GATK

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1 Methods

To identify biological pathways overrepresented among the SNPs, pathway enrichment analysis was performed using the Gene Ontology Biological Process (GO BP) and Kyoto Encyclopedia of Genes and Genomes (KEGG) database. Gene annotations from VEP output were used, and Ensembl gene identifiers were extracted. For KEGG analysis, Ensembl IDs were mapped to Entrez gene identifiers using the org.Gg.eg.db (version 3.20.0) package in R (version 4.4.1, 2024-06-14).

GO BP and KEGG over-representation analysis was carried out with the clusterProfiler package (version 4.14.6) using the enrichGO and enrichKEGG functions respectively. The entire set of annotated chicken genes was used as the background. Statistical significance of enriched pathways was determined based on a hypergeometric test, and multiple testing correction was performed using the Benjamini-Hochberg method. Pathways with an adjusted p-value < 0.05 were considered significantly enriched.

2 Enrichment Analysis

Table 1 GO Biological Process enrichment of SNPs

43 significantly enriched GO BP pathways found.

GO ID	Biological Process	Fold Enrichment	Adjusted p-value	Gene IDs
GO:0048167	**regulation of synaptic plasticity**	1.663	0.02828	CALB1, CALB2, CRHR2, ERC1, ERC2, GRIN2A, GRIN2B, GRIN2C, JPH3, LZTS1, NCDN, NSMF, RIMS2, RIMS3, RIMS4, SCGN, SHISA6, SHISA8, SHISA9, SLC24A1, ZZEF1
GO:0048762	**mesenchymal cell differentiation**	1.570	0.02828	AKNA, ANXA6, CORO1C, HOMER3, KBTBD8, PDPN, PHACTR4, RADIL, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SOX10, SOX8
GO:0060485	**mesenchyme development**	1.570	0.02828	AKNA, ANXA6, CORO1C, HOMER3, KBTBD8, PDPN, PHACTR4, RADIL, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SOX10, SOX8
GO:0002449	**lymphocyte mediated immunity**	1.561	0.02828	B2M, BLB1, BLB2, C4BPG, C4BPM, C4BPS, CADM1, CD1F, CD1G, CD226, CD40, CRCBL, CRTAM, CSF2RB, DMA, DMB1, DMB2, IGLL1, IL12B, IL21R, IL2RB, IL5RA, IL9R, MHCY2B1, MHCY2B2, MHCY2B7, MSH2, SUSD4, TMIGD1, TNFRSF1B
GO:0016064	**immunoglobulin mediated immune response**	1.561	0.03656	B2M, BLB1, BLB2, C4BPG, C4BPM, C4BPS, CD226, CD40, CRCBL, CSF2RB, DMA, DMB1, DMB2, IGLL1, IL12B, IL21R, IL2RB, IL5RA, IL9R, MHCY2B1, MHCY2B2, MHCY2B7, MSH2, SUSD4
GO:0019724	**B cell mediated immunity**	1.561	0.03656	B2M, BLB1, BLB2, C4BPG, C4BPM, C4BPS, CD226, CD40, CRCBL, CSF2RB, DMA, DMB1, DMB2, IGLL1, IL12B, IL21R, IL2RB, IL5RA, IL9R, MHCY2B1, MHCY2B2, MHCY2B7, MSH2, SUSD4
GO:0014032	**neural crest cell development**	1.551	0.04756	ANXA6, CORO1C, HOMER3, KBTBD8, PHACTR4, RADIL, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SOX10, SOX8
GO:0014033	**neural crest cell differentiation**	1.551	0.04756	ANXA6, CORO1C, HOMER3, KBTBD8, PHACTR4, RADIL, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SOX10, SOX8
GO:0048863	**stem cell differentiation**	1.551	0.04756	ANXA6, CORO1C, HOMER3, KBTBD8, PHACTR4, RADIL, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SOX10, SOX8
GO:0048864	**stem cell development**	1.551	0.04756	ANXA6, CORO1C, HOMER3, KBTBD8, PHACTR4, RADIL, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SOX10, SOX8
GO:0071526	**semaphorin-plexin signaling pathway**	1.551	0.04756	HOMER3, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A
GO:0002443	**leukocyte mediated immunity**	1.510	0.02828	B2M, BLB1, BLB2, C12orf4, C4BPG, C4BPM, C4BPS, CADM1, CD1F, CD1G, CD226, CD40, CRCBL, CRTAM, CSF2RB, DMA, DMB1, DMB2, FES, IGLL1, IL12B, IL21R, IL2RB, IL5RA, IL9R, MHCY2B1, MHCY2B2, MHCY2B7, MSH2, PRF1, SUSD4, TICAM1, TMIGD1, TNFRSF1B
GO:0051050	**positive regulation of transport**	1.424	0.02828	AACS, AKAP9, ARC, AZIN1, BICD1, BORCS5, C2CD2L, C2CD5, CACNA1G, CACNA1H, CACNA1I, CADPS, CADPS2, CD47, CNST, CRH, LOC107054855, EXPH5, EZR, FAM132A, FAM173A, FAM173B, GHRH, GHRL, NF2, NF2L, NMB, NPSR1, P2RY2, PICK1, PIRT, RAB27A, RDX, RNF207, SAR1B, STAC, STIM1, LOC121106612, STK11, VIP, WNK1, WNK2, WNK4
GO:0050767	**regulation of neurogenesis**	1.417	0.02828	ASCL1, BHLHE40, BHLHE41, CDKL5, CHODL, DAAM2, DBN1, DBNL, DCT, HES4, HES5A, HES5B, HEY1, HEY2, HEYL, HOMER3, MAP6, METRN, NF2, NF2L, NGF, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SERPINF1, SS18L1, TIAM1, TIAM2, TNFRSF1B, ZNF335
GO:0043062	**extracellular structure organization**	1.386	0.02828	ABI3BP, ADAMTS1, ADAMTS10, ADAMTS13, ADAMTS15, ADAMTS17, ADAMTS18, ADAMTS2, ADAMTS20, ADAMTS4, ADAMTS5, ADAMTS7, ADAMTS8, ADAMTS9, ADAMTSL2, ADAMTSL3, ADAMTSL5, CRTAP, DPT, FBLN1, GFOD2, HAS2, HAS3, LAMB1, LAMB4, MMP1, MMP10, MMP13, MMP15, MMP16, MMP17, MMP2,

GO ID	Biological Process	Fold Enrichment	Adjusted p-value	Gene IDs
				MMP23A, MMP24, MMP27, MMP28, MMP3, MMP7, MMP9, NTN4, NTN4L, P3H4, PDPN, POSTN, RECK, SERPINH1, SMOC2, TEX14, TGFBI, THSD4, VIT
GO:0030198	**extracellular matrix organization**	1.380	0.02828	ABI3BP, ADAMTS1, ADAMTS10, ADAMTS13, ADAMTS15, ADAMTS17, ADAMTS18, ADAMTS2, ADAMTS20, ADAMTS4, ADAMTS5, ADAMTS7, ADAMTS8, ADAMTS9, ADAMTSL2, ADAMTSL3, ADAMTSL5, CRTAP, DPT, FBLN1, GFOD2, HAS2, HAS3, LAMB1, LAMB4, MMP1, MMP10, MMP13, MMP15, MMP16, MMP17, MMP2, MMP23A, MMP24, MMP27, MMP28, MMP3, MMP7, MMP9, NTN4, NTN4L, P3H4, PDPN, POSTN, RECK, SERPINH1, SMOC2, TGFBI, THSD4, VIT
GO:0045229	**external encapsulating structure organization**	1.380	0.02828	ABI3BP, ADAMTS1, ADAMTS10, ADAMTS13, ADAMTS15, ADAMTS17, ADAMTS18, ADAMTS2, ADAMTS20, ADAMTS4, ADAMTS5, ADAMTS7, ADAMTS8, ADAMTS9, ADAMTSL2, ADAMTSL3, ADAMTSL5, CRTAP, DPT, FBLN1, GFOD2, HAS2, HAS3, LAMB1, LAMB4, MMP1, MMP10, MMP13, MMP15, MMP16, MMP17, MMP2, MMP23A, MMP24, MMP27, MMP28, MMP3, MMP7, MMP9, NTN4, NTN4L, P3H4, PDPN, POSTN, RECK, SERPINH1, SMOC2, TGFBI, THSD4, VIT
GO:0051960	**regulation of nervous system development**	1.349	0.02828	ASCL1, BHLHE40, BHLHE41, CDKL5, CHODL, CLSTN1, CLSTN3, CST7, DAAM2, DBN1, DBNL, DCT, GBX1, HES4, HES5A, HES5B, HEY1, HEY2, HEYL, HOMER3, LRTM2, MAP6, METRN, NF2, NF2L, NGF, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, RNF10, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SERPINF1, SLITRK1, SLITRK5, SLITRK6, SS18L1, SYNDIG1, TIAM1, TIAM2, TNFRSF1B, VSTM5, ZNF335
GO:0071826	**protein-RNA complex organization**	1.346	0.02828	AAR2, C12orf45, CELF2, CELF3, CELF5, CELF6, CLNS1A, COIL, CRNKL1, DDX20, DENR, DHX8, DYRK3, EIF2D, EIF2S2, EIF2S3, EIF6, ERAL1, GEMIN4, GEMIN8, ISY1, LSM4, LUC7L, LUC7L2, LUC7L3, MRPL20, MRPS11, MRPS7, MRTO4, NUFIP1, PIH1D2, PRPF18, PRPF6, PRPF8, PUF60, PWP2, RPL23A, RPL3, RPL38, RPL3L, RPLP0, RPS14, RPS15, RPS27, RPS27L, RPS28, RPSA2, RRP7A, RUVBL1, SCAF11, SF3A2, SFSWAP, SHQ1, SNRPC, SNRPD1, SNRPD3, SNRPE, SNRPF, SNRPGP15, SRPK1, SRPK2, SRSF4, SRSF6, STRAP, TFIP11, TRAF7, ZFAND1, ZNHIT3
GO:0022618	**protein-RNA complex assembly**	1.340	0.02828	AAR2, C12orf45, CELF2, CELF3, CELF5, CELF6, CLNS1A, COIL, CRNKL1, DDX20, DENR, EIF2D, EIF2S2, EIF2S3, EIF6, ERAL1, GEMIN4, GEMIN8, ISY1, LSM4, LUC7L, LUC7L2, LUC7L3, MRPL20, MRPS11, MRPS7, MRTO4, NUFIP1, PIH1D2, PRPF18, PRPF6, PRPF8, PUF60, PWP2, RPL23A, RPL3, RPL38, RPL3L, RPLP0, RPS14, RPS15, RPS27, RPS27L, RPS28, RPSA2, RRP7A, RUVBL1, SCAF11, SF3A2, SFSWAP, SHQ1, SNRPC, SNRPD1, SNRPD3, SNRPE, SNRPF, SNRPGP15, SRPK1, SRPK2, SRSF4, SRSF6, STRAP, TRAF7, ZNHIT3
GO:0060284	**regulation of cell development**	1.328	0.03144	ASCL1, BHLHE40, BHLHE41, CDKL5, CHODL, CSF1, CSF3, DAAM2, DBN1, DBNL, DCT, FANCA, FBXO22, GPR137B, HES4, HES5A, HES5B, HEY1, HEY2, HEYL, HOMER3, IL34, MAFB, MAP6, METRN, MTURN, NF2, NF2L, NGF, PDE3A, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, RFLNA, RFLNB, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SERPINF1, SS18L1, TCP11, TIAM1, TIAM2, TNFRSF1B, UBASH3B, ZNF335
GO:0007411	**axon guidance**	1.321	0.02884	BOC, BSG, CDON, CHL1, CYFIP1, CYFIP2, DAG1, DRAXIN, DSCAM, DSCAML1, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, GAP43, HOMER3, IGDCC3, IGDCC4, JAG1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, MYOT, NRP1, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PRTG, PTPRO, RAC1, RAC3, ROBO1, ROBO3, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SLIT3, SMO, TUBB3, UNC5A
GO:0097485	**neuron projection guidance**	1.321	0.02884	BOC, BSG, CDON, CHL1, CYFIP1, CYFIP2, DAG1, DRAXIN, DSCAM, DSCAML1, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, GAP43, HOMER3, IGDCC3, IGDCC4, JAG1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, MYOT, NRP1, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PRTG, PTPRO, RAC1, RAC3, ROBO1, ROBO3, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SLIT3, SMO, TUBB3, UNC5A
GO:0045595	**regulation of cell differentiation**	1.290	0.02828	AAMDC, ALK, APC2, ARHGEF2, ASCL1, BHLHE40, BHLHE41, BRINP1, CASZ1, CDKL5, CEBPB, CEBPD, CHODL, CSF1, CSF3, DAAM2, DBN1, DBNL, DCT, ENPP1, ERRFI1, FANCA, FBXO22, FGFR1, FLOT2, FNDC5, GATA3, GDPD5, GPR137B, HES4, HES5A, HES5B, HEY1, HEY2, HEYL, HOMER3, IL34, MAFB, MAFF, MAFG, MAP6, METRN, METRNL, MTURN, MYF5, MYF6, MYOG, NF2, NF2L, NGF, NOG, NOG2, NTF3, PDE3A, PDPN, PLEKHB1, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PTBP1, PTHLH, RBPMS2, RFLNA, RFLNB, RUNX1, RUNX3, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A,

GO ID	Biological Process	Fold Enrichment	Adjusted p-value	Gene IDs
				SEMA6B, SEMA6C, SEMA6D, SEMA7A, SERPINF1, SOX5, SOX9, SS18L1, TCP11, TIAM1, TIAM2, TMEM119, TNFRSF1B, UBASH3B, ZFHX3, ZNF335
GO:0032535	**regulation of cellular component size**	1.278	0.04867	ADD2, ARHGAP18, ARHGAP28, ARHGAP40, ARPC3, ARPC5L, ATP13A2, BAIAP2, BAIAP2L1, BAIAP2L2, CAPG, CAPZA1, CAPZA2, CAPZA3, CAPZB, CDKL5, CLNS1A, COTL1, CYFIP1, CYFIP2, DBN1, DBNL, FAM206A, FAM49B, FCHSD1, FCHSD2, FLII, GSN, HAX1, HCLS1, HOMER3, KANK3, LMOD1, LMOD2, LMOD3, MTPN, NGF, PEX11A, PEX11B, PFN3, PLEKHH2, SCIN, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SLC12A1, SLC12A3, SLC12A4, SLC12A5, SLC12A7, SSH1, SSH2, SVIL, TMOD2, TMOD3, TMOD4, TMSB4X, TMSB4B, TWF1, TWF2, VILL
GO:2000026	**regulation of multicellular organismal development**	1.269	0.02828	ADGRB2, ASCL1, BGLAP, BHLHE40, BHLHE41, CD40, CDKL5, CHODL, CLSTN1, CLSTN3, CSF1, CSF3, CST7, DAAM2, DBN1, DBNL, DCT, DUSP6, ECSCR, ENPP1, ERRFI1, FANCA, FLT1, GATA2, GATA3, GBX1, GPR137B, HES4, HES5A, HES5B, HEY1, HEY2, HEYL, HOMER3, IL34, ISM1, KRIT1, LAMA1, LAMA2, LAMA3, LAMA5, LECT1, LRTM2, MAFB, MAFF, MAFG, MAP6, METRN, MTDH, MTURN, MYDGF, NF2, NF2L, NGF, NR2C2, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PPP1R16B, PTHLH, RFLNA, RFLNB, RNF10, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SERPINF1, SLITRK1, SLITRK5, SLITRK6, SOX5, SOX9, SS18L1, SYNDIG1, THBS2, TIAM1, TIAM2, TMEM119, TNFRSF1B, UBASH3B, VASH2, VEGFA, VEGFD, VSTM5, ZNF335
GO:0007409	**axonogenesis**	1.263	0.02828	ACTG1L, APLP2, APP, BOC, BSG, CDH2, CDK5, CDKL5, CDON, CHL1, CHODL, CYFIP1, CYFIP2, DAG1, DBN1, DBNL, DRAXIN, DSCAM, DSCAML1, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, GAP43, HOMER3, IGDCC3, IGDCC4, ISL2, JAG1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, LRTM2, MAP1A, MAP1S, MAP6, METRN, MYOT, NGF, NPTX1, NRP1, PAK1, PDIK1L, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PRTG, PTPRO, RAB3A, RAC1, RAC3, ROBO1, ROBO3, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SLIT3, SLITRK1, SLITRK5, SLITRK6, SMO, SPG11, STK35, TIAM1, TIAM2, TUBB3, ULK1, ULK2, UNC5A
GO:0048667	**cell morphogenesis involved in neuron differentiation**	1.249	0.02828	ACTG1L, APLP2, APP, ARHGAP44, BOC, BSG, BTBD3, CDH2, CDK5, CDKL5, CDON, CHL1, CHODL, CYFIP1, CYFIP2, DAG1, DBN1, DBNL, DCDC2, DRAXIN, DSCAM, DSCAML1, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, FAM206A, GAP43, HECW1, HOMER3, IGDCC3, IGDCC4, ISL2, JAG1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, LRTM2, LZTS1, MAP1A, MAP1S, MAP6, METRN, MYOT, NEDD4, NGF, NPTX1, NRP1, PAK1, PDIK1L, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PRTG, PTPRO, RAB3A, RAC1, RAC3, RB1, ROBO1, ROBO3, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SLIT3, SLITRK1, SLITRK5, SLITRK6, SMO, SPG11, SRCIN1, SS18L1, STK35, TANC2, TIAM1, TIAM2, TMEM106B, TUBB3, ULK1, ULK2, UNC5A, UNK, WHRN
GO:0048812	**neuron projection morphogenesis**	1.246	0.02828	ACTG1L, ANKRD27, APLP2, APP, ARHGAP44, BOC, BSG, BTBD3, CDH2, CDK5, CDKL5, CDON, CHL1, CHODL, CYFIP1, CYFIP2, DAG1, DBN1, DBNL, DCDC2, DRAXIN, DSCAM, DSCAML1, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, FAM206A, GAP43, GAS7, HECW1, HOMER3, IGDCC3, IGDCC4, ISL2, JAG1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, LRTM2, LZTS1, MAP1A, MAP1S, MAP6, METRN, MNX1, MYO16, MYOT, NEDD4, NGF, NPTX1, NRN1, NRN1L, NRP1, NTF3, PACSIN1, PAK1, PDIK1L, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PRTG, PTPRO, RAB3A, RAC1, RAC3, ROBO1, ROBO3, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SLIT3, SLITRK1, SLITRK5, SLITRK6, SMO, SPAG6, SPG11, SRCIN1, SS18L1, STK35, TANC2, TIAM1, TIAM2, TMEM106B, TMEM108, TP53TG5, TUBB3, ULK1, ULK2, UNC5A
GO:0048858	**cell projection morphogenesis**	1.242	0.02828	ACTG1L, ANKRD27, APLP2, APP, ARHGAP44, BOC, BSG, BTBD3, CDH2, CDK5, CDKL5, CDON, CHL1, CHODL, CYFIP1, CYFIP2, DAG1, DBN1, DBNL, DCDC2, DRAXIN, DSCAM, DSCAML1, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, FAM206A, GAP43, GAS7, HECW1, HOMER3, IGDCC3, IGDCC4, ISL2, JAG1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, LRTM2, LZTS1, MAP1A, MAP1S, MAP6, METRN, MNX1, MYO16, MYOT, NEDD4, NGF, NPTX1, NRN1, NRN1L, NRP1, NTF3, PACSIN1, PAK1, PDIK1L, PDPN, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PRTG, PTPRO, RAB3A, RAC1, RAC3, ROBO1, ROBO3, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SLIT3, SLITRK1, SLITRK5, SLITRK6, SMO, SPAG6, SPG11, SRCIN1, SS18L1, STK35, TANC2, TIAM1, TIAM2, TMEM106B, TMEM108, TP53TG5, TUBB3, ULK1, ULK2, UNC5A

GO ID	Biological Process	Fold Enrichment	Adjusted p-value	Gene IDs
GO:0120039	**plasma membrane bounded cell projection morphogenesis**	1.242	0.02828	ACTG1L, ANKRD27, APLP2, APP, ARHGAP44, BOC, BSG, BTBD3, CDH2, CDK5, CDKL5, CDON, CHL1, CHODL, CYFIP1, CYFIP2, DAG1, DBN1, DBNL, DCDC2, DRAXIN, DSCAM, DSCAML1, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, FAM206A, GAP43, GAS7, HECW1, HOMER3, IGDCC3, IGDCC4, ISL2, JAG1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, LRTM2, LZTS1, MAP1A, MAP1S, MAP6, METRN, MNX1, MYO16, MYOT, NEDD4, NGF, NPTX1, NRN1, NRN1L, NRP1, NTF3, PACSIN1, PAK1, PDIK1L, PDPN, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PRTG, PTPRO, RAB3A, RAC1, RAC3, ROBO1, ROBO3, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SLIT3, SLITRK1, SLITRK5, SLITRK6, SMO, SPAG6, SPG11, SRCIN1, SS18L1, STK35, TANC2, TIAM1, TIAM2, TMEM106B, TMEM108, TP53TG5, TUBB3, ULK1, ULK2, UNC5A
GO:0022613	**ribonucleoprotein complex biogenesis**	1.227	0.02828	AAR2, BOP1, BYSL, C12orf45, C1D, C1QBP, C8orf59, CELF2, CELF3, CELF5, CELF6, CLNS1A, COIL, CRNKL1, DCAF13, DDX10, DDX20, DDX31, DDX52, DENR, DHX37, DIEXF, DROSHA, EFL1, EIF2D, EIF2S2, EIF2S3, EIF6, EMG1, ERAL1, ERI2, ESF1, EXOSC10, EXOSC2, EXOSC7, EXOSC8, FDXACB1, FTSJ3, GEMIN4, GEMIN8, GPATCH4, GTPBP4, HEATR1, HEATR3, ISY1, LSM4, LTV1, LUC7L, LUC7L2, LUC7L3, MAK16, MALSU1, METTL16, MPHOSPH10, MPHOSPH6, MPV17L2, MRM1, MRPL20, MRPL22, MRPL36, MRPS11, MRPS7, MRTO4, MTERF3, NHP2, NIP7, NOB1, NOC2L, NOC4L, NOL11, NOL9, NOM1, NOP16, NOP2, RRP36, NPM1, NSUN3, NSUN5, NUFIP1, NUP88, NVL, PES1, PIH1D2, POP4, PRPF18, PRPF6, PRPF8, PUF60, PWP1, PWP2, RAN, RBFA, REXO4, RIOK1, RIOK3, RPL14, RPL23A, RPL26L1, RPL3, RPL35, RPL38, RPL3L, RPL7, RPL7A, RPLP0, RPP40, RPS14, RPS15, RPS16, RPS21, RPS27, RPS27L, RPS28, RPSA2, RRNAD1, RRP15, RRP1B, RRP7A, RRS1, RSL24D1, RUVBL1, SBDS, SCAF11, SF3A2, SFSWAP, SHQ1, TSR1, SNRPC, SNRPD1, SNRPD3, SNRPE, SNRPF, SNRPGP15, SRPK1, SRPK2, SRSF4, SRSF6, STRAP, SURF6, TBL3, TFB1M, TFB2M, TRAF7, TSR3, URB1, URB2, UTP11, UTP18, UTP4, UTP6, WBSCR22, WDR18, WDR3, WDR43, XPO1, ZNF622, ZNHIT3
GO:0000902	**cell morphogenesis**	1.219	0.02828	ACTG1L, ANKRD27, APLP2, APP, ARHGAP44, ARHGEF2, BOC, BRWD1, BSG, BTBD3, CAP1, CAP2, CAPZB, CDH1, CDH10, CDH11, CDH12, CDH13, CDH15, CDH17, CDH18, CDH19, CDH2, CDH20, CDH22, CDH3, CDH4, CDH5, CDH6, CDH7, CDH8, CDH9, CDK5, CDKL5, CDON, CHL1, CHODL, CYFIP1, CYFIP2, DAG1, DBN1, DBNL, DCDC2, DRAXIN, DSCAM, DSCAML1, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, EZR, FAM171A1, FAM206A, FAT3, FMNL1, FRY, GAP43, GAS7, HECW1, HOMER3, IGDCC3, IGDCC4, ISL2, JAG1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, LRTM2, LZTS1, MAP1A, MAP1S, MAP6, METRN, MNX1, MYO16, MYOT, NEDD4, NF2, NF2L, NGF, NPTX1, NRN1, NRN1L, NRP1, NTF3, PACSIN1, PAK1, PALM, PDIK1L, PDPN, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PRTG, PTPRO, RAB3A, RAC1, RAC3, RB1, RDX, RHOG, ROBO1, ROBO3, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SLIT3, SLITRK1, SLITRK5, SLITRK6, SMO, SPAG6, SPG11, SRCIN1, SS18L1, STK35, TANC2, TIAM1, TIAM2, TMEM106B, TMEM108, TP53TG5, TUBB3, ULK1, ULK2, UNC5A, UNK, WHRN
GO:0031175	**neuron projection development**	1.209	0.02828	ACTG1L, ADCYAP1, ANKRD27, APLP2, APP, ARHGAP44, ATXN10, BCL11A, BOC, BSG, BTBD3, CAMSAP1, CDH2, CDK5, CDKL5, CDON, CHL1, CHODL, CSMD3, CYFIP1, CYFIP2, DAG1, DBN1, DBNL, DCDC2, DRAXIN, DSCAM, DSCAML1, DTNBP1, EFHC2, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, FAM206A, FRY, GAP43, GAS7, GPM6B, GSK3A, HECW1, HOMER3, IFT88, IGDCC3, IGDCC4, ISL2, JAG1, KIAA0319, KLHL1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, LRTM2, LZTS1, MANF, MAP1A, MAP1S, MAP4, MAP6, MAPT, METRN, MNX1, MYO16, MYOT, NCDN, NDEL1, NEDD4, NEFH, NGF, NPTX1, NRN1, NRN1L, NRP1, NTF3, OMG, PACSIN1, PAK1, PDIK1L, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PPP1R19B, PPP1R9A, PRTG, PTPRO, RAB3A, RAC1, RAC3, RB1, ROBO1, ROBO3, SAMD14, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SEZ6, SLC25A20, SLIT3, SLITRK1, SLITRK5, SLITRK6, SMO, SPAG6, SPG11, SRCIN1, SS18L1, STK35, STMN1, STMN2, STMN3, TANC2, TIAM1, TIAM2, TMEM106B, TMEM108, TP53TG5, TUBB3, TWF1, TWF2, ULK1, ULK2, UNC5A, VAPA, WHRN
GO:0050793	**regulation of developmental process**	1.205	0.02828	AAMDC, ADGRB2, ALK, APC2, ARHGAP44, ARHGEF2, ASCL1, BCL11A, BGLAP, BHLHE40, BHLHE41, BRINP1, BRWD1, CASZ1, CD40, CDH2, CDKL5, CEBPB, CEBPD, CHODL, CLSTN1, CLSTN3, CNOT2, CSF1, CSF3, CSMD3, CST7, DAAM2, DBN1, DBNL, DCT, DUSP6, ECSCR, ENPP1, ERRFI1, EZR, FAM171A1, FANCA, FBXO22, FGFR1, FLOT2, FLT1, FMNL1, FNDC5, FTO, GATA2, GATA3, GBX1, GDPD5, GHRH, GPR137B, HECW1, HES4, HES5A, HES5B, HEY1, HEY2, HEYL, HOMER3, IL34, ISM1, KIAA0319, KRIT1, LAMA1, LAMA2, LAMA3, LAMA5, LATS1, LATS2, LECT1, LRTM2, LZTS1, MAFB, MAFF, MAFG, MAP6, METRN, METRNL, MIEF1, MIEF2, MTDH, MTURN, MYDGF, MYF5, MYF6, MYOG, NEDD4, NF2, NF2L, NGF, NOG, NOG2, NOTCH1, NR2C2, NTF3, PACSIN1, PAK1, PALM, PDE3A, PDPN, PGAM5, PINK1, PLEKHB1, PLEKHO1, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PPP1R16B, PTBP1, PTHLH,

GO ID	Biological Process	Fold Enrichment	Adjusted p-value	Gene IDs
				RAC1, RAC3, RBPMS2, RDX, RFLNA, RFLNB, RHOG, RNF10, RNF207, RUNX1, RUNX3, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SERPINF1, SEZ6, SLITRK1, SLITRK5, SLITRK6, SOX5, SOX9, SRCIN1, SS18L1, SYNDIG1, TANC2, TCP11, THBS2, TIAM1, TIAM2, TMEM119, TNFRSF1B, UBASH3B, VASH2, VEGFA, VEGFD, VSTM5, WWC1, WWC3, ZFHX3, ZNF335
GO:0007015	**actin filament organization**	1.199	0.04772	ACTR2, ADD2, ARFIP2, ARHGAP18, ARHGAP25, ARHGAP28, ARHGAP40, ARHGEF10L, ARHGEF2, ARPC1A, ARPC1B, ARPC3, ARPC4, ARPC5L, BAIAP2, BAIAP2L1, BAIAP2L2, C9ORF58, CALD1, CAPG, CAPZA1, CAPZA2, CAPZA3, CAPZB, CARMIL1, CCDC53, COBL, CORO1C, CORO2B, CORO6, COTL1, CYFIP1, CYFIP2, DBN1, DBNL, DIAPH3, DMTN, DPYSL3, DSTN, ELMO1, ELMO2, ELMO3, ENAH, ESPN, FAM107A, FAM171A1, FAM206A, FAM49B, FCHSD1, FCHSD2, FHOD1, FHOD3, FLII, FSCN1, FSCN2, GAS2L2, GAS2L3, GAS7, GSN, HAX1, HCLS1, HIP1, HIP1R, KANK3, LCP1, LIMD2, LIMK1, LMOD1, LMOD2, LMOD3, MARCKSL1, MPRIP, MTPN, MTSS1, MYO19, MYO1C, MYO1D, MYO1E, MYO1F, MYO1G, MYO1H, MYO5A, MYO5B, MYO5C, NEBL, PACSIN1, PFN3, PHACTR1, PICK1, PLEKHH2, PPP1R19B, PPP1R9A, PSTPIP1, RAC1, RAC3, RFLNA, RFLNB, RHOA, RHOG, RHPN1, RHPN2, RLTPR, SAMD14, SCIN, SHROOM1, SHROOM2, SPIRE1, SPIRE1L, SPIRE2, SSH1, SSH2, SVIL, TCAP, TMOD2, TMOD3, TMOD4, TMSB4X, TMSB4B, TPM1, TPM3, TPM4, TRIOBP, TRPV4, TWF1, TWF2, VILL, WASF2, WASF3, WASHC1, WASHC5, WASL, WHAMM, XIRP1
GO:0051049	**regulation of transport**	1.195	0.03964	AACS, AKAP9, ARC, ARFGAP1, ARHGAP8, ARL6IP5, ASB10, ASB4, AZIN1, BICD1, BORCS5, C12orf4, C2CD2L, C2CD5, CACNA1G, CACNA1H, CACNA1I, CACNB1, CACNB2, CACNG1, CACNG2, CACNG3, CACNG4, CACNG5, CADPS, CADPS2, CALML3, CASK, CASQ2, CASR, CBARP, CD47, CNIH3, CNST, COMMD1, CPLX2, CPLX3, CRH, LOC107054855, DHRS7C, DNAJC13, DNAJC5, DTNBP1, EXPH5, EZR, FAM132A, FAM173A, FAM173B, FES, FXYD6, GCK, GEM, GHRH, GHRL, GIP, GRAMD2, HECW1, HOMER2, HOMER3, ICA1, IL1RAPL1, KCNAB2, KCNE1, KCNE2, KCNE3, KCNG1, KCNIP1, KCNIP3, KCNJ12, KCNJ15, KCNJ16, KCNJ2, KCNJ4, KCNJ5, KCNJ6, KCNJ8, KCNS1, KCNS2, LLGL1, LLGL2, MCTP2, NEDD4, NF2, NF2L, NKAIN1, NKAIN2, NKAIN3, NKAIN4, NMB, NPSR1, NPVF, P2RY2, PACSIN1, PACSIN2, PICK1, PIRT, RAB12, RAB27A, RAB3A, RAB43, RAB4A, RAB8A, RAB8B, RALA, RAP1A, RAP1B, RDX, REM1, RHBDF1, RHBDF2, RINT1, RNF207, RRAD, RUFY1, SAR1B, SCN4B, SEPTIN2L, SEPTIN4, SEPTIN5, SH3TC2, SHISA6, SHISA8, SHISA9, SLMAP, SSTR5, STAC, STIM1, LOC121106612, STK11, STON1, STXBP4, STXBP5, STXBP5L, SYT1, SYT10, SYT11, SYT17, SYT2, SYT6, UBASH3B, UNC119, VIP, WNK1, WNK2, WNK4, WWP2, YIPF5
GO:0015031	**protein transport**	1.184	0.02828	AACS, AGK, AP1B1, AP1G1, AP1M1, AP1S2, AP2B1, AP3B2, AP3D1, AP3M2, AP3S2, AP4B1, AP4E1, APPBP2, ARF1, ARF4, ARF5, ARFIP2, ARFRP1, ARHGAP44, ARL1, ARL11, ARL4A, ARL5B, ARL6, ARL8A, ARL8B, ARL8BL, ARRDC1, ARRDC2, ARRDC4, BCAP29, BLZF1, C2CD2L, C2CD5, CACNG2, CACNG3, CACNG4, CACNG5, CD36, CD74, CHCHD4, CHMP1A, CHMP2B, CLTB, CLTC, CLTCL1, CNST, COG2, COG3, COG7, COPA, COPG1, COPG2, CSE1L, DNAJC15, DNLZ, DSCR3, DUOXA1L, DUOXA2, ERLEC1, ERP29, EXPH5, FAM91A1, GCK, GDI1, GGA1, GGA2, GGA3, GID4, GIP, GNPTAB, GOLGA7, GOLPH3L, GRIP1, GRIP2, GRPEL2, HEATR3, HIKESHI, HNF1A, HNF1B, IFT22, IPO5, IPO8, IPO9, IST1, KPNA1, KPNA2, KPNA3, KPNA6, KPNA7, KPNB1, LLGL1, LLGL2, M6PR, MIA3, MOBP, MON1A, NAPB, NAPG, NEURL1B, NSF, NUP107, NUP133, NUP153, NUP188, NUP214, NUP50, NUP85, NUP88, NUP93, NUP98, NUTF2, PAFAH1B1, PAM16, PEX1, PEX10, PEX13, PEX14, LOC107049500, PEX2, PEX26, PEX3, PEX5, PEX6, PEX7, PHAF1, PICK1, PIK3R4, POM121C, PTPN23, PTTG1IP2, PXK, RAB11A, RAB12, RAB20, RAB3A, RAB43, RAB8A, RAB8B, RABL3, VPS25, RAMP3, RAN, RANBP3, RHBDF1, RHBDF2, RIMS2, ROMO1, RPAIN, RPH3A, RPH3AL, RRBP1, RUFY1, SAMM50, SAR1B, SCAMP2, SCAMP3, SCAMP4, SCAMP5, SCRIB, SEC13, SEC23B, SEC24A, SEC61A1, SEC61A2, SEC61B, SEC61G, SELENOS, SH3TC2, SLC30A8, SNF8, SNUPN, SNX1, SNX10, SNX11, SNX16, SNX20, SNX21, SNX27, SNX33, SNX5, SNX9, SORL1, SSTR5, STAM, STX11, STX12, STX16, STX17, STX19, STX1A, STX2, STX7, STX8, STXBP1, STXBP4, STXBP5, STXBP5L, SVBP, SYS1, SYTL1, SYTL2, SYTL3, SYTL5, TANGO2, TAX1BP3, TBC1D13, TGFBRAP1, TIMM17B, TIMM21, TIMM22, TIMM44, TMCO6, TMCO7, TMED2, TMED3, TMED6, TMEM50A, TMEM50B, TNPO3, TOMM20, TOMM22, TOMM40L, TOMM7, TRAM1L1, TSNARE1, TVP23A, TVP23B, UNC119, UNC119B, VPS11, VPS13C, VPS13D, VPS26B, VPS29, VPS29L, VPS33A, VPS33B, VPS35, VPS36, VPS37B, VPS37D, VPS41, VPS45, XPO1, XPO4, XPO5, XPO6, XPO7, XPOT
GO:0048666	**neuron development**	1.182	0.04614	ACTG1L, ADCYAP1, ANKRD27, APLP2, APP, ARHGAP44, ATP8A2, ATXN10, BCL11A, BOC, BSG, BTBD3, C2orf71, CAMSAP1, CDH2, CDK5, CDKL5, CDON, CHL1, CHODL, CSMD3, CYFIP1, CYFIP2, DAG1, DBN1, DBNL, DCDC2, DCLK1, DRAXIN, DSCAM, DSCAML1, DTNBP1, DZANK1, EFHC2, EFNA2, EFNB2, ENAH, EPHA1, EPHA10, EPHA2, EPHA3, EPHA6, EPHA8, EPHB2, EPHB6, FAM206A, FRY, GAP43, GAS7, GPM6B, GSK3A, HECW1, HOMER3, IFT88, IGDCC3, IGDCC4, ISL2, JAG1, KIAA0319, KLHL1, LAMA1, LAMA2, LAMA3, LAMA5, LAMB4, LHX6, LRTM2, LZTS1, MAFA, MANF, MAP1A, MAP1S, MAP4, MAP6, MAPT, METRN, MNX1, MYO16, MYOT, NCDN, NDEL1, NEDD4, NEFH, NGF, NPTX1, NRN1, NRN1L, NRP1, NTF3, OMG, PACSIN1, PAK1, PBX3, PDIK1L, PLXNA1, PLXNA2, PLXNA4, PLXNB2, PLXNB3, PLXNC1, PLXND1, PPP1R19B, PPP1R9A,

GO ID	Biological Process	Fold Enrichment	Adjusted p-value	Gene IDs
				PRTG, PTPRO, RAB3A, RAC1, RAC3, RB1, ROBO1, ROBO3, RPGRIP1L, SAMD14, SDK1, SEMA3A, SEMA3B, SEMA3C, SEMA3D, SEMA3DL, SEMA3E, SEMA3F, SEMA3G, SEMA4B, LOC107049953, SEMA5A, SEMA6B, SEMA6C, SEMA6D, SEMA7A, SEZ6, SLC25A20, SLIT3, SLITRK1, SLITRK5, SLITRK6, SMO, SPAG6, SPG11, SRCIN1, SS18L1, STK35, STMN1, STMN2, STMN3, TANC2, TENM2, TENM4, TIAM1, TIAM2, TMEM106B, TMEM108, TP53TG5, TUBB3, TWF1, TWF2, ULK1, ULK2, UNC5A, UNK, VAPA, WHRN
GO:0045935	**positive regulation of nucleobase-containing compound metabolic process**	1.159	0.04959	ABRA, ADCYAP1, ALX1, ARID1A, ARID1B, ASCL1, ASXL1, ASXL3, ATAD2, BABAM1, BCL9, BCL9L, BCLAF1, BRCA1, CASZ1, CD40, CDK12, CDK13, CDK5RAP2, CHCHD2, CIITA, CNOT1, CNOT2, CNOT6, CREBBP, CRTC1, CTC1, CTNNB1, CXorf23, DBF4, DBF4B, DCAF6, DCP1A, DCP1B, DCPS, DHX33, DYRK1A, EAF1, ELL, ENY2, EOMES, EP300, EXOSC7, EXOSC8, EYA1, EYA2, EYA3, EYA4, FAM168A, FANCB, FGF7, GABPB1, GABPB2, GATA2, GATA3, GATA5, GATA6, GLTSCR1L, GMEB1, GMEB2, GPATCH3, GUCA1A, HEATR1, HIPK2, HNF1A, HNF1B, HNF4A, HNF4beta, HNRNPU, ICE2, IKBKB, ING1, ISL2, JUP, KANSL3, KAT2A, KAT2B, KMT2A, KMT2C, LBH, LEO1, LMO3, LPIN2, LSM1, MAML1, MAML2, MED10, MED16, MED30, MEF2A, MEF2B, MEF2D, MEIS1, MEOX1, MEOX2, MLLT11, MTF1, MYOG, MYRFL, NCOA2, NCOA3, NCOA6, NPM1, NPM2, NR1D1, NR1D2, NR1H4, NR1I3, NR2C2, NR2E3, NUP85, OCLN, PAN3, PARN, PATL2, PAXBP1, PAXIP1, PDE12, PLEKHN1, PML, PMLL, PNLDC1, POU2AF1, PPARA, PPARD, PPARG, PPARGC1B, PTMS, RAX2, RBM3, RNF10, RNF111, RNF6, RPS6KA1, RXRA, RYBP, SAMD11, SETD4, SF3B4, SMARCC1, SOX12, SOX17, SOX18, SOX21, SREBF2, SRF, SS18, SS18L1, SS18L2, SSBP4, SUPT4H1, SUPT6H, TBX1, TBX15, TBX19, TBX2, TBX20, TBX21, TBX3, TBX4, TBX5, TBX6, TBXT, TCEA1, TEAD3, TET3, TFEB, THOC5, THRA, THRAP3, THRB, TIGAR, TNRC6A, TNRC6B, TNRC6C, TP53BP1, TP53INP1, TP53INP2, TRA2A, TRIM45, TRIP4, UIMC1, WBP2, WBP2NL, YAF2, YAP1, YTHDF1, YTHDF2, YTHDF3, ZC3H12A, ZC3H12D, ZFPM1, ZFPM2, ZNF318, ZNF750, LOC121109895
GO:0045184	**establishment of protein localization**	1.143	0.02828	AACS, AGK, AP1B1, AP1G1, AP1M1, AP1S2, AP2B1, AP3B2, AP3D1, AP3M2, AP3S2, AP4B1, AP4E1, APPBP2, ARF1, ARF4, ARF5, ARFIP2, ARFRP1, ARHGAP44, ARL1, ARL11, ARL4A, ARL5B, ARL6, ARL8A, ARL8B, ARL8BL, ARRDC1, ARRDC2, ARRDC4, BCAP29, BLZF1, C2CD2L, C2CD5, CACNG2, CACNG3, CACNG4, CACNG5, CAMLG, CD36, CD74, CHCHD4, CHMP1A, CHMP2B, CLTB, CLTC, CLTCL1, CNST, COG2, COG3, COG7, COPA, COPG1, COPG2, CSE1L, DNAJC15, DNLZ, DSCR3, DUOXA1L, DUOXA2, ERLEC1, ERP29, EXPH5, FAM91A1, GCK, GDAP1, GDI1, GET4, GGA1, GGA2, GGA3, GID4, GIP, GNPTAB, GOLGA7, GOLPH3L, GRIP1, GRIP2, GRPEL2, HEATR3, HIKESHI, HNF1A, HNF1B, IFT22, IMMP2L, IPO5, IPO8, IPO9, IST1, KPNA1, KPNA2, KPNA3, KPNA6, KPNA7, KPNB1, LLGL1, LLGL2, LONP2, LRWD1, M6PR, MIA3, MIPEP, MOBP, MON1A, NACAD, NAPB, NAPG, SPCS2, NEURL1B, NSF, NUP107, NUP133, NUP153, NUP188, NUP214, NUP50, NUP85, NUP88, NUP93, NUP98, NUTF2, PAFAH1B1, PAM16, PEX1, PEX10, PEX13, PEX14, LOC107049500, PEX2, PEX26, PEX3, PEX5, PEX6, PEX7, PHAF1, PICK1, PIK3R4, PMPCA, PMPCB, POM121C, PTPN23, PTTG1IP2, PXK, RAB11A, RAB12, RAB20, RAB3A, RAB43, RAB8A, RAB8B, RABL3, VPS25, RAMP3, RAN, RANBP3, RHBDF1, RHBDF2, RIMS2, ROMO1, RPAIN, RPH3A, RPH3AL, RRBP1, RUFY1, SAMM50, SAR1B, SCAMP2, SCAMP3, SCAMP4, SCAMP5, SCRIB, SEC13, SEC23B, SEC24A, SEC61A1, SEC61A2, SEC61B, SEC61G, SELENOS, SGTA, SH3TC2, SLC30A8, SNF8, SNUPN, SNX1, SNX10, SNX11, SNX16, SNX20, SNX21, SNX27, SNX33, SNX5, SNX9, SORL1, SRP68, SRP9, SRPRA, SSTR5, STAM, STX11, STX12, STX16, STX17, STX19, STX1A, STX2, STX7, STX8, STXBP1, STXBP4, STXBP5, STXBP5L, SVBP, SYS1, SYTL1, SYTL2, SYTL3, SYTL5, TANGO2, TAX1BP3, TBC1D13, TGFBRAP1, TIMM17B, TIMM21, TIMM22, TIMM44, TMCO6, TMCO7, TMED2, TMED3, TMED6, TMEM50A, TMEM50B, TNPO3, TOMM20, TOMM22, TOMM34, TOMM40L, TOMM7, TRAM1L1, TSNARE1, TVP23A, TVP23B, UNC119, UNC119B, VPS11, VPS13C, VPS13D, VPS26B, VPS29, VPS29L, VPS33A, VPS33B, VPS35, VPS36, VPS37B, VPS37D, VPS41, VPS45, WDPCP, WRB, XPO1, XPO4, XPO5, XPO6, XPO7, XPOT, ZDHHC1, ZDHHC12, ZDHHC14, ZDHHC18, ZDHHC20, ZDHHC23, ZDHHC3, ZDHHC4, ZDHHC7, ZFAND2A, ZFAND6
GO:0065003	**protein-containing complex assembly**	1.138	0.02828	AAR2, ADD2, AFG3L2, APOA2, APOA5, ARHGAP18, ARHGAP28, ARHGAP40, ARPC3, ARPC4, ARPC5L, ATL2, ATP23, ATPAF2, B2M, BAIAP2, BAIAP2L1, BAIAP2L2, BLB1, BLB2, BRF2, C12orf45, C12orf73, C20H20ORF24, C26H6ORF125, CAND1, CAND2, CAPG, CAPZA1, CAPZA2, CAPZA3, CAPZB, CCDC103, CCDC53, CCDC63, CD74, CDC45, CDK5RAP2, CDT1, CELF2, CELF3, CELF5, CELF6, CENPN, CENPP, CENPT, CENPW, CENPX, CEP192, CHAF1A, CHAF1B, CLIP1, CLNS1A, CLTB, CLTC, COA3, COA5, COA6, COBL, COIL, COPS7A, COTL1, COX17, COX19, COX20, COX7A2L, CRNKL1, CRTC1, CYFIP1, CYFIP2, DBN1, DBNL, DDX20, DENR, DIAPH3, DMA, DMB1, DMB2, DMC1, DNAAF4, DNAAF5, DNAI2, EIF2D, EIF2S2, EIF2S3, EIF6, ERAL1, FAM107A, FAM206A, FAM49B, LOC101748987, FCHSD1, FCHSD2, FLII, GAS7, GEMIN4, GEMIN8, GNMT, GSN, GTF2A2, GTF2H5, H-10, H1-01, H1-010, H1-10, H1-8, H2AFYMACROH2A1, HAX1, HCLS1, HIGD1C, HIGD2A, HIP1, HIP1R, HJURP, HMP19, HP1BP3, HSCB, IGLL1, IMMP2L, ISY1, KANK3, KAT6A, KCNA1, KCNA10, KCNA2, KCNA3, KCNA6, KCNB1, KCNB2, KCNC2, KCNC4, KCND2, KCND3, KCNG1, KCNG2, KCNG3, KCNG4, KCNS1, KCNS2, KCNV1, KCTD1, KCTD10, KCTD12, KCTD14, KCTD15, KCTD16, KCTD17, KCTD19, KCTD2, KCTD21, KCTD4, KCTD5, KCTD6, KCTD7, KNTC1, LMOD1, LMOD2, LMOD3, LONP1, LRRC6, LRRC61, LSM4, LUC7L, LUC7L2, LUC7L3, MHCY2B1,

GO ID	Biological Process	Fold Enrichment	Adjusted p-value	Gene IDs
GO:0009057	**macromolecule catabolic process**	1.137	0.03144	MHCY2B2, MHCY2B7, MIS12, MIS18A, MKKS, MRPL20, MRPS11, MRPS7, MRTO4, MTPN, MZT1, NAP1L1, NAPB, NDE1, NDEL1, NDUFA11, NDUFA12, NDUFAF3, NDUFAF5, NDUFAF6, NDUFAF7, NDUFAF8, NDUFS5, NDUFS7, NEDD1, NUFIP1, PEF1, PFN3, PICALM, PIH1D2, POMP, PRNP, PRPF18, PRPF6, PRPF8, PSMD5, PSMD9, PSMG1, PSMG2, PSMG4, PSTPIP1, PTGES3L, PTK2, PUF60, PWP2, RAD51C, RAD52, RPL23A, RPL3, RPL38, RPL3L, RPLP0, RPS14, RPS15, RPS27, RPS27L, RPS28, RPSA2, RRP7A, RUVBL1, SAMM50, SAR1B, SCAF11, SCIN, SCO2, SEC16A, SET, SF3A2, SFSWAP, SHFM1, SHKBP1, SHMT1, SHPRH, SHQ1, SLAIN1, SNAP25, SNAP29, SNAP47, SNRPC, SNRPD1, SNRPD3, SNRPE, SNRPF, SNRPGP15, SPAG1, SPG7, SPIRE1, SPIRE1L, SPIRE2, SRPK1, SRPK2, SRSF4, SRSF6, SSH1, SSH2, STK3, STK4, STRAP, SURF1, SVIL, TAF11, TAF12, TBCC, TBCD, TCAP, TFG, TMEM126A, TMEM70, TMOD2, TMOD3, TMOD4, TMSB4X, TMSB4B, TNFAIP1, TP73, TPPP, TPPP3, TRAF7, TRPM1, TRPM7, TTC19, TUBG1, TUBGCP3, TUBGCP4, TUBGCP5, TUBGCP6, TWF1, TWF2, UNC13A, UNC13C, UQCC1, UVRAG, VAMP1, VAMP3, VILL, WASHC5, ZNHIT3 ABHD10, ABHD17A, ADRM1, AGAP3, AMFR, AMN1, ANAPC1, ANAPC2, ANAPC5, ANGEL2, ANKIB1, AOAH, APC2, ARIH1, ARIH2, ASB11, ASB13, ASB9, AZIN1, BANP, BAP1, BFAR, CARHSP1, CDC26, CDC34, CHFR, CHIA, CLPX, CNOT1, CNOT10, CNOT11, CNOT2, CNOT6, COMMD1, COPS3, CSDC2, CSNK1D, CTSC, CTSH, CTSK, CTSS, CTSZ, CUL1, CUL2, CUL4A, CUL5, CUL9, DCP1A, DCP1B, DCPS, DDA1, DET1, DFFB, DIS3, DIS3L, DNAJB6, DNASE1, DNASE1L2, DNASE1L3, DND1, DTL, C2orf40, ECSCR, EDC3, EDC4, EDEM1, EDEM2, ENDOG, ERLEC1, EXOG, EXOSC10, EXOSC2, EXOSC6, EXOSC7, EXOSC8, FAM46B, FAM46C, FASTK, FASTKD3, FBXL13, FBXL16, FBXL18, FBXL2, FBXL20, FBXL21, FBXL22, FBXL3, FBXL7, FBXO11, FBXO22, FBXO38, FBXO44, FBXO48, FHIT, FZR1, GAA, SMG8, GFAP, GID4, GID8, HERPUD1, HNRNPM, HNRNPU, HYAL1, HYAL2, HYAL3, HYAL6, ITCH, KCTD10, KCTD17, KCTD2, KCTD21, KCTD5, KLHL15, KLHL22, KLHL40, LARP1, LONP1, LONP2, LSM1, LSM4, LSM7, LTN1, LYG2, LYGL, LYPLA1, LYPLA2, LYPLAL1, MEIOC, MRTO4, MYEF2, MYLIP, N4BP1, NAE1, NDFIP1, NDFIP2, NEDD4, NGLY1, NHLRC1, NHLRC3, NPLOC4, NSFL1C, NTAN1, NUB1, OAZ1, OAZ2, OTUD7A, OTUD7B, PAN3, PARK2, PARN, PATL2, PCNP, PCYOX1, PCYOX1L, PDE12, PLEKHN1, PNLDC1, PNPT1, PNRC2, PPT1, PSMA2, PSMA4, PSMA5, PSMA7, PSMB1, PSMB2, PSMB3, PSMB4, PSMB7, PSMC2, PSMC5, PSMD11, PSMD3, PSMD4, PSMD6, PSMD7, PSME3, PSME4, PSMF1, PTPN23, PUM1, PYGB, VPS25, RB1CC1, RBBP6, RBX1, REXO4, RFFL, RNASEH2B, RNASET2, RNF111, RNF114, RNF123, RNF139, RNF14, RNF144B, RNF146, RNF166, RNF19A, RNF19B, RNF213, RNF215, RNF217, RNF26, RNF34, RNF43, RNF5, RNF6, RNF8, RNFT1, RNFT2, RPGR, RPS27A, RSPRY1, SELENOS, SGSH, SH3RF2, SHARPIN, SIAH1, SIAH3, SKIV2L, SKP1, SMG1, SMG5, SMURF1, SMURF2, SNF8, SOCS5, SPAM1, SPOP, SPSB1, SPSB3, STAM, STUB1, TBRG4, TCEB1, TIA1, TIMP2, TIMP3, TIMP4, TMEM259, TNFAIP1, TNFAIP3, TNFRSF1B, TNRC6A, TNRC6B, TNRC6C, TRIB1, TRIM3, TRIM71, TRPC4AP, UBA52, UBAP1L, UBB, LOC101747587, UBE2B, UBE2D2, UBE2G1, UBE2H, UBE3A, UBE3B, UBE3C, UBL7, UBQLN4, UBR2, UBXN11, UBXN2B, UCHL3, UPF1, UPF2, UPF3A, USP14, USP35, VIP, VPS36, VPS37B, VPS37D, WDR26, WWP1, WWP2, XRN2, YME1L1, YTHDF1, YTHDF2, YTHDF3, ZC3H12A, ZC3H12D, ZCCHC17, ZFAND2A, ZNRF3

Table 2 KEGG enrichment

KEGG ID	Biological Process	Fold Enrichment	Adjusted p-value	Gene IDs
gga04517	**IgSF CAM signaling**	1.214	0.00412	ABL1, ACTB, ACTG1, ACTG1L, ACTR2, ACTR3B, AFDN, AKT3, APP, ARPC1A, ARPC1B, ARPC3, ARPC4, ARPC5L, BAIAP2, BCAR1, CABLES1, CABLES2, CADM1, CADM2, CADM3, CASK, CASKIN1, CASKIN2, CD2, CD226, CD244, CD48, CD86, CD88, CDC42, CDH1, CDH2, CLMP, CNTN1, CNTN2, CNTNAP1, CNTNAP2, CRTAM, CSK, CTNNB1, DOK2, DYL1, DYL2, DYNLL2, EPB41L1, EPB41L2, EPB41L3, ERC1, ESAM, EZR, FABP9, FGFR1, FOXO1, GIT1, GLDN, GRB2, GRIP1, GRIP2, GSK3A, IGSF5, IL1RAPL1, IQGAP1, ITGB1, ITGB3, JAM2, JAM3, JAML, KCNA1, KCNA2, KCNA6, KCNQ2, KCNQ3, KIRREL1, KIRREL3, LCK, LCP2, LMO7, LRRTM4, LYN, MAGI1, MAGI2, MAP2K1, MAP2K2, MAPK11, MAPK12, MAPK13, MAPK14, MAPK3, MAPK9, MBP, MPP3, MPP6, MPZ, MTSS1, MTSS1L, MYH10, MYH11, MYH9, MYL12A, MYL12B, MYL9, MYLK2, MYLK3, MYLK4, MYLKSML, NCAM1, NCAM2, NCK1, NECTIN1, NECTIN3, LOC101750739, NFASC, NLGN4, NRCAM, NRP1, NTN1, NTN3, NTRK3, PAK1, PAK5, PARD3, PARD6A, PARD6B, PDPK1, PIK3CD, PIK3R2, PLCG1, PLCG2, PLXNA1, PLXNA2, PLXNA4, PMP22, PPFIA2, PPFIA4, PRKCA, PRKCB, PRKCQ, PTK2, PTPN11, PTPN6, PTPRS, PTPRZ1, PXN, RAC1, RAP1A, RAP1B, RAPGEF6, RDX, RHOA, ROBO1, ROBO2, ROBO3, ROBO4, SH2D1B, SLIT3, SLITRK1, SLITRK5, SLITRK6, SPTAN1, SPTBN1, SRC, SRGAP1, SRGAP2, SRGAP3, TJP1, TRIO, TRPC6, TSTD1, TUB5A, TUBA8A, TUBA8B, TUBAL3, TUBB1, TUBB2A, TUBB2B, TUBB3, TUBB4B, TUBB6, UNC5A, UNC5D, VAV2, WASL

Figure. Kegg enrichment cnetplot

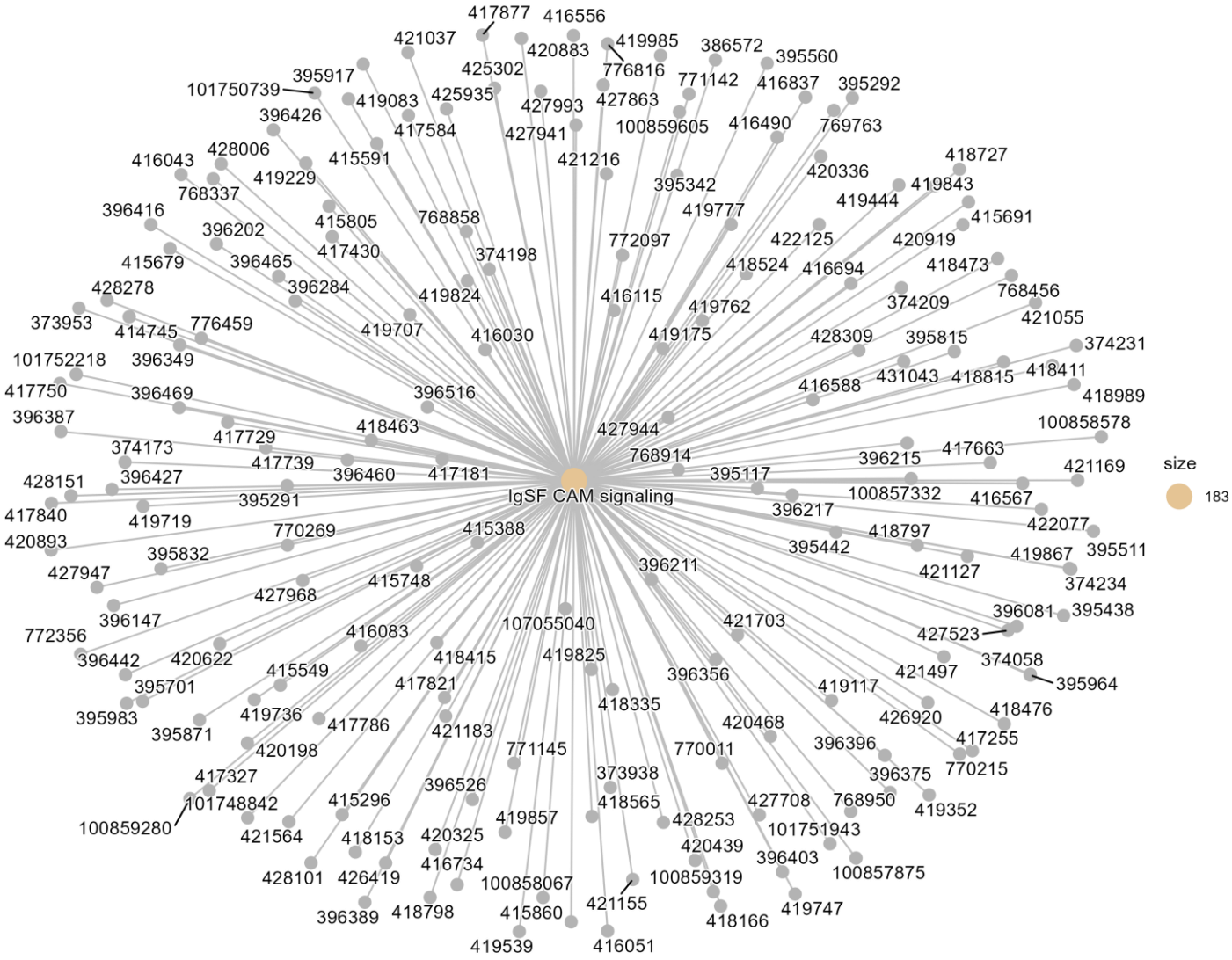

Figure. GO_BP enrichment dotplot

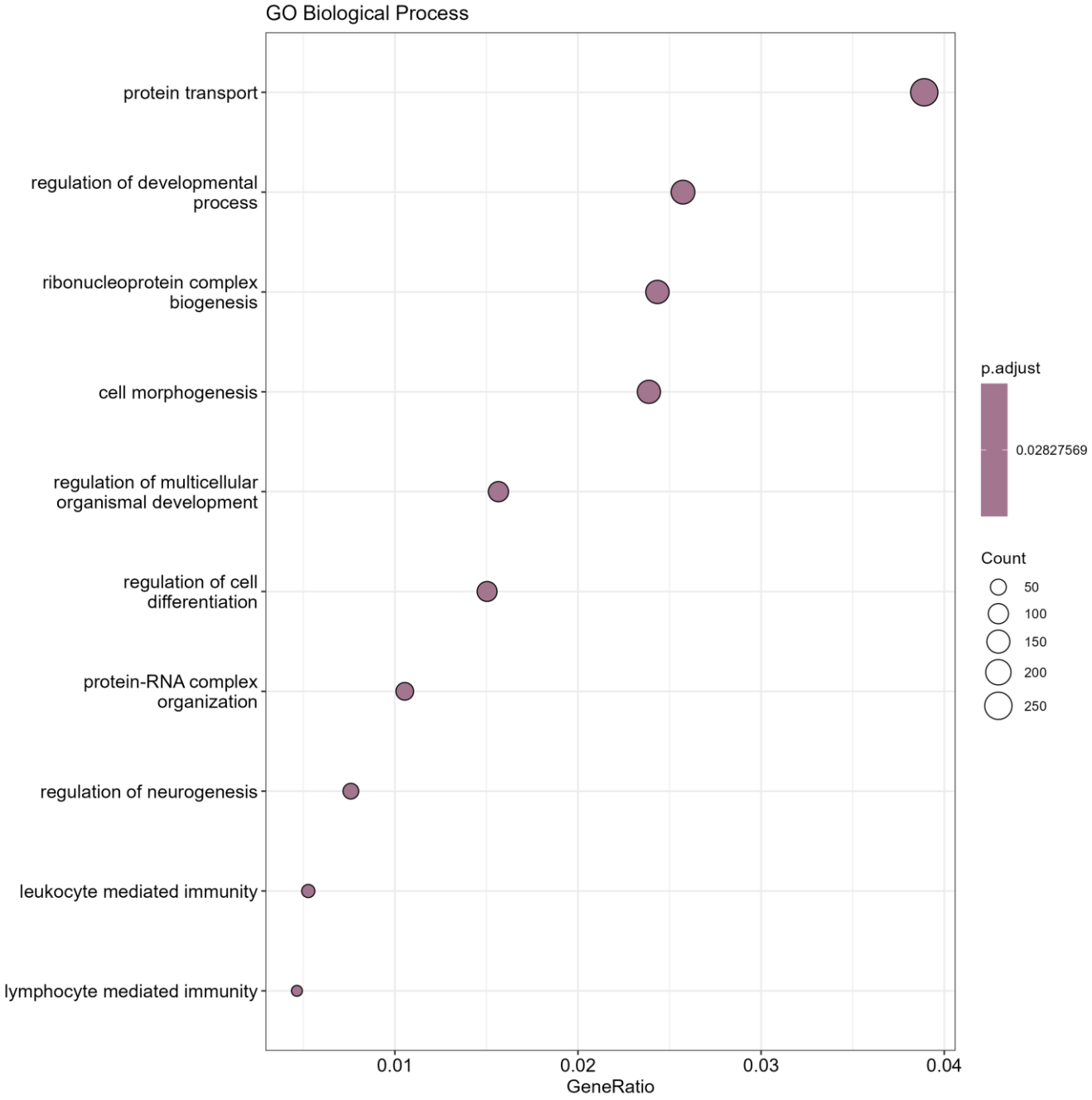

Figure. GO Biological Process enrichment upsetplot

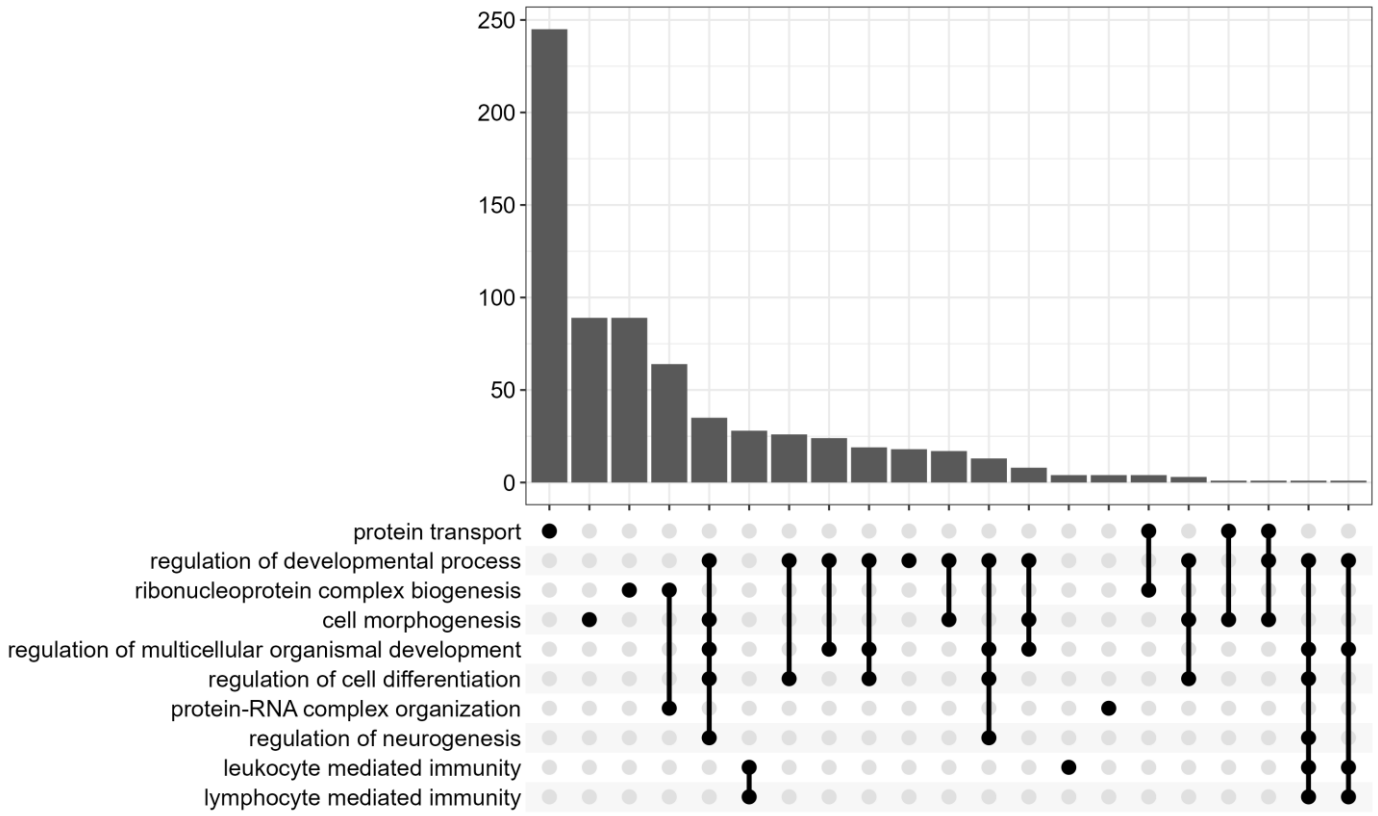

Figure. GO Biological Process enrichment cnetplot