25.1
## [175] Rhdf5lib_1.26.0	aplot_0.2.5
## [177] DelayedArray_0.30.1	tidyselect_1.2.1
## [179] ggforce_0.4.2	xml2_1.3.8
## [181] future_1.40.0	rsvd_1.0.5
## [183] munsell_0.5.1	KernSmooth_2.23-26
## [185] htmlwidgets_1.6.4	fgsea_1.30.0
## [187] rlang_1.1.6	spatstat.sparse_3.1-0
## [189] spatstat.explore_3.4-2	