Electronic Supplementary Material (ESI) for Chemical Communications.

Supporting Information

Metabolic Glycan Labeling-Assisted Discovery of Cell-Surface Markers for Primary Neural Stem and Progenitor Cells

Qing-Ran Bai, Lu Dong, Yi Hao, Xing Chen* and Qin Shen*

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Experimental Procedures

Materials. Most reagents for cell culture were obtained from Life Technology, including DMEM, Fetal bovine serum (FBS), glutamine, sodium pyruvate, N2, B27, bFGF, 0.05% and 0.25% trypsin. Papain was purchased from Worthington. *N*-acetyl-L-cysteine (NAC), Poly-L-Lysine (PLL) and Triton X-100 were obtained from Sigma. TRIzol was obtained from Life Technology. 6-well plates and transwells were from Costar. Ac_4ManNAz, 9AzSia and BTTAA were synthesized as previously reported.[1] [2] [3] Alkyne-Biotin and alkyne-Cy5 were obtained from Click Chemistry Tools. The antibodies were stated in relative sections below.

Animals. ICR mice were obtained from Vital River Laboratory Animal Technology Company (Beijing, China). Mice were bred and maintained in the animal care facility at Center of Biomedical Analysis in Tsinghua University. All animal protocols used in this study were approved by the IACUC (Institutional Animal Care and Use Committee) of Tsinghua University and performed in accordance with guidelines of the IACUC. The laboratory animal facility has been accredited by AAALAC (Association for Assessment and Accreditation of Laboratory Animal Care International). For staging of embryos, mid-day of the vaginal plug identified was calculated as embryonic day 0.5 (E0.5).

Cell culture. Cell lines and primary cells were cultured in incubators at 37 °C with 5% CO_2. For neural progenitor cell culture, embryonic day 10.5 (E10.5) ICR mouse embryos were dissected and the cortices were removed. The cortical tissues were digested with papain and dissociated into single cells, then plated into the PLL coated 6-well plates and cultured in adherent medium (AM) consisting of DMEM, glutamine, sodium pyruvate, N2, B27, NAC, and 10 ng/ml bFGF.[4]

The mouse brain endothelial cell line bEND3 cells and human embryonic kidney cell line 293FT were obtained from ATCC and maintained in DMEM with 10% FBS and passaged by 0.25% trypsin digestion.

For endothelial cell coculture experiment, bEND3 cells were plated into 24 mm transwell membrane inserts (Costar, 0.4 μm pore size) with DMEM supplimented with 10% FBS one day before coculture. 3 h after the cortical cells were plated on PLL-coated 6-well plates (Costar), the transwells were well rinsed with DMEM and the medium was switched to neural medium AM. The transwells were placed above neural culture so that endothelial cells and cortical cells were cocultured in AM without direct contact. The cortical neural cells were prepared for further analysis after 5 days.

Metabolic labeling of cortical cell culture with unnatural sialic acid precursors. Ac_4ManNAz was dissolved in DMSO at the concentration of 200 mM. 9AzSia was dissolved in PBS at the concentration

of 100 mM. One day after neural cells plating, Ac_4ManNAz or 9AzSia was added to the culture at the final concentration. DMSO was added into the control cultures.

Fluorescence labeling of the azide-incorporated sialoproteins in cell culture. The cell cultures treated with unnatural sialic acid precursor were rinsed once with PBS and fixed with 4% PFA in 0.1M PB for 15 min at RT. Cells were washed three times with PBS containing 1% FBS. Then, the cells were incubated for 10 min in PBS containing 50 μM biotin-alkyne, 2.5 mM sodium ascorbate, and premixed BTTAA-$CuSO_4$ complex (50 μM $CuSO_4$, BTTAA: $CuSO_4$ in a 6:1 molar ratio). After the reaction, the cells were washed with PBS containing 1% FBS three times and incubated with 1 μg/mL Alexa Fluor 647-streptavidin (Life Technology) for 30 min.

Overepressing HA-Igsf8 in 293FT cells. Total RNA was purified from E14.5 mouse cortical tissue with TRIzol and retrotranscribed into cDNA with All-in-one RT Mastermix (Abm). Igsf8 was amplified with primer pair: 5'-GAATTCATGGGCGTCCCTAGCCCCACG-3' and 5'-GCGGCCGCACCGCTTCCGCATCCTCTTCAT-3', and then inserted into multicloning site of pLVX-IRES-ZsGreen1 (Clontech). Oligodeoxynucleotides encoding HA tag were synthesized and inserted into pLVX-IRES-ZsGreen1 so that HA tag was fused at C-terminal of Igsf8 protein. Such construct was transfected into 293FT cells with transfection reagent Neofect (Neofect).

Immunofluorescence staining of culture and tissue sections. The cells were fixed as mentioned above. The cells were blocked and permeabilized with blocking buffer (5% BSA, 0.3% Triton X-100 in PBS) for 15 min at RT, then incubated with indicated primary antibodies overnight at 4 °C followed by secondary antibodies incubation for 2 h at RT.

E14.5 ICR mouse embryonic heads were dissected out and fixed with 4% PFA in 0.1M PB overnight at 4 °C. After fixation, the heads were dehydrated with 30% sucrose in PBS and embedded in O.C.T. (Sakura) for cryosectioning. Brain sections were stained following the same procedure as cell culture staining.

The primary antibodies and their dilution ratio in blocking buffer for immunofluorescence staining are listed below: Nestin, 1:20 (Development Studies Hybridoma Bank); Tuj1, 1:1000 (Sigma), Tbr2, 1:200 (Abcam); Ctip2, 1:500 (Abcam); Ki67, 1:500 (Thermo); Igsf8, 1:100 (R&D); PSA-NCAM, 1:200 (Millipore), SNA, 1:20, Mal II, 1:100 (Vector Laboratories Inc.). The secondary antibodies (Alexa fluoro-conjugated, Life Technology) were used at a dilution of 1:1000. DAPI was used at the concentration of 500 ng/mL (Sigma).

Images of neural cell culture were acquired using an epifluorescence microscope (Zeiss Axio Imager D1). Images of sections were taken with a laser scanning confocal microscope (Zeiss LSM 710 Meta). The analysis of image data was performed with ImageJ software (NIH).

Flow cytometry analysis. Flow cytometry analysis was performed with BD Accuri C6 flow cytometer. Fluorescence activated cell sorting (FACS) was performed with BD Influx cell sorter. E14.5 ICR mouse cortices were dissected out and dissociated into single cells as mentioned above. The cells were resuspended in staining buffer (2% FBS in PBS) and stained with FITC conjugated anti-LeX antibody (BD, 1:200), and co-labeled with SNA, Mal II, and anti-PSA-NCAM (Millipore) for 30 min at 4 °C, then stained with Alexa Flour 647-conjugated streptavidin (1:100) or Alexa Flour 647-anti-mouse IgM (1:100) for 30 min at 4 °C before loading into cytometer for analysis. For FACS of Ac_4ManNAz labeled cell culture, the E10.5 mouse embryonic cortical cells were cultured with Ac_4ManNAz for 5 days and prepared into single cell solution with 0.05% trypsin. Then the cells were incubated for 10 min in PBS containing 50 μM biotin-alkyne, 2.5 mM sodium ascorbate, and premixed BTTAA-$CuSO_4$ complex (50 μM $CuSO_4$, BTTAA: $CuSO_4$ in a 6:1 molar ratio). After the reaction, the cells were washed three times with PBS containing 1% FBS and incubated with 1 μg/mL Alexa Fluor 647-streptavidin for 30 min. After that, the cells were washed three times with PBS containing 1% FBS and subjected to FACS analysis. The data was analyzed by FlowJo software.

Purification of Ac_4ManNAz labeled sialylated glycoproteome. For glycoproteomic identification, a reported procedure was used.[5] Briefly, after metabolic labeling, cells were rinsed three times with ice-cold PBS, lysed in RIPA buffer, and centrifuged at 10,000 × g for 10 min to remove cell debris. Protein concentration was determined using BCA assay. 1 mg of proteins in 1 mL RIPA buffer was incubated with 100 μM alkyne-biotin, premixed BTTAA-$CuSO_4$ complex (100 μM $CuSO_4$, BTTAA: $CuSO_4$ at a molar ratio of 2:1), and 2.5 mM sodium ascorbate for 1 h. By adding 20 mL ice-cold methanol, the proteins were precipitated in - 30 °C overnight. The proteins were centrifuged at 4,500 × g for 15 min, and washed twice with 20 mL ice-cold methanol. The protein pellet was resuspended in 4 mL resuspension buffer [Solution A: 4% (wt/vol) SDS and 10 mM EDTA in H_2O; Solution B: 1% (vol/vol) Brij 97, 150 mM NaCl and 50 mM Triethanolamine in H_2O, pH = 7.4; A: B =1:8 (vol/vol)]. 50 μL of streptavidin beads (Thermo Scientific) were washed three times with 1 mL PBS, and added to the protein solution. After 3h of incubation at RT, the beads were washed sequentially with 2% (wt/vol) SDS in PBS, 8 M urea with 250 mM ammonium bicarbonate (ABC), 2.5 M sodium chloride in PBS, 0.5 M ABC, 0.25 M ABC, and 0.05 M ABC. The beads were resuspended in 20 μL of 5 × loading buffer, heated for 10 min at 95 °C to release the enriched sialoglycoproteins and dissolved in 10% SDS-PAGE. Coomassie brilliant blue R-250 was used to display the distribution of the captured proteins in the gel.

Western blot. Western blot was performed according to standard protocol. The antibodies used and their dilution ratio was listed below: GAPDH, 1:5000 (Thermo), HA tag, 1:2000 (Sigma).

In-gel fluorescence scanning. The cell lysates were reacted with 50 μM alkyne-Cy5 in 100 μL reaction buffer containing premixed BTTAA-$CuSO_4$ complex (50 μM $CuSO_4$, BTTAA:$CuSO_4$ in a 2:1 molar ratio) and 2.5 mM freshly prepared sodium ascorbate. After 1h of reaction at 25°C, samples were resolved on 10% SDS-PAGE gels. The gels were scanned on a Typhoon FLA 9500 laser scanner (GE Healthcare, USA) using a 635 nm laser for excitation and LPR filter for detection.

Proteomic analysis by LC-MS/MS. Proteins samples were separated by SDS-PAGE gel and stained with Coomassie brilliant blue R-250. Each lane of the gel was sliced into 8 fractions, and gel slices were washed with Milli-Q water, destained with a 1:1 solution of 50 mM ABC/acetonitrile for 30 min at 37 °C, and dehydrated in 100% acetonitrile. The gel slices were rehydrated with 10 mM DTT in 50 mM ABC, and incubated for 45 min at 56 °C, then the slices were incubated with 55 mM iodoacetamide in 50 mM ABC for 45 min at RT in the dark. After dehydrated in 100% acetonitrile, gel pieces were rehydrated in a trypsin solution (2 ng/μL) and incubated at 37 °C for 16 h. The peptides were eluted in 50% acetonitrile in H_2O with 5% (vol/vol) TFA (200 μL, twice), and SpeedVac dried. Samples were then subjected to an Easy nLC 1000 coupled to an LTQ Velos Pro-Orbitrap Elite mass spectrometer (Thermo Fisher). Peptides were pressure-loaded onto a 100 μm diameter, 2 cm C18 precolumn and separated on a 75 μm diameter, 20 cm C18 capillary column with a gradient running from 95% buffer A [H_2O with 0.1% formic acid] and 5% buffer B [CH_3CN with 0.1% formic acid] to 35% B over 60 min at the flow rate of 300 nL/min, next ramping to 75% B over 2 min and holding at 75% B for 10 min. One full MS scan (375-1600 m/z) was followed by ten data-dependent scans of the nth most intense ions with dynamic exclusion enabled. Peptides were identified using Mascot version 2.3.02 (MatrixScience) and were searched against the SwissProt mouse sequence database to compile the data.

Statistical analysis. The data of image counting was statistically analyzed with Prism software. Unpaired t-test was applied to determine the significance of difference. $P<0.05$ was considered as statistically significant.

Supporting Figures

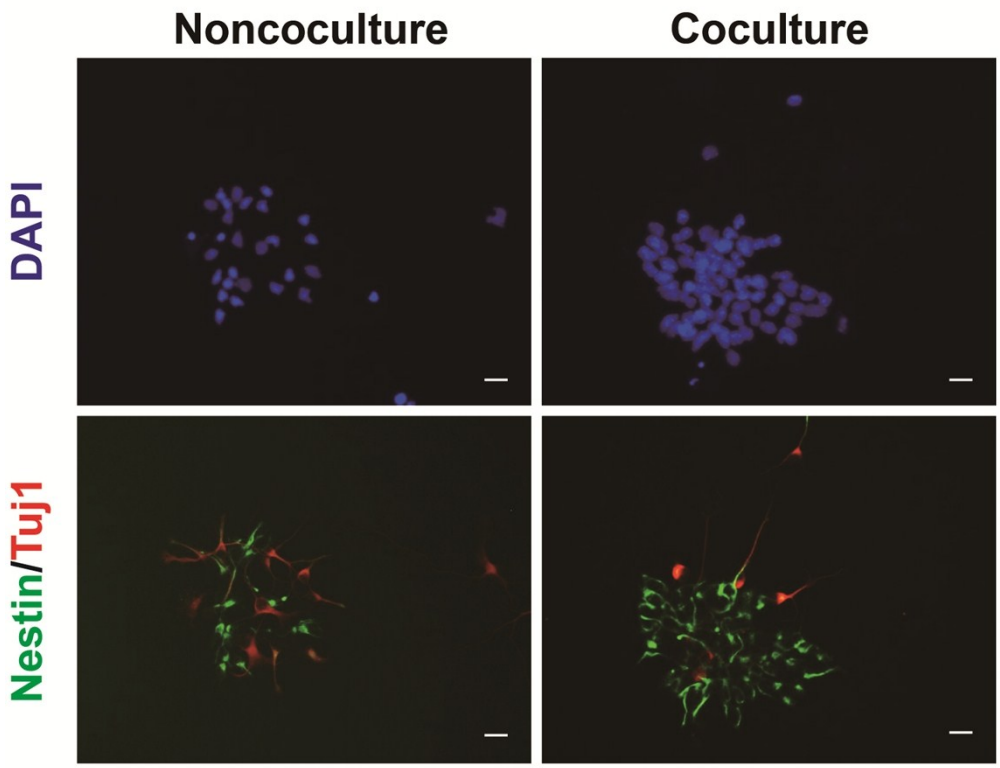

Figure S1. Immunostaining images of cortical cells after 5 days of culture.

Single NSCs isolated from E10.5 mouse cerebral cortex were cultured alone (Noncoculture) or with endothelial cells (Coculture). After 5 days, the cells were immunostained with antibodies against Nestin (green) and Tuj1 (red). The nuclei were stained with DAPI (blue). Scale bar, 20 μm.

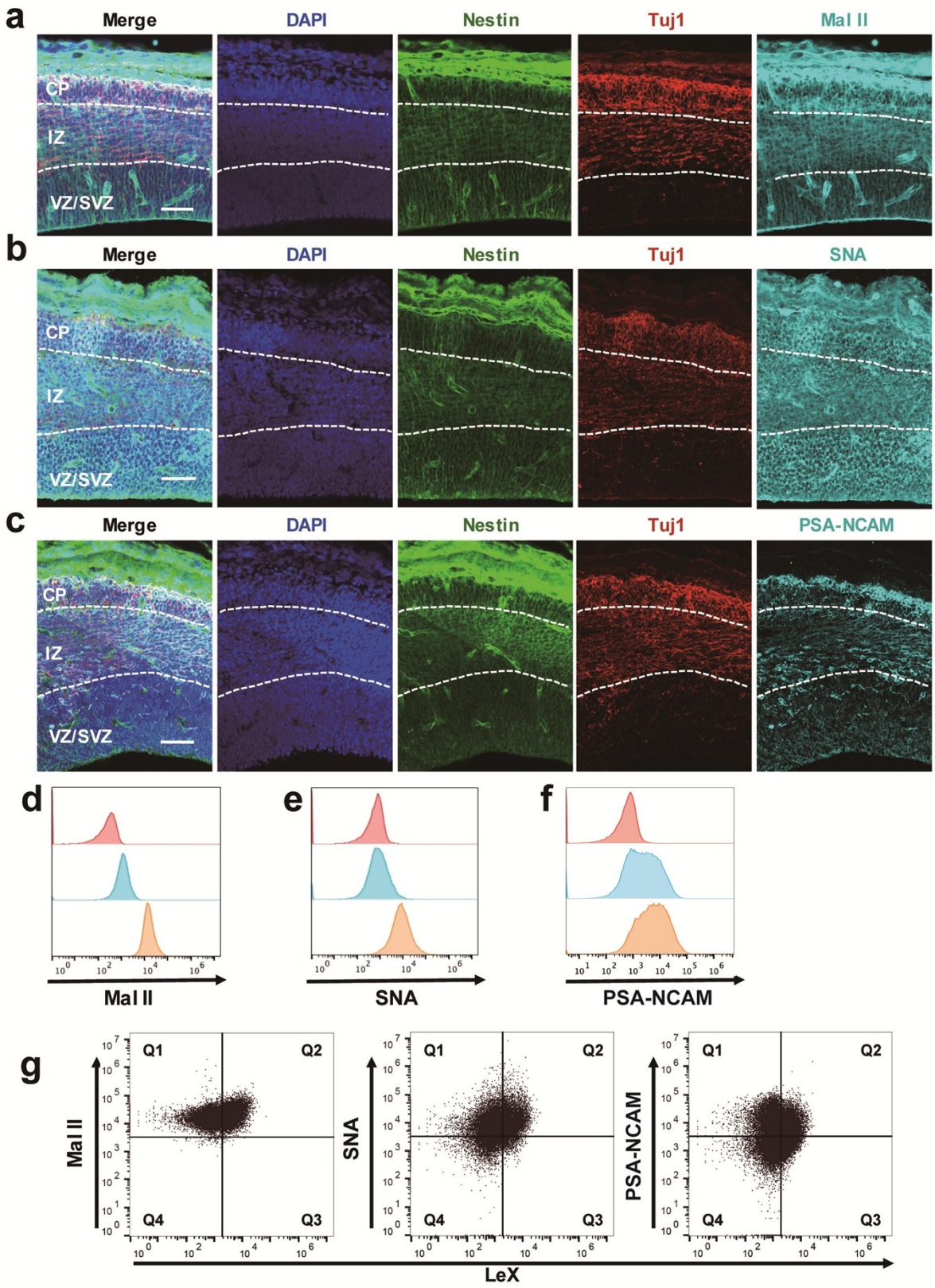

Figure S2. Distribution of sialoglycoproteins in the developing cerebral cortex.

a-c) Images of immunostaining for Nestin (green), Tuj1 (red) and Mal II (a), SNA (b), PSA-NCAM(c) in E14.5 cortical tissue sections. Nuclei were stained by DAPI. Scale bars, 50 μm. Dashed lines demarcated different cortical regions. VZ, the ventricular zone. SVZ, the subventricular zone. IZ, the intermediate zone. CP, the cortical plate. d-f) FACS analysis of primary cortical cells isolated from E14.5 cortex. X-axis indicates the intensity of Cy5 conjucated Mal II (d), SNA (e) or antibody against PSA-NCAM (f).

Y-axis refers to the cell counts. Blue and orange peaks indicate low and high concentration, respectively. Red peaks indicate staining control. g) FACS analysis of E14.5 cortical cells labeled by high concentration of Mal II, SNA or PSA-NCAM antibody. The cells were co-labeled by a FITC-LeX antibody to distinguish LeX^+ and LeX^- cell population. Points in Q4 quadrant indicate double negative populations.

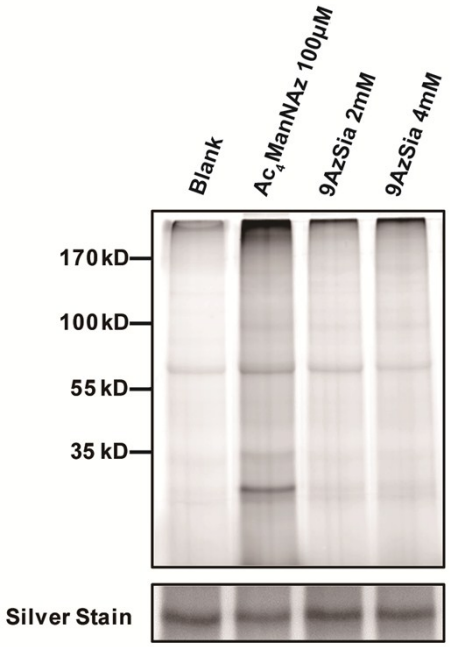

Figure S3. Ac_4ManNAz efficiently labels primary NSCs compared to 9AzSia.

Primary NSCs isolated from the mouse cerebral cortex at E10.5 were cultured and labeled by Ac_4ManNAz and 9AzSia with indicated concentration for 5 days. Then the cells were lysed and reacted with alkyne-Cy5 for in gel fluorescence assay. Silver staining of total proteins were used as internal control.

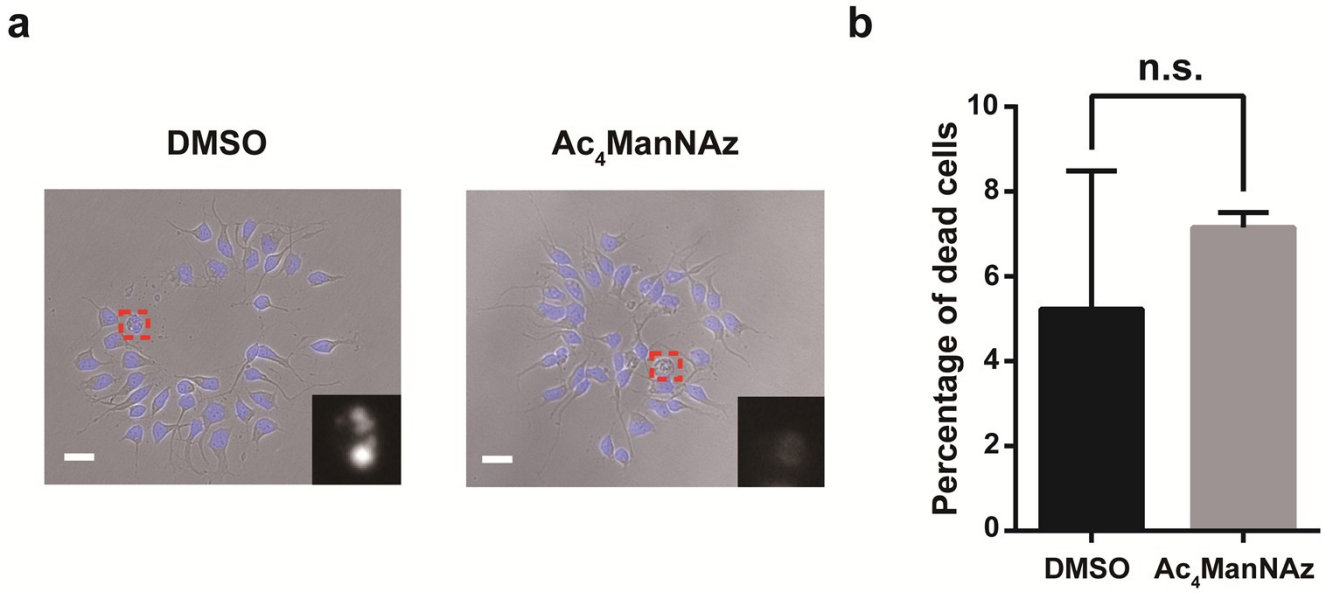

Figure S4. Toxicity of Ac_4ManNAz labeling on primary neural stem and progenitor cells.

a) Phase-contrast and DAPI staining images of cultured cortical cells with or without the azidosugar. E10.5 primary neural stem and progenitor cells were isolated and cultured for 5 days with DMSO or 100 μM Ac_4ManNAz respectively. The cultures were fixed and stained with DAPI (blue). The inserts were the magnified view of red-dashed boxes indicated cells, showing disintegrated nuclei (DAPI signal in white color) of dead cells. Scale bars, 20 μm. b) The statistic result of percentage of dead cells in cultures with DMSO or Ac_4ManNAz. The dead cells were determined by combinatory evaluation of cell morphology under phase-contrast microscopy and DAPI fluorescent staining.[6]

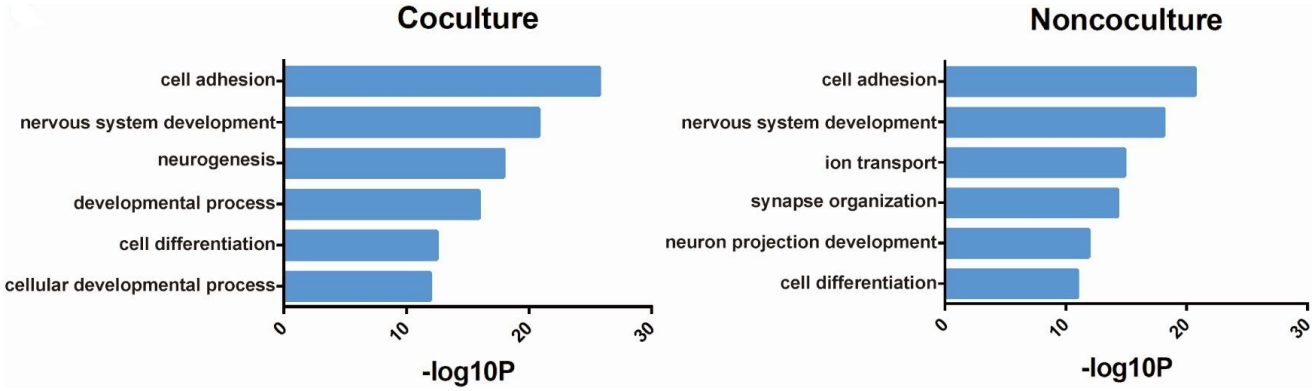

Figure S5. Gene ontology analysis of identified membrane sialoglycoproteins from the endothelial cocultured neural cells and noncocultured neural cells.

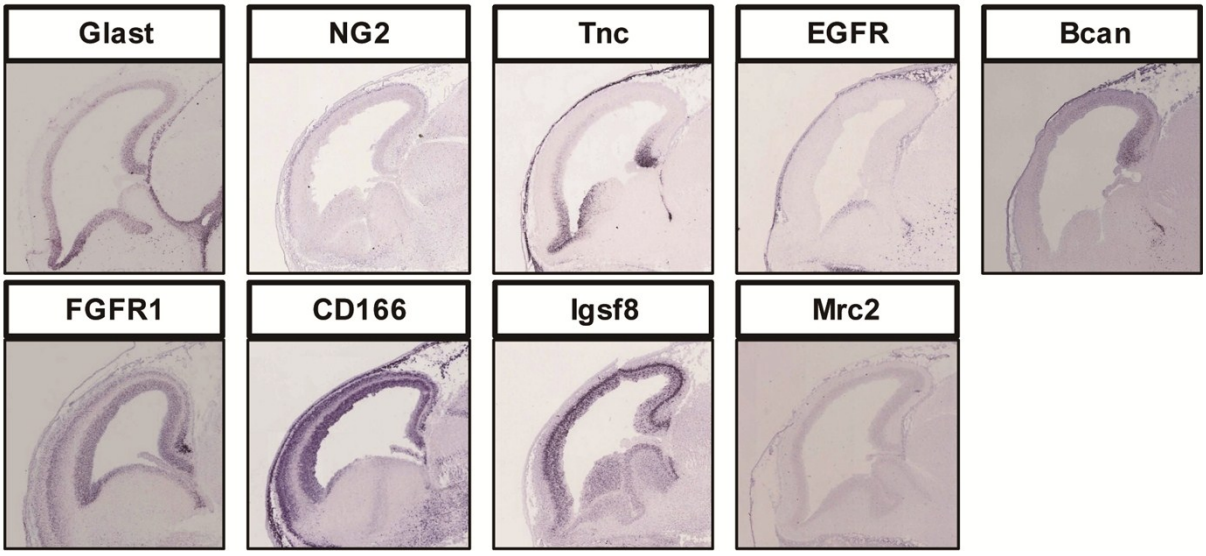

Figure S6. In situ hybridization of sialoglycoprotein candidates enriched in neural stem and progenitor cells shows mRNAs of these proteins are expressed in the cerebral cortex of E14.5 mouse brain. The images were adapted from Eurexpress.[7]

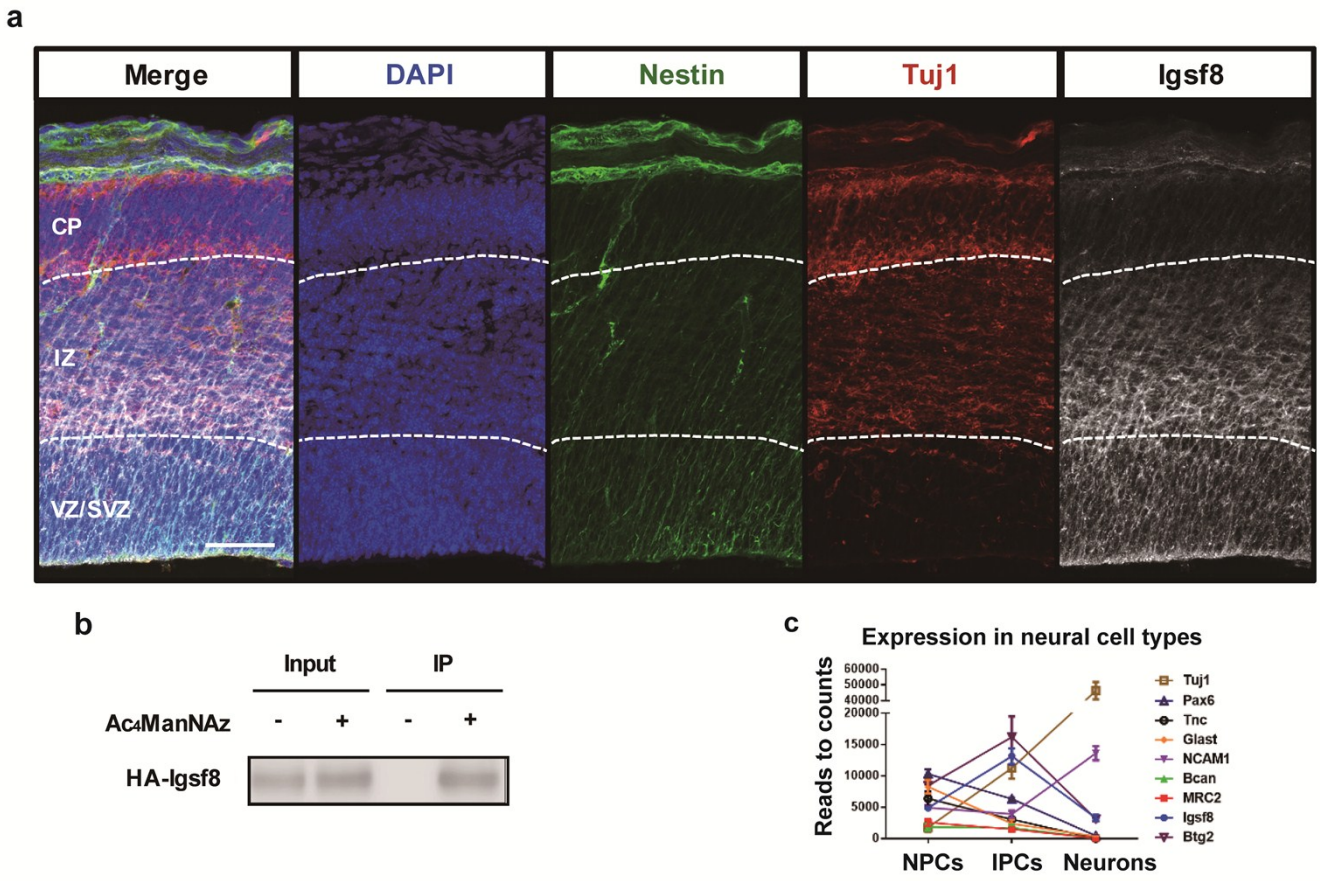

Figure S7. Expression of Igsf8 in E14.5 mouse cerebral cortex.

a) Images of E14.5 cortical tissue sections immunostained for Nestin (green), Tuj1 (red) and Igsf8 (grey). Nuclei were stained by DAPI (blue). Scale bar, 50 μm. Dashed lines demarcated different cortical regions. VZ, the ventricular zone. SVZ, the subventricular zone. IZ, the intermediate zone. CP, the cortical plate. b) Igsf8 is sialylated as shown by a pull-down assay using streptavidin beads after $Ac_4ManNAz$ labeling and click with alkyne-biotin in HA-Igsf8 overexpressing 293FT cells. c) Igsf8 mRNA is highly expressed in $Btg2^+$ IPCs.[8]

Supporting Table S1

High confidence proteins selectively identified in coculture or noncoculture samples by mass spectrometry. Proteins were categorized into the high-confidence list if they were identified in Ac_4ManNAz treated samples with ≥ 5 spectral counts and ≥ 5 folds increase above the vehicle-administered samples. Red indicates proteins located in cell membrane, ER/Golgi or secreted pathway; blue indicated proteins located in cytosol, nucleus or mitochondria.

Coculture				Noncoculture			
Protein Name	Gene Name	NEG	POS	Protein Name	Gene Name	NEG	POS
Neural cell adhesion molecule 1	Ncam1	9	505	Neural cell adhesion molecule 1	Ncam1	11	532
Prolow-density lipoprotein receptor-related protein 1	Lrp1	7	272	Prolow-density lipoprotein receptor-related protein 1	Lrp1	12	255
Golgi apparatus protein 1	Glg1	13	79	Glypican-2	Gpc2	0	82
Leucine-rich repeat-containing protein 4B	Lrrc4b	1	72	Golgi apparatus protein 1	Glg1	4	75
Sodium/potassium-transporting ATPase subunit beta-1	Atp1b1	6	70	Reticulon-4	Rtn4	11	74
Neuronal membrane glycoprotein M6-a	Gpm6a	4	68	Sodium/potassium-transporting ATPase subunit beta-1	Atp1b1	8	67
Cation-independent mannose-6-phosphate receptor	Igf2r	0	67	Ephrin-B1	Efnb1	9	63
Plexin-B1	Plxnb1	0	66	Leucine-rich repeat-containing protein 4B	Lrrc4b	1	62
Ephrin-B1	Efnb1	9	62	Neuronal membrane glycoprotein M6-a	Gpm6a	3	62
Excitatory amino acid transporter 1	Slc1a3	4	61	4F2 cell-surface antigen heavy chain	Slc3a2	7	61
Neuronal cell adhesion molecule	Nrcam	2	60	Neuroligin-3	Nlgn3	1	58
Synaptic vesicle glycoprotein 2A	Sv2a	1	57	Plexin-B1	Plxnb1	1	57
Neuroligin-2	Nlgn2	0	51	Cation-independent mannose-6-phosphate receptor	Igf2r	0	52
Glypican-2	Gpc2	0	50	Glypican-4	Gpc4	2	48
Contactin-1	Cntn1	5	49	Agrin	Agrn	0	47
Low-density lipoprotein receptor	Ldlr	2	47	Neuronal cell adhesion molecule	Nrcam	2	41
Netrin receptor DCC	Dcc	2	47	Cell adhesion molecule 4	Cadm4	0	41
Neuroligin-3	Nlgn3	3	46	Neuroligin-2	Nlgn2	0	40
V-type proton ATPase 116 kDa subunit a isoform 1	Atp6v0a1	3	46	Immunoglobulin superfamily containing leucine-rich repeat protein 2	Islr2	1	38

Immunoglobulin superfamily containing leucine-rich repeat protein 2	Islr2	0	46	V-type proton ATPase 116 kDa subunit a isoform 1	Atp6v0a1	7	37
Receptor-type tyrosine-protein phosphatase alpha	Ptpra	1	45	Coxsackievirus and adenovirus receptor homolog	Cxadr	0	37
Coxsackievirus and adenovirus receptor homolog	Cxadr	1	44	Sodium/potassium-transporting ATPase subunit beta-3	Atp1b3	0	37
Sodium- and chloride-dependent GABA transporter 3	Slc6a11	4	44	Transferrin receptor protein 1	Tfrc	1	36
Integrin beta-1	Itgb1	2	42	Netrin receptor DCC	Dcc	5	36
Transferrin receptor protein 1	Tfrc	4	39	Immunoglobulin superfamily member 3	Igsf3	0	35
Neurofascin	Nfasc	0	38	Insulin-like growth factor 1 receptor	Igf1r	0	35
Neogenin	Neo1	0	35	Carboxypeptidase D	Cpd	0	34
Sodium/potassium-transporting ATPase subunit beta-3	Atp1b3	0	34	Neogenin	Neo1	0	34
Integrin alpha-6	Itga6	3	33	Receptor-type tyrosine-protein phosphatase alpha	Ptpra	0	34
Immunoglobulin superfamily member 3	Igsf3	0	33	Protocadherin Fat 3	Fat3	1	32
Versican core protein	Vcan	0	33	Lactadherin	Mfge8	0	32
Neuronal membrane glycoprotein M6-b	Gpm6b	2	32	Synaptic vesicle glycoprotein 2A	Sv2a	1	31
Cell adhesion molecule 4	Cadm4	0	32	Voltage-dependent calcium channel subunit alpha-2/delta-1	Cacna2d1	0	30
Neural cell adhesion molecule 2	Ncam2	0	32	UPF0635 protein C6orf134 homolog		3	29
Glypican-4	Gpc4	1	31	Ephrin-B2	Efnb2	0	29
Carboxypeptidase D	Cpd	0	31	Transmembrane 9 superfamily member 3	Tm9sf3	0	28
Neural cell adhesion molecule L1	L1cam	0	31	Excitatory amino acid transporter 1	Slc1a3	0	27
Sodium- and chloride-dependent taurine transporter	Slc6a6	2	30	Neuropilin-2	Nrp2	0	27
Chondroitin sulfate proteoglycan 4	Cspg4	0	30	Solute carrier family 12 member 5	Slc12a5	0	27
Reticulon-1	Rtn1	2	29	Plexin-A2	Plxna2	1	26
Ephrin type-B receptor 2	Ephb2	0	29	Cadherin-2	Cdh2	0	26
Lactadherin	Mfge8	0	29	Integrin beta-1	Itgb1	0	26
Neuropilin-2	Nrp2	0	29	Neuronal membrane glycoprotein M6-b	Gpm6b	0	26
Solute carrier family 2, facilitated glucose transporter member 1	Slc2a1	2	28	Sodium- and chloride-dependent GABA transporter 3	Slc6a11	3	25
Agrin	Agrn	0	28	Contactin-1	Cntn1	1	24

Cadherin-2	Cdh2	0	28	Secreted frizzled-related protein 1	Sfrp1	1	24
Delta and Notch-like epidermal growth factor-related receptor	Dner	0	28	Lysosome membrane protein 2	Scarb2	0	24
Glucosylceramidase	Gba	0	26	TM2 domain-containing protein 2	Tm2d2	0	24
Solute carrier family 12 member 5	Slc12a5	0	26	Ephrin type-B receptor 2	Ephb2	0	23
Roundabout homolog 2	Robo2	2	25	Glypican-1	Gpc1	0	23
Protocadherin Fat 3	Fat3	0	25	Insulin receptor	Insr	0	23
EGF-like repeat and discoidin I-like domain-containing protein 3	Edil3	0	24	Integrin alpha-6	Itga6	0	23
Nicastrin	Ncstn	1	23	Glucosylceramidase	Gba	4	22
BDNF/NT-3 growth factors receptor	Ntrk2	0	23	Neurofascin	Nfasc	0	22
Chloride transport protein 6	Clcn6	0	23	Solute carrier family 2, facilitated glucose transporter member 1	Slc2a1	0	22
Latrophilin-3	Lphn3	0	23	Nicastrin	Ncstn	1	20
Voltage-dependent calcium channel subunit alpha-2/delta-1	Cacna2d1	0	23	EGF-like repeat and discoidin I-like domain-containing protein 3	Edil3	0	20
Large neutral amino acids transporter small subunit 1	Slc7a5	1	22	Latrophilin-3	Lphn3	0	20
Cell adhesion molecule 2	Cadm2	0	22	Prominin-1	Prom1	0	20
Excitatory amino acid transporter 2	Slc1a2	0	21	SLIT-ROBO Rho GTPase-activating protein 2	Srgap2	1	19
Sulfhydryl oxidase 2	Qsox2	0	21	Reticulon-1	Rtn1	3	18
Basement membrane-specific heparan sulfate proteoglycan core protein	Hspg2	0	20	Chloride transport protein 6	Clcn6	0	18
CD166 antigen	Alcam	0	19	Neurocan core protein	Ncan	0	18
Leucyl-cystinyl aminopeptidase	Lnpep	0	19	Transmembrane protein 2	Tmem2	0	18
Neutral amino acid transporter A	Slc1a4	0	19	Versican core protein	Vcan	0	18
Anoctamin-6	Ano6	0	18	Anoctamin-6	Ano6	0	17
Leucine-rich repeat-containing protein 8A	Lrrc8a	0	18	Leucine-rich repeat-containing protein 8A	Lrrc8a	0	17
Lymphocyte antigen 6H	Ly6h	0	18	Neural cell adhesion molecule L1	L1cam	0	17
Lysosomal acid phosphatase	Acp2	0	18	Sodium- and chloride-dependent GABA transporter 1	Slc6a1	1	16
Lysosome membrane protein 2	Scarb2	0	18	Basement membrane-specific heparan sulfate proteoglycan core protein	Hspg2	0	16

Neurocan core protein	Ncan	0	18	Basigin	Bsg	0	16
Neuroplastin	Nptn	0	18	Ephrin-B3	Efnb3	0	16
Protein CASC4	Casc4	0	18	Lysosomal acid phosphatase	Acp2	0	16
Receptor-type tyrosine-protein phosphatase gamma	Ptprg	0	18	Neutral amino acid transporter A	Slc1a4	0	16
Epidermal growth factor receptor	Egfr	1	17	Cadherin EGF LAG seven-pass G-type receptor 3	Celsr3	0	15
Tyrosine-protein kinase-like 7	Ptk7	2	17	Ciliary neurotrophic factor receptor subunit alpha	Cntfr	0	15
Limbic system-associated membrane protein	Lsamp	0	17	GPI inositol-deacylase	Pgap1	0	15
Sodium bicarbonate cotransporter 3	Slc4a7	0	17	G-protein coupled receptor 56	Gpr56	0	15
Astrotactin-1	Astn1	1	16	Immunoglobulin superfamily DCC subclass member 4	Igdcc4	0	15
OX-2 membrane glycoprotein	Cd200	2	16	Integrin alpha-V	Itgav	0	15
Sodium- and chloride-dependent GABA transporter 1	Slc6a1	2	16	Neural cell adhesion molecule 2	Ncam2	0	15
Tenascin	Tnc	2	16	Sphingomyelin phosphodiesterase 2	Smpd2	0	15
SLIT-ROBO Rho GTPase-activating protein 2	Srgap2	3	16	Alpha-mannosidase 2C1	Man2c1	1	14
G-protein coupled receptor 56	Gpr56	0	16	BDNF/NT-3 growth factors receptor	Ntrk2	0	14
Immunoglobulin superfamily DCC subclass member 4	Igdcc4	0	16	Cell adhesion molecule 2	Cadm2	0	14
Immunoglobulin superfamily member 21	Igsf21	0	16	Cell adhesion molecule 3	Cadm3	0	14
Prominin-1	Prom1	0	16	Latrophilin-1	Lphn1	0	14
Synaptotagmin-1	Syt1	0	16	Neuroplastin	Nptn	0	14
Cell cycle control protein 50A	Tmem30a	0	15	Podocalyxin-like protein 2	Podxl2	0	14
Electrogenic sodium bicarbonate cotransporter 1	Slc4a4	0	15	Tyrosine-protein kinase-like 7	Ptk7	1	13
Insulin-like growth factor 1 receptor	Igf1r	0	15	KLRAQ motif-containing protein 1	Klraq1	2	13
Integrin alpha-5	Itga5	0	15	Cell cycle control protein 50A	Tmem30a	0	13
Transmembrane 9 superfamily member 3	Tm9sf3	0	15	Glypican-6	Gpc6	0	13
Uncharacterized protein KIAA0319-like	Kiaa0319l	0	15	Large neutral amino acids transporter small subunit 1	Slc7a5	0	13
Cell adhesion molecule 3	Cadm3	0	14	Plexin-A1	Plxna1	0	13
Ephrin-B2	Efnb2	0	14	Protein CASC4	Casc4	0	13
Leucine-rich repeat and immunoglobulin-like	Lingo1	0	14	Sodium bicarbonate cotransporter 3	Slc4a7	0	13

domain-containing nogo receptor-interacting protein 1							
Podocalyxin-like protein 2	Podxl2	0	14	Trophoblast glycoprotein	Tpbg	0	13
Transmembrane emp24 domain-containing protein 4	Tmed4	0	14	Niemann-Pick C1 protein	Npc1	1	12
Basigin	Bsg	1	13	Phospholipase D3	Pld3	2	12
Transmembrane emp24 domain-containing protein 9	Tmed9	1	13	Astrotactin-1	Astn1	0	12
Integrin alpha-V	Itgav	0	13	Delta and Notch-like epidermal growth factor-related receptor	Dner	0	12
Low-density lipoprotein receptor-related protein 8	Lrp8	0	13	Disks large-associated protein 4	Dlgap4	0	12
Neuropilin-1	Nrp1	0	13	Glutamate receptor 1	Gria1	0	12
Repulsive guidance molecule A	Rgma	0	13	Glutamate receptor 2	Gria2	0	12
Reticulon-4 receptor-like 2	Rtn4rl2	0	13	Leucyl-cystinyl aminopeptidase	Lnpep	0	12
Seizure protein 6	Sez6	0	13	Low-density lipoprotein receptor	Ldlr	0	12
Solute carrier family 12 member 7	Slc12a7	0	13	Neurotrimin	Ntm	0	12
Solute carrier family 12 member 9	Slc12a9	0	13	Phosphatidylinositol-binding clathrin assembly protein	Picalm	0	12
Trophoblast glycoprotein	Tpbg	0	13	Synaptotagmin-1	Syt1	0	12
Lysosome-associated membrane glycoprotein 2	Lamp2	1	12	Excitatory amino acid transporter 2	Slc1a2	0	11
Amyloid beta A4 protein	App	0	12	Poliovirus receptor-related protein 2	Pvrl2	0	11
Golgi integral membrane protein 4	Golim4	0	12	Reticulon-4 receptor-like 2	Rtn4rl2	0	11
High affinity cationic amino acid transporter 1	Slc7a1	0	12	Uncharacterized protein C17orf68 homolog		0	11
Inositol monophosphatase 3	Impad1	0	12	Lymphocyte antigen 6H	Ly6h	1	10
Neurotrimin	Ntm	0	12	Integrin alpha-5	Itga5	0	10
Niemann-Pick C1 protein	Npc1	0	12	Latrophilin-2 (Fragment)	Lphn2	0	10
Plexin-A2	Plxna2	0	12	Protein shisa-6-like		0	10
Poliovirus receptor-related protein 2	Pvrl2	0	12	SLIT and NTRK-like protein 4	Slitrk4	0	10
Protein tweety homolog 1	Ttyh1	0	12	Sodium- and chloride-dependent creatine transporter 1	Slc6a8	0	10
Sodium/potassium-transporting ATPase subunit beta-2	Atp1b2	0	12	Sodium-coupled neutral amino acid transporter 2	Slc38a2	0	10
Solute carrier family 12 member 2	Slc12a2	0	12	SPARC-related modular calcium-binding protein 1	Smoc1	0	10

Alkaline phosphatase, tissue-nonspecific isozyme	Alpl	0	11	Tetraspanin-6	Tspan6	0	10
Alpha-1,6-mannosyl-glycoprotein 2-beta-N-acetylglucosaminyltransferase	Mgat2	0	11	Tetraspanin-7	Tspan7	0	10
Contactin-4	Cntn4	0	11	Uncharacterized protein KIAA0319-like	Kiaa0319l	0	10
Glypican-1	Gpc1	0	11	Alpha-1,6-mannosyl-glycoprotein 2-beta-N-acetylglucosaminyltransferase	Mgat2	0	9
Immunoglobulin superfamily member 8	Igsf8	0	11	Armadillo repeat-containing protein 10	Armc10	0	9
Latrophilin-2 (Fragment)	Lphn2	0	11	Contactin-6	Cntn6	0	9
Neurexin-1-alpha	Nrxn1	0	11	Ganglioside-induced differentiation-associated protein 1-like 1	Gdap1l1	0	9
Neuronal growth regulator 1	Negr1	0	11	Low-density lipoprotein receptor-related protein 8	Lrp8	0	9
Protein tweety homolog 3	Ttyh3	0	11	OX-2 membrane glycoprotein	Cd200	0	9
Solute carrier family 23 member 2	Slc23a2	0	11	Protein tweety homolog 1	Ttyh1	0	9
Tetraspanin-6	Tspan6	0	11	Protocadherin Fat 4	Fat4	0	9
Armadillo repeat-containing protein 10	Armc10	1	10	Seizure 6-like protein 2	Sez6l2	0	9
Alpha-type platelet-derived growth factor receptor	Pdgfra	0	10	SLIT and NTRK-like protein 1	Slitrk1	0	9
Cell adhesion molecule 1	Cadm1	0	10	Solute carrier family 12 member 2	Slc12a2	0	9
Ciliary neurotrophic factor receptor subunit alpha	Cntfr	0	10	Solute carrier family 12 member 7	Slc12a7	0	9
Contactin-6	Cntn6	0	10	Solute carrier family 23 member 2	Slc23a2	0	9
Latrophilin-1	Lphn1	0	10	Transmembrane emp24 domain-containing protein 4	Tmed4	0	9
Polypeptide N-acetylgalactosaminyltransferase 1	Galnt1	0	10	Transmembrane emp24 domain-containing protein 9	Tmed9	0	9
Seizure 6-like protein 2	Sez6l2	0	10	Sodium- and chloride-dependent taurine transporter	Slc6a6	1	8
Sodium- and chloride-dependent creatine transporter 1	Slc6a8	0	10	Uncharacterized protein C6orf174 homolog		1	8
Sodium/myo-inositol cotransporter	Slc5a3	0	10	Ephrin type-A receptor 4	Epha4	0	8
Tetraspanin-7	Tspan7	0	10	Neuroligin-1	Nlgn1	0	8
Ephrin type-A receptor 4	Epha4	0	9	Neuronal growth regulator 1	Negr1	0	8
Ephrin-B3	Efnb3	0	9	Pannexin-1	Panx1	0	8
Gamma-glutamyltransferase 7	Ggt7	0	9	Protein FAM3C	Fam3c	0	8
Leucine-rich repeat neuronal protein 1	Lrrn1	0	9	Seizure protein 6	Sez6	0	8
Receptor-type tyrosine-protein phosphatase eta	Ptprj	0	9	Sulfhydryl oxidase 2	Qsox2	0	8

Transmembrane protein 2	Tmem2	0	9	Transmembrane protein 33	Tmem33	0	8
Brevican core protein	Bcan	1	8	SLIT-ROBO Rho GTPase-activating protein 3	Srgap3	1	7
UPF0635 protein C6orf134 homolog		1	8	Dystroglycan	Dag1	0	7
Cadherin EGF LAG seven-pass G-type receptor 3	Celsr3	0	8	Frizzled-2	Fzd2	0	7
CD44 antigen	Cd44	0	8	Galectin-1	Lgals1	0	7
Choline transporter-like protein 2	Slc44a2	0	8	High affinity cationic amino acid transporter 1	Slc7a1	0	7
Insulin receptor	Insr	0	8	Liprin-alpha-3	Ppfia3	0	7
Lipid phosphate phosphatase-related protein type 3	Lppr3	0	8	Low-density lipoprotein receptor-related protein 4	Lrp4	0	7
Nidogen-1	Nid1	0	8	Neurexin-1-alpha	Nrxn1	0	7
SLIT and NTRK-like protein 2	Slitrk2	0	8	Neuropilin-1	Nrp1	0	7
SLIT and NTRK-like protein 4	Slitrk4	0	8	Repulsive guidance molecule A	Rgma	0	7
Tenascin-R	Tnr	0	8	Roundabout homolog 1	Robo1	0	7
Very low-density lipoprotein receptor	Vldlr	0	8	Sodium-coupled neutral amino acid transporter 1	Slc38a1	0	7
Alpha-mannosidase 2C1	Man2c1	1	7	Solute carrier family 12 member 9	Slc12a9	0	7
Sphingomyelin phosphodiesterase 2	Smpd2	1	7	Transmembrane protein 132A	Tmem132a	0	7
Basic fibroblast growth factor receptor 1	Fgfr1	0	7	V-type proton ATPase 116 kDa subunit a isoform 2	Atp6v0a2	0	7
Beta-1,4-galactosyltransferase 5	B4galt5	0	7	Zinc transporter SLC39A7	Slc39a7	0	7
Dystroglycan	Dag1	0	7	ATP-binding cassette sub-family D member 3	Abcd3	1	6
GDNF family receptor alpha-2	Gfra2	0	7	Beta-hexosaminidase subunit beta	Hexb	1	6
Glutamate receptor 2	Gria2	0	7	Discoidin, CUB and LCCL domain-containing protein 2	Dcbld2	0	6
Glypican-6	Gpc6	0	7	Dolichyl-phosphate beta-glucosyltransferase	Alg5	0	6
Poliovirus receptor-related protein 1	Pvrl1	0	7	Glycoprotein endo-alpha-1,2-mannosidase-like protein	Maneal	0	6
Prostaglandin F2 receptor negative regulator	Ptgfrn	0	7	Kelch repeat and BTB domain-containing protein 4	Kbtbd4	0	6
Protocadherin Fat 4	Fat4	0	7	Leukocyte surface antigen CD47	Cd47	0	6
SLIT and NTRK-like protein 1	Slitrk1	0	7	Limbic system-associated membrane protein	Lsamp	0	6
Transmembrane protein 132E	Tmem132e	0	7	Major prion protein	Prnp	0	6
Transmembrane protein 9	Tmem9	0	7	Tenascin-R	Tnr	0	6
UPF0552 protein C15orf38 homolog		0	7	Thyroid adenoma-associated protein homolog	Thada	0	6
Tetraspanin-31	Tspan31	1	6	Uncharacterized protein KIAA1211	Kiaa1211	0	6

C-type mannose receptor 2	Mrc2	0	6	Voltage-dependent calcium channel subunit alpha-2/delta-2	Cacna2d2	0	6
Dolichyl-phosphate beta-glucosyltransferase	Alg5	0	6	Amyloid-like protein 1	Aplp1	0	5
IgLON family member 5	Iglon5	0	6	BEN domain-containing protein 3	Bend3	0	5
Keratinocyte-associated transmembrane protein 2	Kct2	0	6	BolA-like protein 1	Bola1	0	5
Leukocyte surface antigen CD47	Cd47	0	6	Cadherin EGF LAG seven-pass G-type receptor 2	Celsr2	0	5
Orphan sodium- and chloride-dependent neurotransmitter transporter NTT4	Slc6a17	0	6	Contactin-4	Cntn4	0	5
Phospholipase D3	Pld3	0	6	Extracellular leucine-rich repeat and fibronectin type-III domain-containing protein 1	Elfn1	0	5
Protein dispatched homolog 2	Disp2	0	6	Fibulin-2	Fbln2	0	5
Protein FAM20B	Fam20b	0	6	Frizzled-7	Fzd7	0	5
Protein ITFG3	Itfg3	0	6	GDNF family receptor alpha-2	Gfra2	0	5
Sodium-coupled neutral amino acid transporter 1	Slc38a1	0	6	Glutamate receptor, ionotropic kainate 2	Grik2	0	5
Solute carrier family 22 member 23	Slc22a23	0	6	Golgi membrane protein 1	Golm1	0	5
Sortilin	Sort1	0	6	Leucine-rich repeat-containing protein 40	Lrrc40	0	5
Uncharacterized protein KIAA1467	Kiaa1467	0	6	Monoacylglycerol lipase ABHD12	Abhd12	0	5
Vezatin	Vezt	0	6	Protein tweety homolog 3	Ttyh3	0	5
Voltage-dependent calcium channel subunit alpha-2/delta-2	Cacna2d2	0	6	Pumilio domain-containing protein C14orf21 homolog		0	5
Protein tyrosine phosphatase-like protein PTPLAD1	Ptplad1	1	5	Receptor-type tyrosine-protein phosphatase gamma	Ptprg	0	5
SLIT-ROBO Rho GTPase-activating protein 3	Srgap3	1	5	Reelin	Reln	0	5
Calsyntenin-1	Clstn1	0	5	SLIT and NTRK-like protein 2	Slitrk2	0	5
Crumbs homolog 2	Crb2	0	5	Syndecan-3	Sdc3	0	5
Disks large-associated protein 4	Dlgap4	0	5	Transmembrane emp24 domain-containing protein 1	Tmed1	0	5
Galactosylgalactosylxylosylprotein 3-beta-glucuronosyltransferase 3	B3gat3	0	5	Transmembrane protein 9	Tmem9	0	5
Galectin-1	Lgals1	0	5	Glyceraldehyde-3-phosphate dehydrogenase	Gapdh	110	737
GDNF family receptor alpha-1	Gfra1	0	5	Tubulin beta-4 chain	Tubb4	0	358
Glutamate receptor 1	Gria1	0	5	Tubulin alpha-1C chain	Tuba1c	0	205
H(+)/Cl(-) exchange transporter 3	Clcn3	0	5	Alpha-internexin	Ina	29	145

Heparan sulfate 2-O-sulfotransferase 1	Hs2st1	0	5	T-complex protein 1 subunit beta	Cct2	16	128
Integrin beta-5	Itgb5	0	5	Voltage-dependent anion-selective channel protein 3	Vdac3	11	115
Leucine-rich repeat-containing protein 8C	Lrrc8c	0	5	Actin, alpha cardiac muscle 1	Actc1	0	113
Potassium-transporting ATPase alpha chain 1	Atp4a	0	5	Protein arginine N-methyltransferase 1	Prmt1	13	110
Seizure 6-like protein	Sez6l	0	5	Adenylyl cyclase-associated protein 1	Cap1	8	100
Sodium-coupled neutral amino acid transporter 2	Slc38a2	0	5	Drebrin	Dbn1	14	74
Vascular cell adhesion protein 1	Vcam1	0	5	Lamina-associated polypeptide 2, isoforms alpha/zeta	Tmpo	5	71
Vesicular integral-membrane protein VIP36	Lman2	0	5	Heterogeneous nuclear ribonucleoprotein A3	Hnrnpa3	5	63
Voltage-dependent calcium channel gamma-8 subunit	Cacng8	0	5	Nucleolar protein 58	Nop58	2	61
Voltage-dependent anion-selective channel protein 3	Vdac3	15	122	Beta-actin-like protein 2	Actbl2	0	61
Alpha-internexin	Ina	11	86	Ras-related protein Rab-14	Rab14	8	55
T-complex protein 1 subunit beta	Cct2	10	73	Inositol monophosphatase 1	Impa1	9	51
Lamina-associated polypeptide 2, isoforms alpha/zeta	Tmpo	4	57	Heterogeneous nuclear ribonucleoprotein F	Hnrnpf	7	50
Prolyl endopeptidase	Prep	4	53	Tumor suppressor p53-binding protein 1	Tp53bp1	2	46
Histone H2A.J	H2afj	0	44	L-asparaginase	Asrgl1	8	46
Thymidylate synthase	Tyms	0	41	Mitochondrial carrier homolog 2	Mtch2	2	44
Adenylyl cyclase-associated protein 1	Cap1	4	39	Exportin-5	Xpo5	8	42
S-methyl-5~-thioadenosine phosphorylase	Mtap	4	36	Cytoplasmic FMR1-interacting protein 2	Cyfip2	2	41
Nucleolar protein 58	Nop58	5	36	Triple functional domain protein	Trio	1	40
Proline-, glutamic acid- and leucine-rich protein 1	Pelp1	3	35	Nuclear pore complex protein Nup155	Nup155	3	40
Lethal(2) giant larvae protein homolog 1	Llgl1	6	35	Phosphoacetylglucosamine mutase	Pgm3	5	40
F-actin-capping protein subunit beta	Capzb	4	32	Crk-like protein	Crkl	0	39
Mitochondrial carrier homolog 2	Mtch2	6	31	S-methyl-5~-thioadenosine phosphorylase	Mtap	1	37
Beta-actin-like protein 2	Actbl2	0	28	E3 ubiquitin-protein ligase HUWE1	Huwe1	6	37
E3 ubiquitin-protein ligase HUWE1	Huwe1	3	27	CLIP-associating protein 1	Clasp1	5	34
Glycogen phosphorylase, brain form	Pygb	4	27	Lethal(2) giant larvae protein homolog 1	Llgl1	5	34
Serine/threonine-protein kinase DCLK2	Dclk2	2	26	Glutathione S-transferase Mu 5	Gstm5	3	33

Crk-like protein	Crkl	0	26	Phosphoribosylformylglycinamidine synthase	Pfas	6	33
Tumor suppressor p53-binding protein 1	Tp53bp1	1	25	Acyl-coenzyme A thioesterase 1	Acot1	4	32
Dynamin-1-like protein	Dnm1l	2	24	Glutathione reductase, mitochondrial	Gsr	4	32
Centrosomal protein of 170 kDa	Cep170	4	24	Vesicle-associated membrane protein-associated protein A	Vapa	6	32
Keratin, type II cuticular Hb6	Krt86	0	24	Bifunctional protein NCOAT	Mgea5	4	31
Serine/threonine-protein phosphatase PP1-alpha catalytic subunit	Ppp1ca	3	22	Heterogeneous nuclear ribonucleoprotein L-like	Hnrpll	4	31
26S proteasome non-ATPase regulatory subunit 13	Psmd13	4	22	Proline-, glutamic acid- and leucine-rich protein 1	Pelp1	4	30
Histone H2B type 3-A	Hist3h2ba	0	22	Structural maintenance of chromosomes flexible hinge domain-containing protein 1	Smchd1	6	30
Keratin, type I cuticular Ha1	Krt31	0	22	Thymidylate synthase	Tyms	0	30
Ran-binding protein 3	Ranbp3	1	21	DNA-(apurinic or apyrimidinic site) lyase	Apex1	3	29
Enhancer of mRNA-decapping protein 4	Edc4	4	21	GMP synthase [glutamine-hydrolyzing]	Gmps	5	29
Protein RUFY3	Rufy3	4	21	Interferon-inducible double stranded RNA-dependent protein kinase activator A	Prkra	5	29
Methylosome protein 50	Wdr77	2	20	Dedicator of cytokinesis protein 7	Dock7	0	29
CLIP-associating protein 1	Clasp1	1	19	Probable global transcription activator SNF2L1	Smarca1	0	29
Membrane-associated progesterone receptor component 1	Pgrmc1	2	19	Methylosome protein 50	Wdr77	1	27
Keratin, type II cuticular Hb1 (Fragment)	Krt81	0	19	Destrin	Dstn	3	26
Cytoplasmic FMR1-interacting protein 2	Cyfip2	1	18	Vesicle-associated membrane protein-associated protein B	Vapb	0	26
KH domain-containing, RNA-binding, signal transduction-associated protein 1	Khdrbs1	2	18	Ubiquitin carboxyl-terminal hydrolase 7	Usp7	1	25
Zinc finger protein 326	Znf326	2	18	Putative oxidoreductase GLYR1	Glyr1	4	25
Trifunctional purine biosynthetic protein adenosine-3	Gart	3	17	Kinesin-like protein KIF21A	Kif21a	3	24
Keratin, type II cuticular Hb3	Krt83	0	17	Trifunctional purine biosynthetic protein adenosine-3	Gart	0	24
Keratin, type II cuticular Hb5	Krt85	0	17	Actin-related protein 2/3 complex subunit 1A	Arpc1a	1	23
Fragile X mental retardation syndrome-related protein 1	Fxr1	0	16	Rho guanine nucleotide exchange factor 12	Arhgef12	2	23
CDKN2A-interacting protein	Cdkn2aip	1	15	Zinc finger protein 326	Znf326	3	23

Cytoplasmic dynein 1 light intermediate chain 1	Dync1li1	3	15	Zinc finger protein 638	Znf638	3	23
40S ribosomal protein S10	Rps10	1	14	Calretinin	Calb2	0	23
Opioid growth factor receptor	Ogfr	1	14	Keratin, type II cytoskeletal 75	Krt75	0	23
Peroxiredoxin-5, mitochondrial	Prdx5	1	14	Inorganic pyrophosphatase	Ppa1	1	22
SUMO-activating enzyme subunit 2	Uba2	2	14	3~(2~),5~-bisphosphate nucleotidase 1	Bpnt1	2	22
BAG family molecular chaperone regulator 5	Bag5	0	14	Ubiquitin thioesterase OTUB1	Otub1	3	22
Protein phosphatase 1E	Ppm1e	0	14	Scaffold attachment factor B2	Safb2	4	22
Serine/threonine-protein phosphatase 4 regulatory subunit 1	Ppp4r1	0	14	CLIP-associating protein 2	Clasp2	2	21
Zinc finger protein 512	Znf512	0	14	Protein MON2 homolog	Mon2	2	21
Diacylglycerol kinase epsilon	Dgke	1	13	KH domain-containing, RNA-binding, signal transduction-associated protein 1	Khdrbs1	3	21
Proteasome assembly chaperone 1	Psmg1	1	13	Importin-7	Ipo7	4	21
Protein NDRG2	Ndrg2	1	13	Kinesin-like protein KIF21B	Kif21b	4	21
Neurobeachin	Nbea	2	13	Microtubule-associated protein 1A	Map1a	0	21
Superkiller viralicidic activity 2-like 2	Skiv2l2	2	13	Kinesin light chain 1	Klc1	2	20
Keratin, type I cytoskeletal 15	Krt15	0	13	Serine/threonine-protein phosphatase PP1-beta catalytic subunit	Ppp1cb	2	20
Kinesin heavy chain isoform 5A	Kif5a	0	13	Tyrosine-protein kinase BAZ1B	Baz1b	3	20
60 kDa SS-A/Ro ribonucleoprotein	Trove2	1	12	NMDA receptor-regulated protein 1	Narg1	4	20
Nucleobindin-1	Nucb1	1	12	Aladin	Aaas	0	20
Scaffold attachment factor B2	Safb2	1	12	Sister chromatid cohesion protein PDS5 homolog A	Pds5a	3	19
Adenylosuccinate lyase	Adsl	2	12	Nuclear receptor coactivator 5	Ncoa5	0	19
Prostaglandin E synthase 3	Ptges3	2	12	Nucleoporin NUP188 homolog	Nup188	1	18
60S ribosomal protein L35	Rpl35	0	12	General transcription factor 3C polypeptide 1	Gtf3c1	2	18
Calretinin	Calb2	0	12	Thioredoxin-like protein 1	Txnl1	2	18
DNA (cytosine-5)-methyltransferase 3A	Dnmt3a	0	12	Glycogen phosphorylase, brain form	Pygb	3	18
Keratin, type I cuticular Ha5	Krt35	0	12	2~,5~-phosphodiesterase 12	Pde12	0	18
Hydroxyacyl-coenzyme A dehydrogenase, mitochondrial	Hadh	1	11	Histone-arginine methyltransferase CARM1	Carm1	0	18
Phosphoribosyl pyrophosphate synthase-associated protein 1	Prpsap1	1	11	MMS19 nucleotide excision repair protein homolog	Mms19	1	17

Ubiquitin carboxyl-terminal hydrolase 10	Usp10	2	11	Prostaglandin E synthase 3	Ptges3	1	17
Microsomal glutathione S-transferase 3	Mgst3	0	11	Tropomyosin alpha-3 chain	Tpm3	1	17
Plasminogen activator inhibitor 1 RNA-binding protein	Serbp1	0	11	Nucleophosmin	Npm1	2	17
ARF GTPase-activating protein GIT1	Git1	1	10	40S ribosomal protein S12	Rps12	3	17
cAMP-dependent protein kinase catalytic subunit beta	Prkacb	1	10	Anaphase-promoting complex subunit 1	Anapc1	3	17
Splicing factor, arginine/serine-rich 13A	Sfrs13a	1	10	Huntingtin	Htt	0	17
C-Jun-amino-terminal kinase-interacting protein 3	Mapk8ip3	2	10	Protein FAM98B	Fam98b	0	17
Cytoplasmic tRNA 2-thiolation protein 2	Ctu2	2	10	Death-inducer obliterator 1	Dido1	2	16
Neurochondrin	Ncdn	2	10	5~-3~ exoribonuclease 2	Xrn2	3	16
S-formylglutathione hydrolase	Esd	2	10	Ubiquitin-conjugating enzyme E2 variant 2	Ube2v2	3	16
2~,5~-phosphodiesterase 12	Pde12	0	10	Importin-9	Ipo9	0	16
3~(2~),5~-bisphosphate nucleotidase 1	Bpnt1	0	10	Nucleoside diphosphate kinase B	Nme2	0	16
Hepatoma-derived growth factor	Hdgf	0	10	Tyrosine-protein kinase CSK	Csk	0	16
Interferon-inducible double stranded RNA-dependent protein kinase activator A	Prkra	0	10	Ubiquitin carboxyl-terminal hydrolase 24	Usp24	0	16
Keratin, type I cuticular Ha4	Krt34	0	10	Hemoglobin subunit zeta	Hbz	1	15
Kinesin light chain 4	Klc4	0	10	60 kDa SS-A/Ro ribonucleoprotein	Trove2	2	15
Tubulin-specific chaperone D	Tbcd	0	10	Ubiquitin carboxyl-terminal hydrolase 4	Usp4	3	15
60S ribosomal protein L32	Rpl32	1	9	BAG family molecular chaperone regulator 5	Bag5	0	15
Cytosolic acyl coenzyme A thioester hydrolase	Acot7	1	9	Kinesin light chain 4	Klc4	0	15
Replication factor C subunit 4	Rfc4	1	9	Neurofibromin	Nf1	0	15
Zinc finger CCCH domain-containing protein 11A	Zc3h11a	1	9	RAC-alpha serine/threonine-protein kinase	Akt1	0	15
A-kinase anchor protein 8	Akap8	0	9	Sterile alpha and TIR motif-containing protein 1	Sarm1	0	15
Cofilin-2	Cfl2	0	9	60S ribosomal protein L7	Rpl7	1	14
Pyrroline-5-carboxylate reductase 3	Pycrl	0	9	Sentrin-specific protease 7	Senp7	1	14
Rho-related GTP-binding protein RhoC	Rhoc	0	9	Synaptojanin-1	Synj1	1	14
Septin-8	Sept8	0	9	N-acylneuraminate cytidylyltransferase	Cmas	2	14
SWI/SNF-related matrix-associated actin-dependent regulator of chromatin subfamily D member 3	Smarcd3	0	9	NEDD8 ultimate buster 1	Nub1	2	14

2-amino-3-ketobutyrate coenzyme A ligase, mitochondrial	Gcat	1	8	Phosphomevalonate kinase	Pmvk	2	14
Cell division control protein 2 homolog	Cdc2	1	8	Tubulin-specific chaperone D	Tbcd	2	14
Choline-phosphate cytidylyltransferase A	Pcyt1a	1	8	Keratin, type I cytoskeletal 13	Krt13	0	14
Ubiquitin carboxyl-terminal hydrolase 24	Usp24	1	8	LanC-like protein 2	Lancl2	0	14
Actin-related protein 2/3 complex subunit 5-like protein	Arpc5l	0	8	Proteasome assembly chaperone 1	Psmg1	0	14
E3 ubiquitin-protein ligase MARCH5	March5	0	8	SWI/SNF-related matrix-associated actin-dependent regulator of chromatin subfamily D member 3	Smarcd3	0	14
Phosphoacetylglucosamine mutase	Pgm3	0	8	Xaa-Pro aminopeptidase 1	Xpnpep1	1	13
SH3 domain-binding glutamic acid-rich-like protein	Sh3bgrl	0	8	Zinc finger protein 512	Znf512	1	13
Sorting nexin-27	Snx27	0	8	60S ribosomal protein L21	Rpl21	2	13
40S ribosomal protein S24	Rps24	1	7	Eukaryotic translation initiation factor 4B	Eif4b	2	13
Adenylosuccinate synthetase isozyme 2	Adss	1	7	Cell division protein kinase 5	Cdk5	0	13
Phosphatidylinositol-5-phosphate 4-kinase type-2 beta	Pip4k2b	1	7	NEDD8-activating enzyme E1 catalytic subunit	Uba3	0	13
RNA 3~-terminal phosphate cyclase	Rtcd1	1	7	Serine/threonine-protein kinase VRK1	Vrk1	0	13
Sentrin-specific protease 7	Senp7	1	7	tRNA-dihydrouridine synthase 3-like	Dus3l	0	13
Sideroflexin-3	Sfxn3	1	7	Ubiquitin carboxyl-terminal hydrolase 10	Usp10	0	13
Triple functional domain protein	Trio	1	7	A-kinase anchor protein 8	Akap8	1	12
Tyrosyl-DNA phosphodiesterase 1	Tdp1	1	7	DmX-like protein 2	Dmxl2	1	12
Zinc finger protein 638	Znf638	1	7	Proteasome activator complex subunit 2	Psme2	1	12
ADP-ribosylation factor 1	Arf1	0	7	Zinc finger ZZ-type and EF-hand domain-containing protein 1	Zzef1	1	12
Cell division protein kinase 5	Cdk5	0	7	Copine-1	Cpne1	2	12
Coiled-coil domain-containing protein 22	Ccdc22	0	7	Ubiquitin-conjugating enzyme E2 O	Ube2o	2	12
General transcription factor 3C polypeptide 1	Gtf3c1	0	7	A-kinase anchor protein 12	Akap12	0	12
Keratin, type I cytoskeletal 13	Krt13	0	7	Alpha-centractin	Actr1a	0	12
Kinesin light chain 2	Klc2	0	7	Eukaryotic initiation factor 4A-II	Eif4a2	0	12
Lysophosphatidylcholine acyltransferase 1	Lpcat1	0	7	Sorting nexin-27	Snx27	0	12
Microtubule-associated protein 1A	Map1a	0	7	Tyrosine-protein phosphatase non-receptor type 1	Ptpn1	0	12

Mitogen-activated protein kinase 10	Mapk10	0	7	Phospholipid hydroperoxide glutathione peroxidase, mitochondrial	Gpx4	1	11
Mitogen-activated protein kinase 8	Mapk8	0	7	WD repeat-containing protein 47	Wdr47	1	11
MMS19 nucleotide excision repair protein homolog	Mms19	0	7	Cytoplasmic tRNA 2-thiolation protein 2	Ctu2	2	11
Nuclear receptor coactivator 5	Ncoa5	0	7	Phosphatidylinositol 3,4,5-trisphosphate-dependent Rac exchanger 1 protein	Prex1	2	11
Programmed cell death 6-interacting protein	Pdcd6ip	0	7	Proteasome activator complex subunit 1	Psme1	2	11
Succinate dehydrogenase cytochrome b560 subunit, mitochondrial	Sdhc	0	7	Proteasome activator complex subunit 4	Psme4	2	11
TBC1 domain family member 13	Tbc1d13	0	7	Serine/threonine-protein phosphatase 5	Ppp5c	2	11
Tetratricopeptide repeat protein 5	Ttc5	0	7	Splicing factor, arginine/serine-rich 13A	Sfrs13a	2	11
Torsin-1A-interacting protein 1	Tor1aip1	0	7	THO complex subunit 2	Thoc2	2	11
Transcriptional activator protein Pur-alpha	Pura	0	7	A.T hook DNA-binding motif-containing protein 1	Ahdc1	0	11
Transcriptional regulator ATRX	Atrx	0	7	Adenylosuccinate synthetase isozyme 2	Adss	0	11
Tyrosine-protein kinase CSK	Csk	0	7	Basic leucine zipper and W2 domain-containing protein 1	Bzw1	0	11
6-phosphofructokinase, liver type	Pfkl	1	6	COP9 signalosome complex subunit 7b	Cops7b	0	11
Calpain-2 catalytic subunit	Capn2	1	6	Keratin, type I cytoskeletal 15	Krt15	0	11
CTP synthase 1	Ctps	1	6	Nucleobindin-1	Nucb1	0	11
Cytochrome c oxidase subunit 4 isoform 1, mitochondrial	Cox4i1	1	6	NudC domain-containing protein 1	Nudcd1	0	11
NADH dehydrogenase [ubiquinone] 1 alpha subcomplex subunit 10, mitochondrial	Ndufa10	1	6	Programmed cell death 6-interacting protein	Pdcd6ip	0	11
Phospholipid hydroperoxide glutathione peroxidase, mitochondrial	Gpx4	1	6	Protein ELYS	Ahctf1	0	11
Pogo transposable element with ZNF domain	Pogz	1	6	Protein LAS1 homolog	Las1l	0	11
Protein FAM49B	Fam49b	1	6	Putative splicing factor, arginine/serine-rich 14	Sfrs14	0	11
Serine/threonine-protein phosphatase 4 regulatory subunit 2	Ppp4r2	1	6	Ras-related protein Rab-10	Rab10	0	11
39S ribosomal protein L15, mitochondrial	Mrpl15	0	6	Spastin	Spast	0	11
Cold shock domain-containing protein E1	Csde1	0	6	Asparagine synthetase [glutamine-hydrolyzing]	Asns	1	10
Cold-inducible RNA-binding protein	Cirbp	0	6	Cullin-associated NEDD8-dissociated protein 2	Cand2	1	10

E3 ubiquitin-protein ligase TTC3	Ttc3	0	6	Kelch-like ECH-associated protein 1	Keap1	1	10
Exportin-7	Xpo7	0	6	Phosphoribosyl pyrophosphate synthase-associated protein 1	Prpsap1	1	10
Fermitin family homolog 2	Fermt2	0	6	Drebrin-like protein	Dbnl	2	10
Glycylpeptide N-tetradecanoyltransferase 2	Nmt2	0	6	Kinesin-like protein KIF1A	Kif1a	2	10
Hemoglobin subunit beta-1	Hbb-b1	0	6	Large proline-rich protein BAT3	Bat3	2	10
Keratin, type II cuticular Hb2	Krt82	0	6	Serine-threonine kinase receptor-associated protein	Strap	2	10
Kinetochore-associated protein 1	Kntc1	0	6	ADP-ribosylation factor 1	Arf1	0	10
Myotubularin-related protein 5	Sbf1	0	6	Centrosomal protein of 97 kDa	Cep97	0	10
NEDD8-activating enzyme E1 catalytic subunit	Uba3	0	6	Diacylglycerol kinase epsilon	Dgke	0	10
NudC domain-containing protein 1	Nudcd1	0	6	E3 ubiquitin-protein ligase BRE1B	Rnf40	0	10
Phosphoprotein associated with glycosphingolipid-enriched microdomains 1	Pag1	0	6	Fragile X mental retardation syndrome-related protein 1	Fxr1	0	10
Phosphorylated adapter RNA export protein	Phax	0	6	Histone deacetylase 2	Hdac2	0	10
Proteasome activator complex subunit 2	Psme2	0	6	Nuclear pore complex protein Nup214	Nup214	0	10
Ras-related protein Rab-6A	Rab6a	0	6	Proteasome assembly chaperone 2	Psmg2	0	10
Signal peptidase complex catalytic subunit SEC11A	Sec11a	0	6	Protein FAM49B	Fam49b	0	10
Treacle protein	Tcof1	0	6	Ras-related C3 botulinum toxin substrate 3	Rac3	0	10
Tyrosine-protein phosphatase non-receptor type 11	Ptpn11	0	6	Ras-related protein Rap-1A	Rap1a	0	10
UMP-CMP kinase 2, mitochondrial	Cmpk2	0	6	TBC1 domain family member 13	Tbc1d13	0	10
Uncharacterized protein C19orf43 homolog		0	6	Transcriptional activator protein Pur-alpha	Pura	0	10
WD repeat domain phosphoinositide-interacting protein 3	Wdr45l	0	6	Translation initiation factor eIF-2B subunit delta	Eif2b4	0	10
3-hydroxyacyl-CoA dehydrogenase type-2	Hsd17b10	1	5	Vacuolar protein sorting-associated protein 4A	Vps4a	0	10
60S ribosomal protein L13a	Rpl13a	1	5	WD repeat-containing protein 91	Wdr91	0	10
ADP-ribosylation factor-like protein 6-interacting protein 1	Arl6ip1	1	5	Rho guanine nucleotide exchange factor 2	Arhgef2	1	9
ATP synthase subunit f, mitochondrial	Atp5j2	1	5	Serine/threonine-protein phosphatase 4 regulatory subunit 2	Ppp4r2	1	9
Catenin delta-1	Ctnnd1	1	5	Arf-GAP with GTPase, ANK repeat and PH domain-containing protein 3	Agap3	0	9
Condensin complex subunit 1	Ncapd2	1	5	cAMP-dependent protein kinase type II-alpha	Prkar2a	0	9

				regulatory subunit			
Copine-2	Cpne2	1	5	CAP-Gly domain-containing linker protein 2	Clip2	0	9
Cytoplasmic dynein 1 intermediate chain 2	Dync1i2	1	5	Diphosphoinositol polyphosphate phosphohydrolase 1	Nudt3	0	9
Dihydrofolate reductase	Dhfr	1	5	Ester hydrolase C11orf54 homolog		0	9
Dynactin subunit 2	Dctn2	1	5	Eukaryotic translation initiation factor 3 subunit L	Eif3l	0	9
Immunity-related GTPase family Q protein	Irgq	1	5	Hepatoma-derived growth factor	Hdgf	0	9
Long-chain-fatty-acid--CoA ligase 4	Acsl4	1	5	Histone deacetylase 6	Hdac6	0	9
Nucleoporin NUP188 homolog	Nup188	1	5	Histone H2A.V	H2afv	0	9
Sorting nexin-1	Snx1	1	5	Hydroxyacyl-coenzyme A dehydrogenase, mitochondrial	Hadh	0	9
Striatin-4	Strn4	1	5	Luc7-like protein 3	Luc7l3	0	9
Thioredoxin-related transmembrane protein 2	Tmx2	1	5	NFATC2-interacting protein	Nfatc2ip	0	9
Trans-2,3-enoyl-CoA reductase	Tecr	1	5	Nuclear RNA export factor 1	Nxf1	0	9
Zinc finger CCCH domain-containing protein 4	Zc3h4	1	5	Serine/threonine-protein phosphatase 6 regulatory subunit 3	Saps3	0	9
60S acidic ribosomal protein P1	Rplp1	0	5	Translin	Tsn	0	9
Branched-chain-amino-acid aminotransferase, cytosolic	Bcat1	0	5	tRNA (guanine-N(7)-)-methyltransferase subunit WDR4	Wdr4	0	9
Catenin alpha-2	Ctnna2	0	5	U2-associated protein SR140	Sr140	0	9
Cyclic AMP-responsive element-binding protein 1	Creb1	0	5	UPF0600 protein C5orf51 homolog		0	9
Ester hydrolase C11orf54 homolog		0	5	Uridine 5~-monophosphate synthase	Umps	0	9
Eukaryotic translation initiation factor 3 subunit G	Eif3g	0	5	WD repeat and FYVE domain-containing protein 3	Wdfy3	0	9
Glutamate--cysteine ligase catalytic subunit	Gclc	0	5	60S ribosomal protein L26	Rpl26	1	8
GrpE protein homolog 1, mitochondrial	Grpel1	0	5	Cytosolic acyl coenzyme A thioester hydrolase	Acot7	1	8
Guanine nucleotide-binding protein subunit alpha-13	Gna13	0	5	Glucose-6-phosphate isomerase	Gpi	1	8
Histone H1.0	H1f0	0	5	Nipped-B-like protein	Nipbl	1	8
Inorganic pyrophosphatase 2, mitochondrial	Ppa2	0	5	Serine/arginine repetitive matrix protein 2	Srrm2	1	8
Mitochondrial import inner membrane translocase subunit Tim17-B	Timm17b	0	5	2-amino-3-ketobutyrate coenzyme A ligase, mitochondrial	Gcat	0	8
Parafibromin	Cdc73	0	5	AMP deaminase 2	Ampd2	0	8

Protein farnesyltransferase/geranylgeranyltransferase type-1 subunit alpha	Fnta	0	5	C-Jun-amino-terminal kinase-interacting protein 3	Mapk8ip3	0	8
Protein phosphatase 1A	Ppm1a	0	5	Constitutive coactivator of PPAR-gamma-like protein 1	FAM120A	0	8
Septin-10	Sept10	0	5	Diphosphoinositol polyphosphate phosphohydrolase 3-alpha	Nudt10	0	8
Serine/threonine-protein kinase 24	Stk24	0	5	Elongator complex protein 4	Elp4	0	8
Sister chromatid cohesion protein PDS5 homolog B	Pds5b	0	5	Hamartin	Tsc1	0	8
Testis-expressed sequence 10 protein	Tex10	0	5	Hemoglobin subunit beta-1	Hbb-b1	0	8
tRNA-dihydrouridine synthase 3-like	Dus3l	0	5	Microsomal glutathione S-transferase 3	Mgst3	0	8
Ubiquitin-conjugating enzyme E2 L3	Ube2l3	0	5	Mitochondrial-processing peptidase subunit beta	Pmpcb	0	8
Ubiquitin-conjugating enzyme E2 variant 2	Ube2v2	0	5	Myotubularin-related protein 5	Sbf1	0	8
				NAD-dependent malic enzyme, mitochondrial	Me2	0	8
				Phosphorylated adapter RNA export protein	Phax	0	8
				Pre-mRNA-processing factor 40 homolog A	Prpf40a	0	8
				Protein prune homolog	Prune	0	8
				Putative ATP-dependent RNA helicase DHX57	Dhx57	0	8
				Ral GTPase-activating protein subunit alpha-1	Ralgapa1	0	8
				Ras-related protein Rab-5B	Rab5b	0	8
				RNA-binding protein 4	Rbm4	0	8
				Selenium-binding protein 1	Selenbp1	0	8
				Serine/threonine-protein kinase WNK2	Wnk2	0	8
				T-complex protein 11-like protein 1	Tcp11l1	0	8
				Terminal uridylyltransferase 4	Zcchc11	0	8
				Ubiquitin carboxyl-terminal hydrolase 34	Usp34	0	8
				Ubiquitin-conjugating enzyme E2 L3	Ube2l3	0	8
				Zinc finger protein neuro-d4	Dpf1	0	8
				AP-3 complex subunit delta-1	Ap3d1	1	7
				CCR4-NOT transcription complex subunit 7	Cnot7	1	7
				E3 ubiquitin-protein ligase TRIM33	Trim33	1	7
				E3 ubiquitin-protein ligase TTC3	Ttc3	1	7

Isopentenyl-diphosphate Delta-isomerase 1	Idi1	1	7
Prolactin regulatory element-binding protein	Preb	1	7
Scavenger mRNA-decapping enzyme DcpS	Dcps	1	7
Spermatogenesis-associated serine-rich protein 2	Spats2	1	7
Torsin-1A-interacting protein 1	Tor1aip1	1	7
Transcriptional repressor p66-beta	Gatad2b	1	7
Aminoacyl tRNA synthetase complex-interacting multifunctional protein 1	Aimp1	0	7
Aminoacyl tRNA synthetase complex-interacting multifunctional protein 2	Aimp2	0	7
Caspase-6	Casp6	0	7
Catenin delta-2	Ctnnd2	0	7
Cell division control protein 2 homolog	Cdc2	0	7
E3 ubiquitin-protein ligase BRE1A	Rnf20	0	7
Fibronectin type III and SPRY domain-containing protein 1	Fsd1	0	7
GTP-binding protein 1	Gtpbp1	0	7
Guanine nucleotide-binding protein subunit alpha-13	Gna13	0	7
Histone H3.2	Hist1h3b	0	7
Histone-binding protein RBBP7	Rbbp7	0	7
Hydroxymethylglutaryl-CoA lyase, mitochondrial	Hmgcl	0	7
Integrator complex subunit 5	Ints5	0	7
Kinesin light chain 2	Klc2	0	7
NAC-alpha domain-containing protein 1	Nacad	0	7
Nuclear-interacting partner of ALK	Zc3hc1	0	7
Phosphatidylinositol-5-phosphate 4-kinase type-2 beta	Pip4k2b	0	7
Poly(A)-specific ribonuclease PARN	Parn	0	7
Protein fto	Fto	0	7
Protein phosphatase Slingshot homolog 2	Ssh2	0	7
Protein VAC14 homolog	Vac14	0	7
Ras-related protein Rab-8B	Rab8b	0	7
Septin-10	Sept10	0	7

Serine/threonine-protein kinase WNK1	Wnk1	0	7
Testis-expressed sequence 10 protein	Tex10	0	7
tRNA (adenine-N(1)-)-methyltransferase non-catalytic subunit TRM6	Trmt6	0	7
Tuberin	Tsc2	0	7
Type I inositol-3,4-bisphosphate 4-phosphatase	Inpp4a	0	7
Ubiquitin-like modifier-activating enzyme 6	Uba6	0	7
Uncharacterized protein C19orf43 homolog		0	7
Zinc finger protein 609	Znf609	0	7
Zinc finger protein 618	Znf618	0	7
Ankyrin-2	Ank2	1	6
cAMP-dependent protein kinase catalytic subunit beta	Prkacb	1	6
Cytochrome c oxidase subunit 2	Mtco2	1	6
Cytosolic Fe-S cluster assembly factor NUBP2	Nubp2	1	6
Elongator complex protein 3	Elp3	1	6
Inactive hydroxysteroid dehydrogenase-like protein 1	Hsdl1	1	6
LanC-like protein 1	Lancl1	1	6
NADH dehydrogenase [ubiquinone] 1 alpha subcomplex subunit 10, mitochondrial	Ndufa10	1	6
Negative elongation factor E	Rdbp	1	6
Neurochondrin	Ncdn	1	6
Oligosaccharyltransferase complex subunit OSTC	Ostc	1	6
Plasminogen activator inhibitor 1 RNA-binding protein	Serbp1	1	6
Sorting nexin-1	Snx1	1	6
Transformation/transcription domain-associated protein	Trrap	1	6
Vacuolar protein sorting-associated protein 18 homolog	Vps18	1	6
Activator of 90 kDa heat shock protein ATPase homolog 1	Ahsa1	0	6
Beta-arrestin-2	Arrb2	0	6
Copine-2	Cpne2	0	6

Dual specificity mitogen-activated protein kinase kinase 4	Map2k4	0	6
Dynactin subunit 2	Dctn2	0	6
E3 ubiquitin-protein ligase MARCH5	March5	0	6
Glycine dehydrogenase [decarboxylating], mitochondrial	Gldc	0	6
Hemoglobin subunit beta-H1	Hbb-bh1	0	6
LIM domain and actin-binding protein 1	Lima1	0	6
Multivesicular body subunit 12B	Fam125b	0	6
Nitrilase homolog 1	Nit1	0	6
N-terminal acetyltransferase B complex subunit MDM20	Mdm20	0	6
Nucleoporin NDC1	Tmem48	0	6
Polymerase delta-interacting protein 2	Poldip2	0	6
Proteasome subunit beta type-2	Psmb2	0	6
Protein enabled homolog	Enah	0	6
Protein FAM118B	Fam118b	0	6
Protein NDRG2	Ndrg2	0	6
Protein N-terminal asparagine amidohydrolase	Ntan1	0	6
Protein Shroom2	Shroom2	0	6
Ras-related protein Rab-12	Rab12	0	6
Ras-related protein Rab-33B	Rab33b	0	6
REST corepressor 2	Rcor2	0	6
Rho guanine nucleotide exchange factor 7	Arhgef7	0	6
Rho-associated protein kinase 2	Rock2	0	6
SAM domain and HD domain-containing protein 1	Samhd1	0	6
Septin-8	Sept8	0	6
Serine/threonine-protein kinase MRCK alpha	Cdc42bpa	0	6
STIP1 homology and U box-containing protein 1	Stub1	0	6
SUMO-conjugating enzyme UBC9	Ube2i	0	6
TBC1 domain family member 24	Tbc1d24	0	6
THUMP domain-containing protein 3	Thumpd3	0	6
Transcriptional activator protein Pur-beta	Purb	0	6

Twinfilin-2	Twf2	0	6
U2 small nuclear ribonucleoprotein A~	Snrpa1	0	6
Ubiquitin carboxyl-terminal hydrolase 15	Usp15	0	6
Ubiquitin-conjugating enzyme E2 D3	Ube2d3	0	6
Ubiquitin-like protein 4A	Ubl4a	0	6
UPF0363 protein C7orf20 homolog		0	6
WD repeat domain phosphoinositide-interacting protein 3	Wdr45l	0	6
Apoptotic chromatin condensation inducer in the nucleus	Acin1	1	5
Catenin alpha-2	Ctnna2	1	5
COP9 signalosome complex subunit 6	Cops6	1	5
Hematological and neurological expressed 1-like protein	Hn1l	1	5
Sterol-4-alpha-carboxylate 3-dehydrogenase, decarboxylating	Nsdhl	1	5
Synaptobrevin homolog YKT6	Ykt6	1	5
Trans-2,3-enoyl-CoA reductase	Tecr	1	5
AH receptor-interacting protein	Aip	0	5
Ataxin-2	Atxn2	0	5
ATPase WRNIP1	Wrnip1	0	5
Beta-arrestin-1	Arrb1	0	5
Calcineurin-like phosphoesterase domain-containing protein 1	Cpped1	0	5
Calcium/calmodulin-dependent protein kinase type II subunit alpha	Camk2a	0	5
COBW domain-containing protein 1	Cbwd1	0	5
Cysteine protease ATG4B	Atg4b	0	5
Derlin-1	Derl1	0	5
Endoribonuclease Dicer	Dicer1	0	5
Gephyrin	Gphn	0	5
GTP-binding protein GUF1 homolog	Guf1	0	5
Histone H3.3	H3f3a	0	5
Integrin-linked kinase-associated serine/threonine	Ilkap	0	5

phosphatase 2C			
Kinetochore-associated protein 1	Kntc1	0	5
Lysophosphatidylcholine acyltransferase 1	Lpcat1	0	5
Mitochondrial import receptor subunit TOM40 homolog	Tomm40	0	5
Mitogen-activated protein kinase 9	Mapk9	0	5
Myosin light polypeptide 6	Myl6	0	5
Myosin-Ib	Myo1b	0	5
Non-syndromic hearing impairment protein 5 homolog	Dfna5	0	5
Nuclear pore complex protein Nup133	Nup133	0	5
Nuclear valosin-containing protein-like	Nvl	0	5
Nucleolar protein 9	Nol9	0	5
Phosphomannomutase 2	Pmm2	0	5
Phosphoprotein associated with glycosphingolipid-enriched microdomains 1	Pag1	0	5
Phosphoribosyl pyrophosphate synthase-associated protein 2	Prpsap2	0	5
Probable saccharopine dehydrogenase	Sccpdh	0	5
Protein farnesyltransferase/geranylgeranyltransferase type-1 subunit alpha	Fnta	0	5
Rho GTPase-activating protein 21	Arhgap21	0	5
Ribosomal RNA processing protein 1 homolog B	Rrp1b	0	5
Striatin	Strn	0	5
TBC domain-containing protein kinase-like protein	Tbck	0	5
T-box brain protein 1	Tbr1	0	5
Tubulin-folding cofactor B	Tbcb	0	5
Ubiquitin carboxyl-terminal hydrolase 48	Usp48	0	5
Ubiquitin-fold modifier-conjugating enzyme 1	Ufc1	0	5
Ubiquitin-like modifier-activating enzyme 5	Uba5	0	5
Ubiquitin-protein ligase E3C	Ube3c	0	5
UBX domain-containing protein 4	Ubxn4	0	5
YEATS domain-containing protein 4	Yeats4	0	5

	YrdC domain-containing protein, mitochondrial	Yrdc	0	5

Supporting Table S2

Sialylated glycoproteins selectively identified with high confidence in coculture or noncoculture samples by mass spectrometry. Identified glycoproteins were categorized into the high-confidence list if they were identified in Ac_4ManNAz treated samples with ≥ 5 spectral counts and ≥ 5 folds increase above the vehicle-administered samples and located in cell membrane, ER/Golgi or secreted pathway. Ratio indicated spectral counts of proteins in Ac_4ManNAz treated coculture over in Ac_4ManNAz treated noncoculture.

Protein Name	Gene Name	Coculture		Noncoculture		High confidence in		Ratio
		Blank	Ac4ManNAz	Blank	Ac4ManNAz	Coculture	Noncoculture	
Neural cell adhesion molecule 1	Ncam1	9	505	11	532	√	√	0.95
Prolow-density lipoprotein receptor-related protein 1	Lrp1	7	272	12	255	√	√	1.07
4F2 cell-surface antigen heavy chain	Slc3a2	21	102	7	61		√	1.67
Golgi apparatus protein 1	Glg1	13	79	4	75	√	√	1.05
Reticulon-4	Rtn4	16	74	11	74		√	1.00
Leucine-rich repeat-containing protein 4B	Lrrc4b	1	72	1	62	√	√	1.16
Sodium/potassium-transporting ATPase subunit beta-1	Atp1b1	6	70	8	67	√	√	1.04
Neuronal membrane glycoprotein M6-a	Gpm6a	4	68	3	62	√	√	1.10
Cation-independent mannose-6-phosphate receptor	Igf2r	0	67	0	52	√	√	1.29
Plexin-B1	Plxnb1	0	66	1	57	√	√	1.16
Ephrin-B1	Efnb1	9	62	9	63	√	√	0.98
Excitatory amino acid transporter 1 (Glast)	Slc1a3	4	61	0	27	√	√	2.26
Neuronal cell adhesion molecule	Nrcam	2	60	2	41	√	√	1.46
Synaptic vesicle glycoprotein 2A	Sv2a	1	57	1	31	√	√	1.84
Neuroligin-2	Nlgn2	0	51	0	40	√	√	1.28
Glypican-2	Gpc2	0	50	0	82	√	√	0.61
Contactin-1	Cntn1	5	49	1	24	√	√	2.04
Low-density lipoprotein receptor	Ldlr	2	47	0	12	√	√	3.92
Netrin receptor DCC	Dcc	2	47	5	36	√	√	1.31

V-type proton ATPase 116 kDa subunit a isoform 1	Atp6v0a1	3	46	7	37	√	√	1.24
Immunoglobulin superfamily containing leucine-rich repeat protein 2	Islr2	0	46	1	38	√	√	1.21
Neuroligin-3	Nlgn3	3	46	1	58	√	√	0.79
Receptor-type tyrosine-protein phosphatase alpha	Ptpra	1	45	0	34	√	√	1.32
Sodium- and chloride-dependent GABA transporter 3	Slc6a11	4	44	3	25	√	√	1.76
Coxsackievirus and adenovirus receptor homolog	Cxadr	1	44	0	37	√	√	1.19
Integrin beta-1	Itgb1	2	42	0	26	√	√	1.62
Transferrin receptor protein 1	Tfrc	4	39	1	36	√	√	1.08
Neurofascin	Nfasc	0	38	0	22	√	√	1.73
Neogenin	Neo1	0	35	0	34	√	√	1.03
Sodium/potassium-transporting ATPase subunit beta-3	Atp1b3	0	34	0	37	√	√	0.92
Versican core protein	Vcan	0	33	0	18	√	√	1.83
Integrin alpha-6	Itga6	3	33	0	23	√	√	1.43
Immunoglobulin superfamily member 3	Igsf3	0	33	0	35	√	√	0.94
Neural cell adhesion molecule 2	Ncam2	0	32	0	15	√	√	2.13
Neuronal membrane glycoprotein M6-b	Gpm6b	2	32	0	26	√	√	1.23
Cell adhesion molecule 4	Cadm4	0	32	0	41	√	√	0.78
Neural cell adhesion molecule L1	L1cam	0	31	0	17	√	√	1.82
Carboxypeptidase D	Cpd	0	31	0	34	√	√	0.91
Glypican-4	Gpc4	1	31	2	48	√	√	0.65
Chondroitin sulfate proteoglycan 4 (NG2)	Cspg4	0	30	0	0	√		60.00
Sodium- and chloride-dependent taurine transporter	Slc6a6	2	30	1	8	√	√	3.75
Reticulon-1	Rtn1	2	29	3	18	√	√	1.61
Ephrin type-B receptor 2	Ephb2	0	29	0	23	√	√	1.26
Neuropilin-2	Nrp2	0	29	0	27	√	√	1.07
Lactadherin	Mfge8	0	29	0	32	√	√	0.91

Delta and Notch-like epidermal growth factor-related receptor	Dner	0	28	0	12	√	√	2.33
Solute carrier family 2, facilitated glucose transporter member 1	Slc2a1	2	28	0	22	√	√	1.27
Cadherin-2	Cdh2	0	28	0	26	√	√	1.08
Agrin	Agrn	0	28	0	47	√	√	0.60
Glucosylceramidase	Gba	0	26	4	22	√	√	1.18
Solute carrier family 12 member 5	Slc12a5	0	26	0	27	√	√	0.96
Roundabout homolog 2	Robo2	2	25	3	14	√		1.79
Protocadherin Fat 3	Fat3	0	25	1	32	√	√	0.78
EGF-like repeat and discoidin I-like domain-containing protein 3	Edil3	0	24	0	20	√	√	1.20
BDNF/NT-3 growth factors receptor	Ntrk2	0	23	0	14	√	√	1.64
Chloride transport protein 6	Clcn6	0	23	0	18	√	√	1.28
Latrophilin-3	Lphn3	0	23	0	20	√	√	1.15
Nicastrin	Ncstn	1	23	1	20	√	√	1.15
Voltage-dependent calcium channel subunit alpha-2/delta-1	Cacna2d1	0	23	0	30	√	√	0.77
Large neutral amino acids transporter small subunit 1	Slc7a5	1	22	0	13	√	√	1.69
Cell adhesion molecule 2	Cadm2	0	22	0	14	√	√	1.57
Sulfhydryl oxidase 2	Qsox2	0	21	0	8	√	√	2.63
Excitatory amino acid transporter 2	Slc1a2	0	21	0	11	√	√	1.91
Basement membrane-specific heparan sulfate proteoglycan core protein	Hspg2	0	20	0	16	√	√	1.25
CD166 antigen	Alcam	0	19	0	0	√		38.00
Leucyl-cystinyl aminopeptidase	Lnpep	0	19	0	12	√	√	1.58
Neutral amino acid transporter A	Slc1a4	0	19	0	16	√	√	1.19
Receptor-type tyrosine-protein phosphatase gamma	Ptprg	0	18	0	5	√	√	3.60
Lymphocyte antigen 6H	Ly6h	0	18	1	10	√	√	1.80
Protein CASC4	Casc4	0	18	0	13	√	√	1.38

Neuroplastin	Nptn	0	18	0	14	√	√	1.29
Lysosomal acid phosphatase	Acp2	0	18	0	16	√	√	1.13
Anoctamin-6	Ano6	0	18	0	17	√	√	1.06
Leucine-rich repeat-containing protein 8A	Lrrc8a	0	18	0	17	√	√	1.06
Neurocan core protein	Ncan	0	18	0	18	√	√	1.00
Lysosome membrane protein 2	Scarb2	0	18	0	24	√	√	0.75
Epidermal growth factor receptor	Egfr	1	17	0	0	√		34.00
Limbic system-associated membrane protein	Lsamp	0	17	0	6	√	√	2.83
Sodium bicarbonate cotransporter 3	Slc4a7	0	17	0	13	√	√	1.31
Tyrosine-protein kinase-like 7	Ptk7	2	17	1	13	√	√	1.31
Immunoglobulin superfamily member 21	Igsf21	0	16	0	3	√		5.33
Tenascin	Tnc	2	16	1	4	√		4.00
OX-2 membrane glycoprotein	Cd200	2	16	0	9	√	√	1.78
Astrotactin-1	Astn1	1	16	0	12	√	√	1.33
Synaptotagmin-1	Syt1	0	16	0	12	√	√	1.33
Phosphatidylinositol-binding clathrin assembly protein	Picalm	4	16	0	12		√	1.33
G-protein coupled receptor 56	Gpr56	0	16	0	15	√	√	1.07
Immunoglobulin superfamily DCC subclass member 4	Igdcc4	0	16	0	15	√	√	1.07
Sodium- and chloride-dependent GABA transporter 1	Slc6a1	2	16	1	16	√	√	1.00
SLIT-ROBO Rho GTPase-activating protein 2	Srgap2	3	16	1	19	√	√	0.84
Prominin-1	Prom1	0	16	0	20	√	√	0.80
Electrogenic sodium bicarbonate cotransporter 1	Slc4a4	0	15	0	2	√		7.50
Integrin alpha-5	Itga5	0	15	0	10	√	√	1.50
Uncharacterized protein KIAA0319-like	Kiaa0319l	0	15	0	10	√	√	1.50
Cell cycle control protein 50A	Tmem30a	0	15	0	13	√	√	1.15
GPI inositol-deacylase	Pgap1	4	15	0	15		√	1.00
Transmembrane 9 superfamily member 3	Tm9sf3	0	15	0	28	√	√	0.54
Insulin-like growth factor 1 receptor	Igf1r	0	15	0	35	√	√	0.43

Leucine-rich repeat and immunoglobulin-like domain-containing nogo receptor-interacting protein 1	Lingo1	0	14	0	0	√		28.00
Transmembrane emp24 domain-containing protein 4	Tmed4	0	14	0	9	√	√	1.56
Cell adhesion molecule 3	Cadm3	0	14	0	14	√	√	1.00
Podocalyxin-like protein 2	Podxl2	0	14	0	14	√	√	1.00
Ephrin-B2	Efnb2	0	14	0	29	√	√	0.48
Neuropilin-1	Nrp1	0	13	0	7	√	√	1.86
Repulsive guidance molecule A	Rgma	0	13	0	7	√	√	1.86
Solute carrier family 12 member 9	Slc12a9	0	13	0	7	√	√	1.86
Seizure protein 6	Sez6	0	13	0	8	√	√	1.63
Low-density lipoprotein receptor-related protein 8	Lrp8	0	13	0	9	√	√	1.44
Solute carrier family 12 member 7	Slc12a7	0	13	0	9	√	√	1.44
Transmembrane emp24 domain-containing protein 9	Tmed9	1	13	0	9	√	√	1.44
Reticulon-4 receptor-like 2	Rtn4rl2	0	13	0	11	√	√	1.18
Trophoblast glycoprotein	Tpbg	0	13	0	13	√	√	1.00
Integrin alpha-V	Itgav	0	13	0	15	√	√	0.87
Basigin	Bsg	1	13	0	16	√	√	0.81
Amyloid beta A4 protein	App	0	12	0	2	√		6.00
Lysosome-associated membrane glycoprotein 2	Lamp2	1	12	0	2	√		6.00
Golgi integral membrane protein 4	Golim4	0	12	0	3	√		4.00
Inositol monophosphatase 3	Impad1	0	12	0	4	√		3.00
Sodium/potassium-transporting ATPase subunit beta-2	Atp1b2	0	12	0	4	√		3.00
High affinity cationic amino acid transporter 1	Slc7a1	0	12	0	7	√	√	1.71
Protein tweety homolog 1	Ttyh1	0	12	0	9	√	√	1.33
Solute carrier family 12 member 2	Slc12a2	0	12	0	9	√	√	1.33
Poliovirus receptor-related protein 2	Pvrl2	0	12	0	11	√	√	1.09
Neurotrimin	Ntm	0	12	0	12	√	√	1.00
Niemann-Pick C1 protein	Npc1	0	12	1	12	√	√	1.00

Plexin-A2	Plxna2	0	12	1	26	√	√	0.46
Alkaline phosphatase, tissue-nonspecific isozyme	Alpl	0	11	0	1	√		11.00
Immunoglobulin superfamily member 8	Igsf8	0	11	0	4	√		2.75
Contactin-4	Cntn4	0	11	0	5	√	√	2.20
Protein tweety homolog 3	Ttyh3	0	11	0	5	√	√	2.20
Neurexin-1-alpha	Nrxn1	0	11	0	7	√	√	1.57
Neuronal growth regulator 1	Negr1	0	11	0	8	√	√	1.38
Protein FAM3C	Fam3c	3	11	0	8		√	1.38
Alpha-1,6-mannosyl-glycoprotein 2-beta-N-acetylglucosaminyltransferase	Mgat2	0	11	0	9	√	√	1.22
Solute carrier family 23 member 2	Slc23a2	0	11	0	9	√	√	1.22
Latrophilin-2 (Fragment)	Lphn2	0	11	0	10	√	√	1.10
Tetraspanin-6	Tspan6	0	11	0	10	√	√	1.10
Glypican-1	Gpc1	0	11	0	23	√	√	0.48
Polypeptide N-acetylgalactosaminyltransferase 1	Galnt1	0	10	0	1	√		10.00
Cell adhesion molecule 1	Cadm1	0	10	0	2	√		5.00
Alpha-type platelet-derived growth factor receptor	Pdgfra	0	10	0	3	√		3.33
Sodium/myo-inositol cotransporter	Slc5a3	0	10	0	3	√		3.33
Armadillo repeat-containing protein 10	Armc10	1	10	0	9	√	√	1.11
Contactin-6	Cntn6	0	10	0	9	√	√	1.11
Seizure 6-like protein 2	Sez6l2	0	10	0	9	√	√	1.11
Sodium- and chloride-dependent creatine transporter 1	Slc6a8	0	10	0	10	√	√	1.00
Tetraspanin-7	Tspan7	0	10	0	10	√	√	1.00
Latrophilin-1	Lphn1	0	10	0	14	√	√	0.71
Ciliary neurotrophic factor receptor subunit alpha	Cntfr	0	10	0	15	√	√	0.67
Leucine-rich repeat neuronal protein 1	Lrrn1	0	9	0	2	√		4.50
Receptor-type tyrosine-protein phosphatase eta	Ptprj	0	9	0	2	√		4.50
Gamma-glutamyltransferase 7	Ggt7	0	9	0	4	√		2.25
Ephrin type-A receptor 4	Epha4	0	9	0	8	√	√	1.13

Ephrin-B3	Efnb3	0	9	0	16	√	√	0.56
Transmembrane protein 2	Tmem2	0	9	0	18	√	√	0.50
Choline transporter-like protein 2	Slc44a2	0	8	0	1	√		8.00
CD44 antigen	Cd44	0	8	0	2	√		4.00
Nidogen-1	Nid1	0	8	0	2	√		4.00
Very low-density lipoprotein receptor	Vldlr	0	8	0	2	√		4.00
Lipid phosphate phosphatase-related protein type 3	Lppr3	0	8	0	3	√		2.67
Brevican core protein	Bcan	1	8	0	4	√		2.00
SLIT and NTRK-like protein 2	Slitrk2	0	8	0	5	√	√	1.60
Tenascin-R	Tnr	0	8	0	6	√	√	1.33
ATP-binding cassette sub-family D member 3	Abcd3	5	8	1	6		√	1.33
Uncharacterized protein KIAA1211	Kiaa1211	2	8	0	6		√	1.33
SLIT and NTRK-like protein 4	Slitrk4	0	8	0	10	√	√	0.80
Cadherin EGF LAG seven-pass G-type receptor 3	Celsr3	0	8	0	15	√	√	0.53
Insulin receptor	Insr	0	8	0	23	√	√	0.35
UPF0635 protein C6orf134 homolog		1	8	3	29	√	√	0.28
Basic fibroblast growth factor receptor 1	Fgfr1	0	7	0	0	√		14.00
Beta-1,4-galactosyltransferase 5	B4galt5	0	7	0	0	√		14.00
Transmembrane protein 132E	Tmem132e	0	7	0	0	√		14.00
Poliovirus receptor-related protein 1	Pvrl1	0	7	0	1	√		7.00
UPF0552 protein C15orf38 homolog		0	7	0	3	√		2.33
Prostaglandin F2 receptor negative regulator	Ptgfrn	0	7	0	4	√		1.75
GDNF family receptor alpha-2	Gfra2	0	7	0	5	√	√	1.40
Transmembrane protein 9	Tmem9	0	7	0	5	√	√	1.40
Dystroglycan	Dag1	0	7	0	7	√	√	1.00
Protocadherin Fat 4	Fat4	0	7	0	9	√	√	0.78
SLIT and NTRK-like protein 1	Slitrk1	0	7	0	9	√	√	0.78
Glutamate receptor 2	Gria2	0	7	0	12	√	√	0.58

Glypican-6	Gpc6	0	7	0	13	√	√	0.54
Alpha-mannosidase 2C1	Man2c1	1	7	1	14	√	√	0.50
Sphingomyelin phosphodiesterase 2	Smpd2	1	7	0	15	√	√	0.47
C-type mannose receptor 2	Mrc2	0	6	0	0	√		12.00
Orphan sodium- and chloride-dependent neurotransmitter transporter NTT4	Slc6a17	0	6	0	0	√		12.00
Solute carrier family 22 member 23	Slc22a23	0	6	0	0	√		12.00
Tetraspanin-31	Tspan31	1	6	0	0	√		12.00
Protein ITFG3	Itfg3	0	6	0	1	√		6.00
IgLON family member 5	Iglon5	0	6	0	2	√		3.00
Keratinocyte-associated transmembrane protein 2	Kct2	0	6	0	2	√		3.00
Sortilin	Sort1	0	6	0	2	√		3.00
Uncharacterized protein KIAA1467	Kiaa1467	0	6	0	2	√		3.00
Protein dispatched homolog 2	Disp2	0	6	0	4	√		1.50
Protein FAM20B	Fam20b	0	6	0	4	√		1.50
Vezatin	Vezt	0	6	0	4	√		1.50
Dolichyl-phosphate beta-glucosyltransferase	Alg5	0	6	0	6	√	√	1.00
Leukocyte surface antigen CD47	Cd47	0	6	0	6	√	√	1.00
Voltage-dependent calcium channel subunit alpha-2/delta-2	Cacna2d2	0	6	0	6	√	√	1.00
Sodium-coupled neutral amino acid transporter 1	Slc38a1	0	6	0	7	√	√	0.86
Phospholipase D3	Pld3	0	6	2	12	√	√	0.50
Secreted frizzled-related protein 1	Sfrp1	4	6	1	24		√	0.25
Potassium-transporting ATPase alpha chain 1	Atp4a	0	5	0	0	√		10.00
Vascular cell adhesion protein 1	Vcam1	0	5	0	0	√		10.00
Voltage-dependent calcium channel gamma-8 subunit	Cacng8	0	5	0	0	√		10.00
Calsyntenin-1	Clstn1	0	5	0	1	√		5.00

H(+)/Cl(-) exchange transporter 3	Clcn3	0	5	0	1	√		5.00
Integrin beta-5	Itgb5	0	5	0	1	√		5.00
Seizure 6-like protein	Sez6l	0	5	0	2	√		2.50
Crumbs homolog 2	Crb2	0	5	0	3	√		1.67
Galactosylgalactosylxylosylprotein 3-beta-glucuronosyltransferase 3	B3gat3	0	5	0	3	√		1.67
Leucine-rich repeat-containing protein 8C	Lrrc8c	0	5	0	3	√		1.67
GDNF family receptor alpha-1	Gfra1	0	5	0	4	√		1.25
Heparan sulfate 2-O-sulfotransferase 1	Hs2st1	0	5	0	4	√		1.25
Protein tyrosine phosphatase-like protein PTPLAD1	Ptplad1	1	5	0	4	√		1.25
Vesicular integral-membrane protein VIP36	Lman2	0	5	0	4	√		1.25
Galectin-1	Lgals1	0	5	0	7	√	√	0.71
SLIT-ROBO Rho GTPase-activating protein 3	Srgap3	1	5	1	7	√	√	0.71
Sodium-coupled neutral amino acid transporter 2	Slc38a2	0	5	0	10	√	√	0.50
Disks large-associated protein 4	Dlgap4	0	5	0	12	√	√	0.42
Glutamate receptor 1	Gria1	0	5	0	12	√	√	0.42
Amyloid-like protein 1	Aplp1	0	4	0	5		√	0.80
Golgi membrane protein 1	Golm1	0	4	0	5		√	0.80
Leucine-rich repeat-containing protein 40	Lrrc40	0	4	0	5		√	0.80
Pumilio domain-containing protein C14orf21 homolog		0	4	0	5		√	0.80
Transmembrane emp24 domain-containing protein 1	Tmed1	0	4	0	5		√	0.80
Glycoprotein endo-alpha-1,2-mannosidase-like protein	Maneal	0	4	0	6		√	0.67
Major prion protein	Prnp	0	4	0	6		√	0.67
Frizzled-2	Fzd2	0	4	0	7		√	0.57
V-type proton ATPase 116 kDa subunit a isoform 2	Atp6v0a2	0	4	0	7		√	0.57
Neuroligin-1	Nlgn1	0	4	0	8		√	0.50
Transmembrane protein 33	Tmem33	1	4	0	8		√	0.50

SPARC-related modular calcium-binding protein 1	Smoc1	0	4	0	10		√	0.40
BEN domain-containing protein 3	Bend3	0	3	0	5		√	0.60
Glutamate receptor, ionotropic kainate 2	Grik2	0	3	0	5		√	0.60
Monoacylglycerol lipase ABHD12	Abhd12	0	3	0	5		√	0.60
Reelin	Reln	1	3	0	5		√	0.60
Syndecan-3	Sdc3	0	3	0	5		√	0.60
Thyroid adenoma-associated protein homolog	Thada	0	3	0	6		√	0.50
Roundabout homolog 1	Robo1	0	3	0	7		√	0.43
Pannexin-1	Panx1	0	3	0	8		√	0.38
Ganglioside-induced differentiation-associated protein 1-like 1	Gdap1l1	0	3	0	9		√	0.33
KLRAQ motif-containing protein 1	Klraq1	0	3	2	13		√	0.23
Plexin-A1	Plxna1	0	3	0	13		√	0.23
Extracellular leucine-rich repeat and fibronectin type-III domain-containing protein 1	Elfn1	0	2	0	5		√	0.40
Beta-hexosaminidase subunit beta	Hexb	1	2	1	6		√	0.33
Low-density lipoprotein receptor-related protein 4	Lrp4	0	2	0	7		√	0.29
Uncharacterized protein C6orf174 homolog		0	2	1	8		√	0.25
Protein shisa-6-like		0	2	0	10		√	0.20
Uncharacterized protein C17orf68 homolog		0	2	0	11		√	0.18
BolA-like protein 1	Bola1	0	1	0	5		√	0.20
Cadherin EGF LAG seven-pass G-type receptor 2	Celsr2	0	1	0	5		√	0.20
Fibulin-2	Fbln2	0	1	0	5		√	0.20
Discoidin, CUB and LCCL domain-containing protein 2	Dcbld2	0	1	0	6		√	0.17
Transmembrane protein 132A	Tmem132a	0	1	0	7		√	0.14
Zinc transporter SLC39A7	Slc39a7	1	1	0	7		√	0.14
TM2 domain-containing protein 2	Tm2d2	0	1	0	24		√	0.04
Frizzled-7	Fzd7	0	0	0	5		√	0.10
Kelch repeat and BTB domain-containing protein 4	Kbtbd4	0	0	0	6		√	0.08

Liprin-alpha-3	Ppfia3	0	0	0	7		√	0.07

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