Spatial dynamics of mammalian brain development and neuroinflammation by multimodal tri-omics mapping

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Table of Contents

1
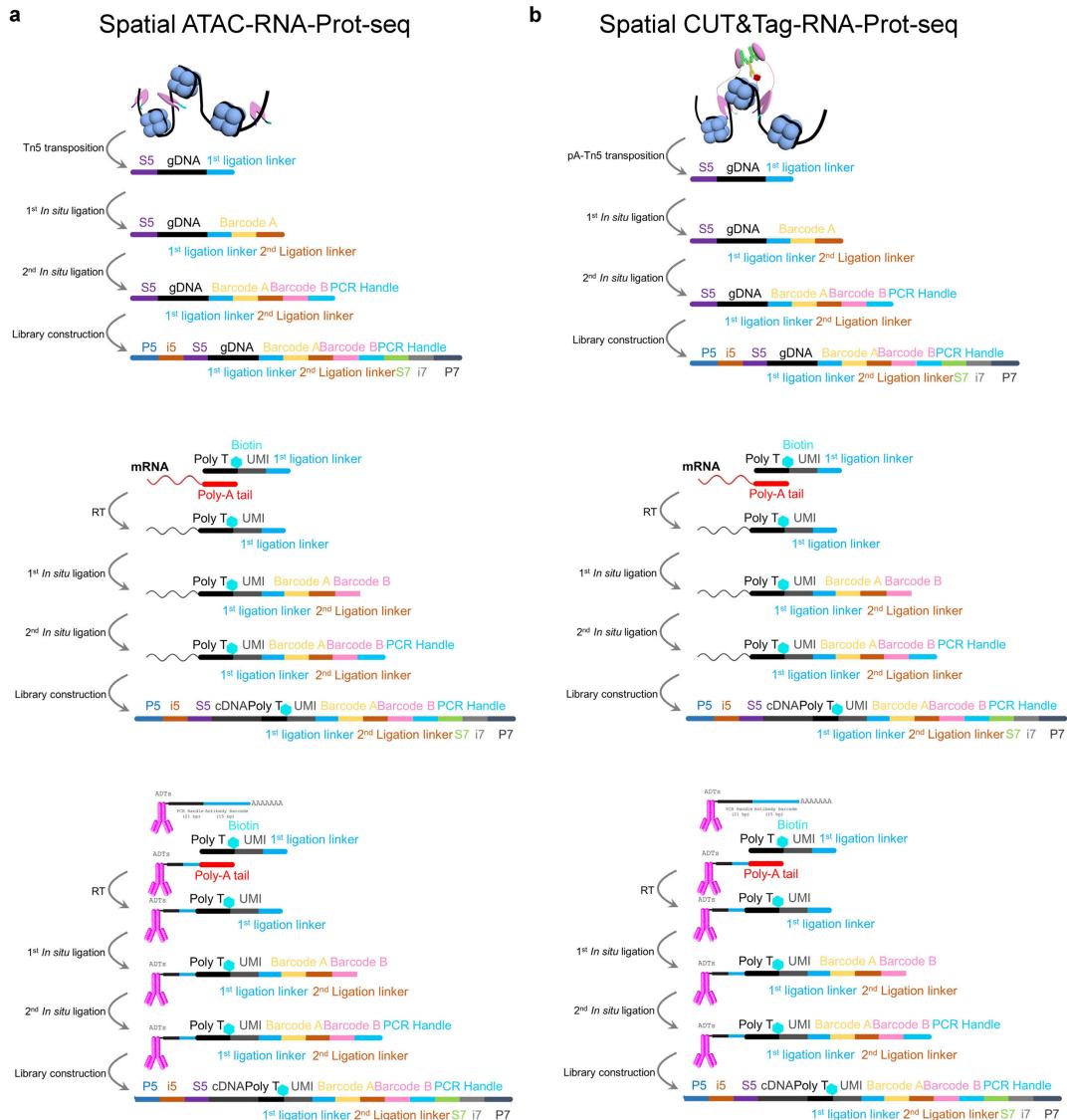
Extended Data Fig. 1 Workflow of spatial ATAC–RNA–Prot-seq (DBiT ARP-seq) and spatial CUT&Tag–RNA–Prot-seq (DBiT CTRP-seq). a, Chemistry workflow of ATAC (top), RNA (middle), and protein (bottom) in DBiT ARP-seq. **b**, Chemistry workflow of CUT&Tag (top), RNA (middle), and protein (bottom) in DBiT CTRP-seq.

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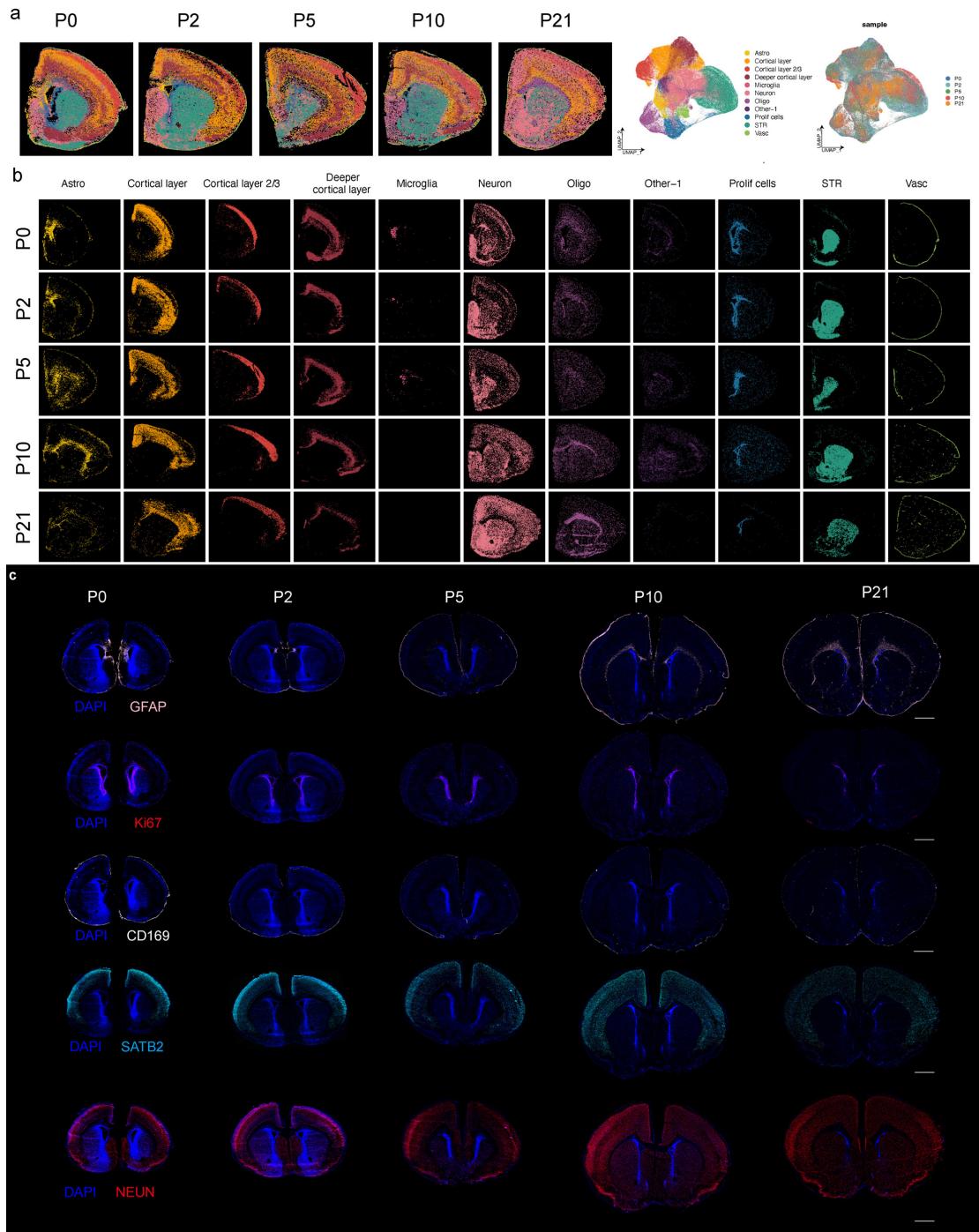
Extended Data Fig. 2 Further data analysis of CODEX images for postnatal mouse brains.

a, Seurat clustering of the CODEX images in **Fig. 1b**. **b,** Spatial map of the cell types from **a**.

c, CODEX images of GFAP, Ki67, CD169, and SATB2 for postnatal mouse brains. Scale bar,

1 mm.
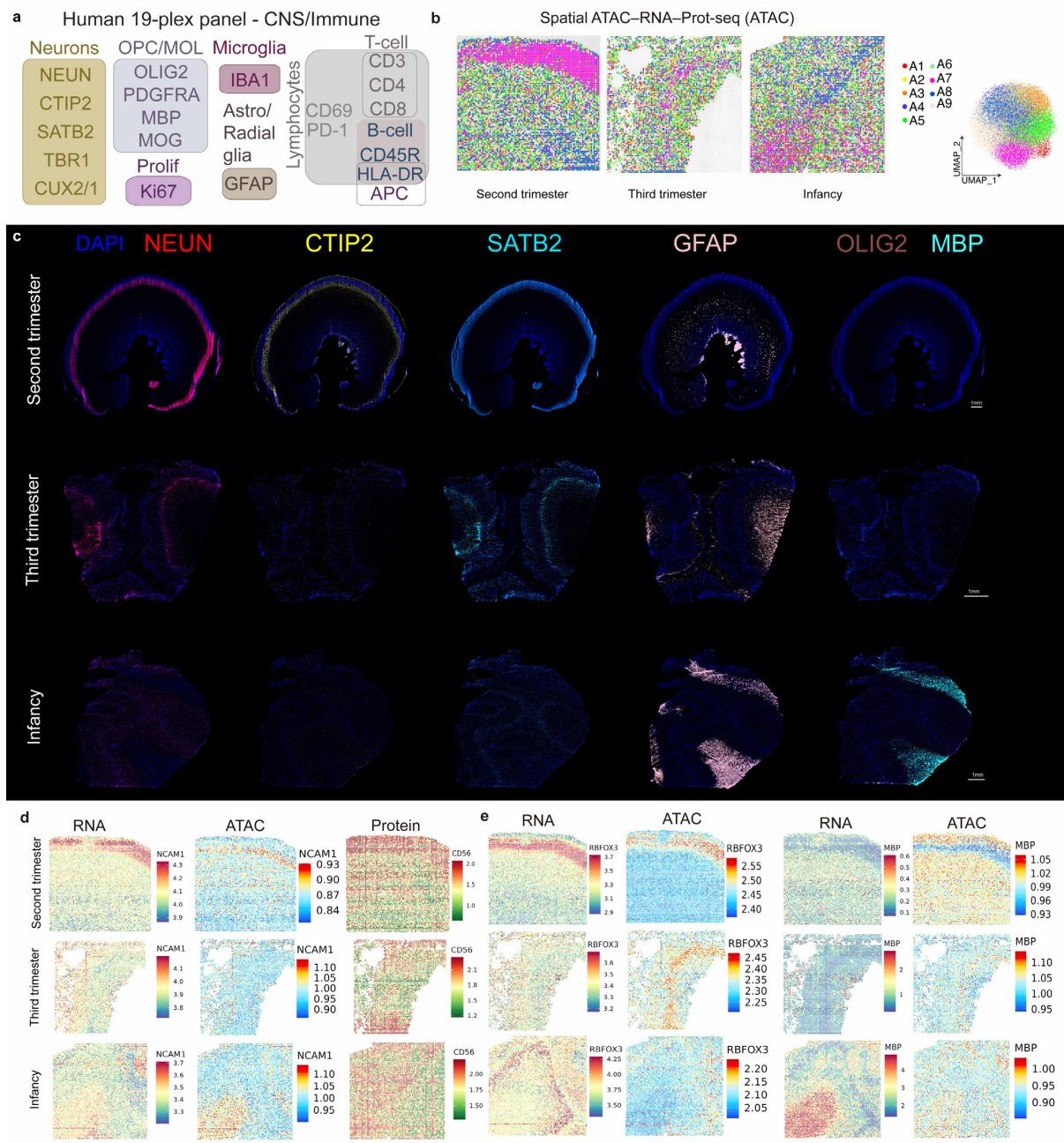
**Extended Data Fig. 3 Further data analysis of human brains in spatial ATAC–RNA–Prot-seq (DBiT ARP-seq). a**, CODEX protein panel for human. **b,** ATAC UMAP and spatial distribution of ATAC data of the human brain V1 regions at different stages. **c,** CODEX images of NEUN, CTIP2, SATB2, GFAP, OLIG2, and MBP for human brain V1 region at second trimester, third trimester, and infancy. Scale bar, 1 mm. **d,** Spatial mapping of gene expression, gene activity score (GAS), and ADT protein expression for *NCAM1*(CD56). **e,** Spatial mapping of gene expression and GAS for *RBFOX3* and *MBP*.

a

P0S1 P0S2 P0S3 P2S1 P2S2

P5S1 P5S2 P10S1 P10S2 P21S1

P21S2 LPC5S1 LPC5S2 LPC21S1 LPC21S2

LPC5_H3K27me3S1 LPC5_H3K27me3S2 LPC21_H3K27me3S1 LPC21_H3K27me3S2

Second trimester Third trimester Infacy

b

group
- P0rep1 P10rep1 LPC5_H3K27me3rep1
- P0rep2 P10rep2 LPC5_H3K27me3rep2
- P0rep3 P21rep1 LPC21_H3K27me3rep1
- P2rep1 P21rep2 LPC21_H3K27me3rep2
- P2rep2 LPC5rep1 Second trimester
- P5rep1 LPC5rep2 Third trimester
- P5rep2 LPC21rep1 Infacy LPC21rep2

1

2 **Extended Data Fig. 4 Quality control metrics for DBiT ARP-seq and DBiT CTRP-seq**
3 **datasets. a,** Scatterplots showing the TSS enrichment score vs unique nuclear fragments per
4 pixel for all the samples finished. **b,** The insert size distribution of ATAC and CUT&Tag
5 fragments (left) and the enrichment of ATAC or CUT&Tag reads around TSSs (right) in DBiT
6 ARP-seq and DBiT CTRP-seq.
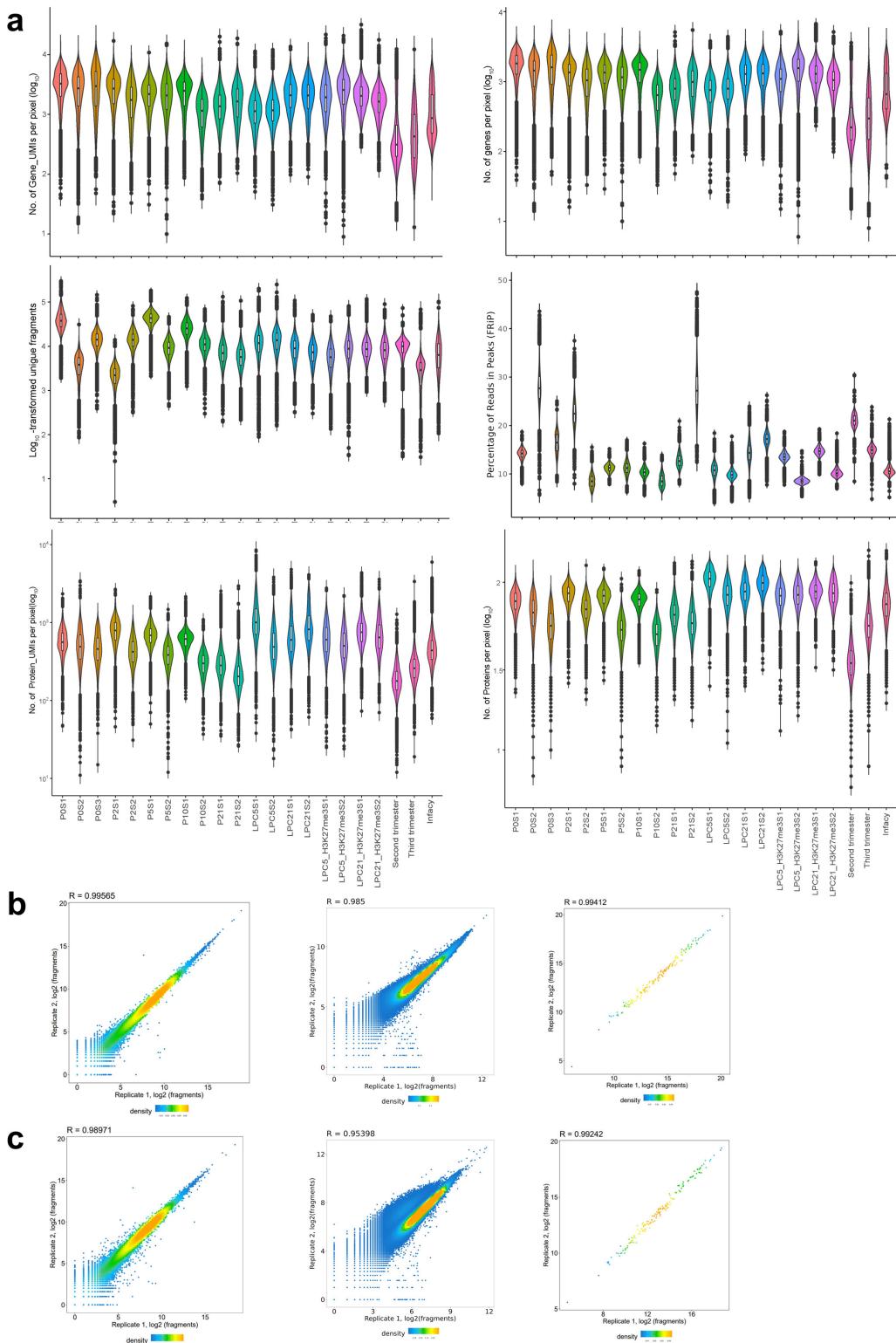
Extended Data Fig. 5 Quality control metrics for DBiT ARP-seq and DBiT CTRP-seq datasets. a, Gene and UMI count distribution (upper), comparison of number of unique fragments and fraction of reads in peaks (FRiP) (middle), ADT protein and UMI count (bottom) of processed samples for DBiT ARP-seq and DBiT CTRP-seq (H3K27me3). The box plots show the median (centre line), the first and third quartiles (box limits), and 1.5x the interquartile

range (whiskers). **b,** The reproducibility of DBiT ARP-seq between biological replicates on ATAC data (left), RNA data (middle), and ADT protein data (right) for 5DPL mouse brains. **c,** The reproducibility of DBiT CTRP-seq (H3K27me3) between biological replicates on CUT&Tag data (left), RNA data (middle), and ADT protein data (right) for 5DPL mouse brains.
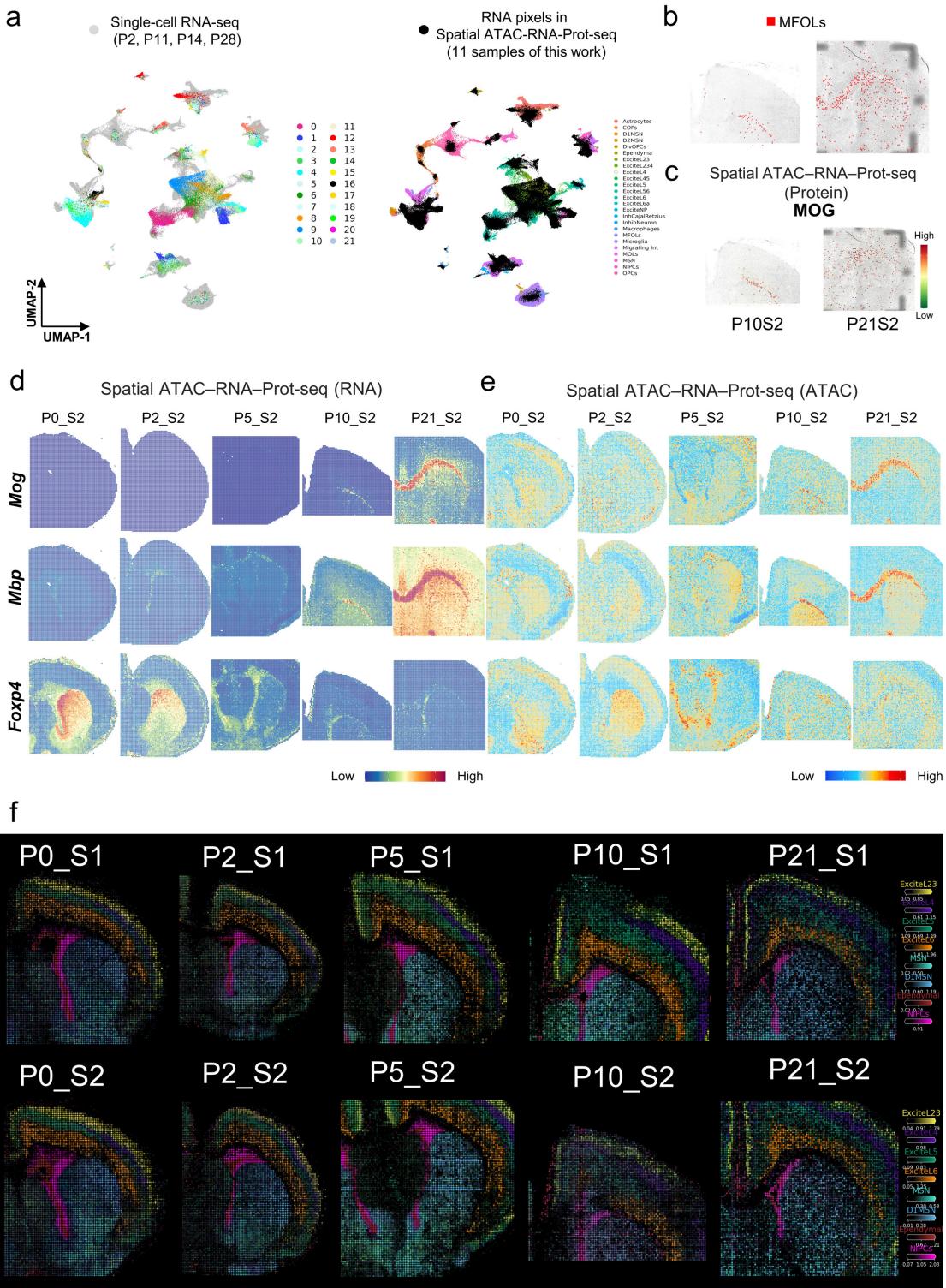
Extended Data Fig. 6 Further analysis of spatial ATAC–RNA–Prot-seq (DBiT ARP-seq) for postnatal mouse brains. a, Integration of scRNA-seq data from P2, P11, P14, P28 mouse brains with our spatial RNA data in DBiT ARP-seq. **b,** Spatial mapping of MFOLs identified by label transfer from scRNA-seq to spatial RNA of P10 and P21 mouse brains. **c,** MOG expression in P10 and P21 mouse brain from the ADT protein data in DBiT ARP-seq. **d-e,** spatial mapping of gene expression (**d**) and GAS (**e**) for selected marker genes from replicates

9

in DBiT ARP-seq. **f,** Cell types predicted by cell2location from all processed postnatal mouse brain samples.

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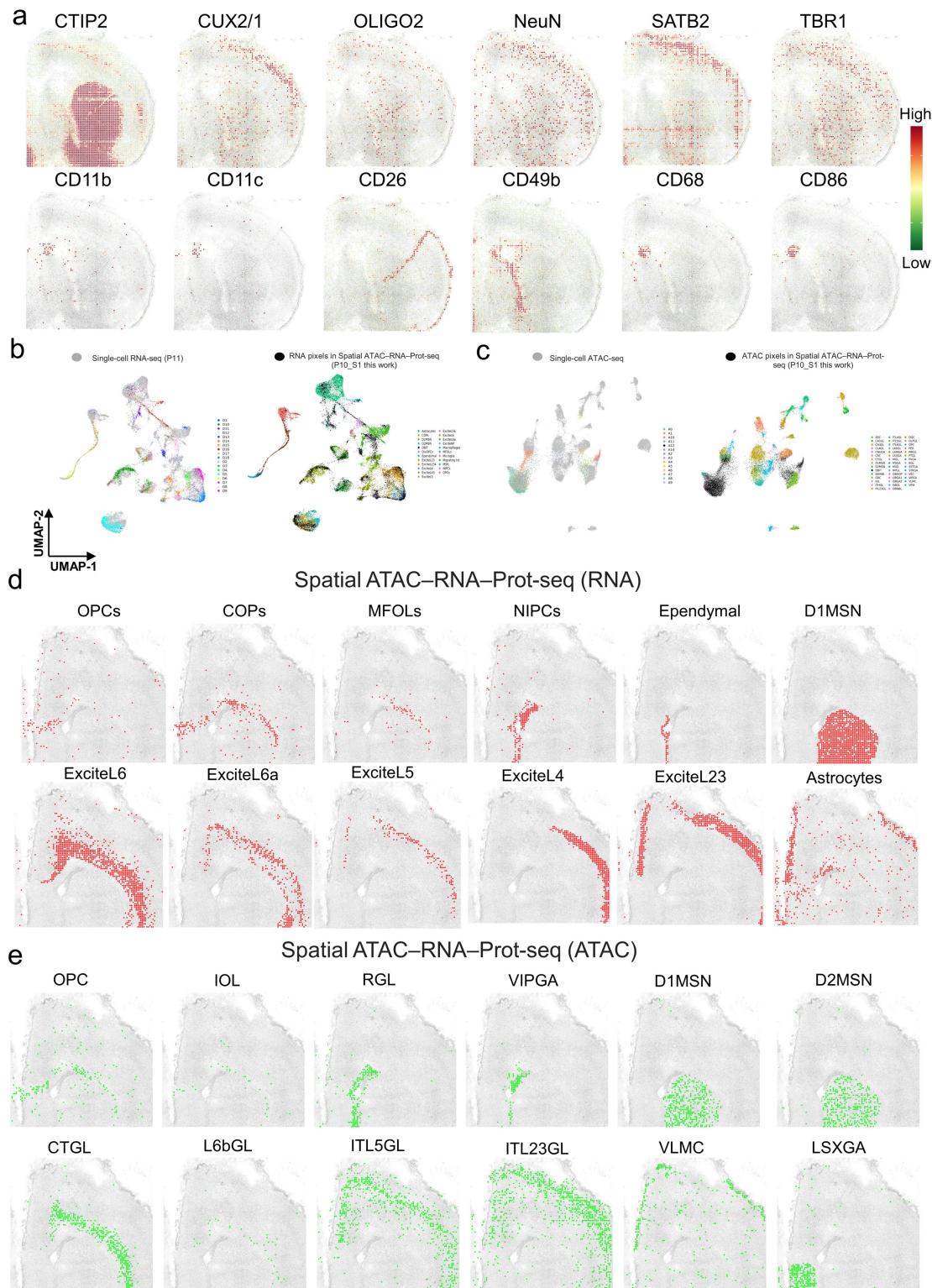
Extended Data Fig. 7 Further analysis of spatial ATAC–RNA–Prot-seq (DBiT ARP-seq)
for postnatal mouse brains. a, Expression of several ADT proteins in DBiT ARP-seq from P0.
b, Integration of P10 spatial RNA data and scRNA-seq data from mouse brain. **c**, Integration
of P10 spatial ATAC data and scATAC-seq data from mouse brain. **d**, Spatial mapping of cell
types identified by label transfer from scRNA-seq to P10 spatial RNA data. **e**, Spatial mapping

1   of cell types identified by label transfer from scATAC-seq to P10 spatial ATAC data.

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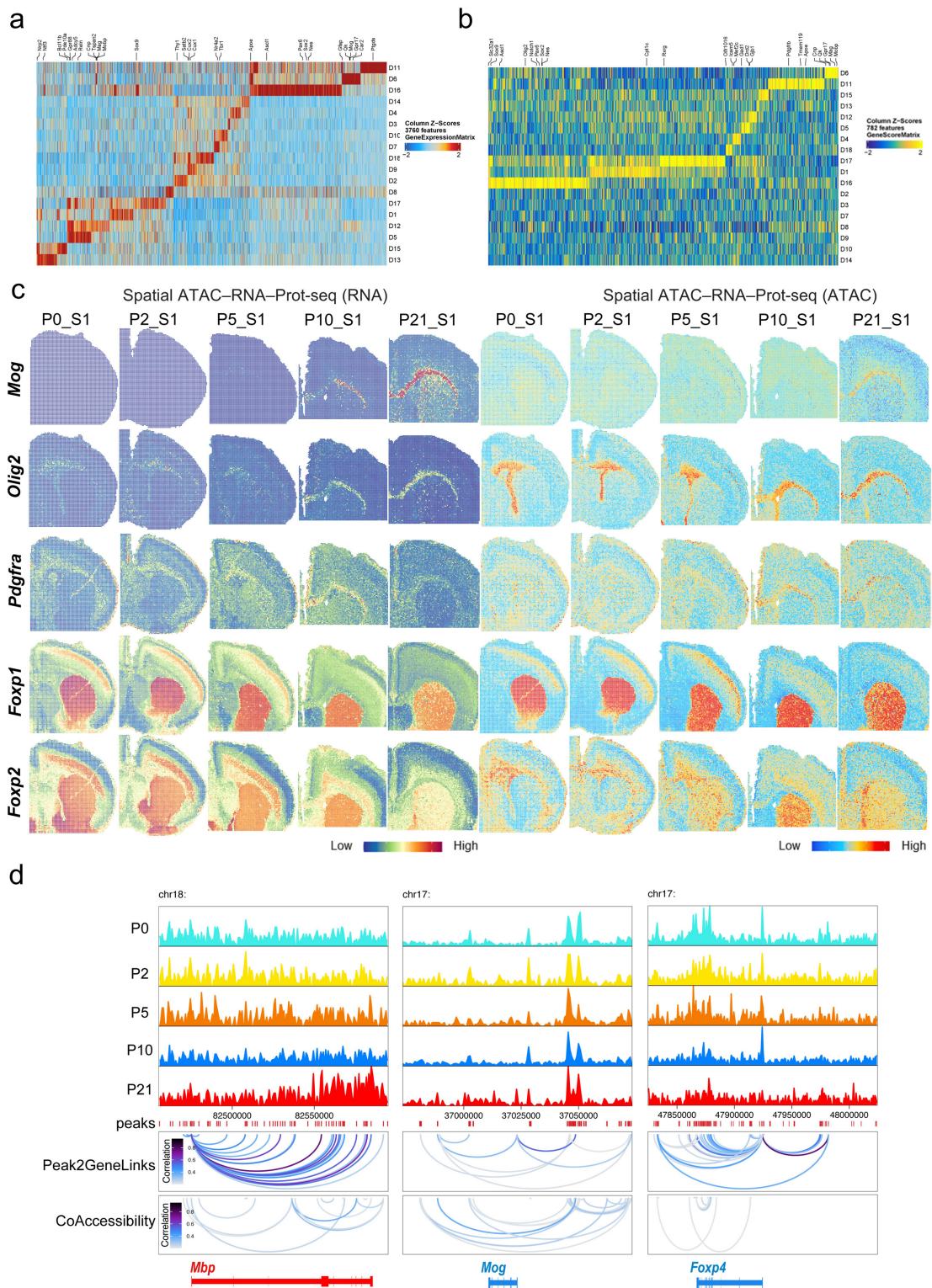
Extended Data Fig. 8 Further analysis of spatial ATAC–RNA–Prot-seq (DBiT ARP-seq)
for postnatal mouse brains. a, Marker gene expression in each spatial domain in **Fig. 1i**. **b,**
Marker GAS in each spatial domain in **Fig. 1i**. **c,** Spatial mapping of gene expression and GAS
for selected marker genes in different clusters for RNA and ATAC in DBiT ARP-seq. **d,**
Genome track visualization of marker genes with peak-to-gene links for distal regulatory

1   elements and peak co-accessibility.

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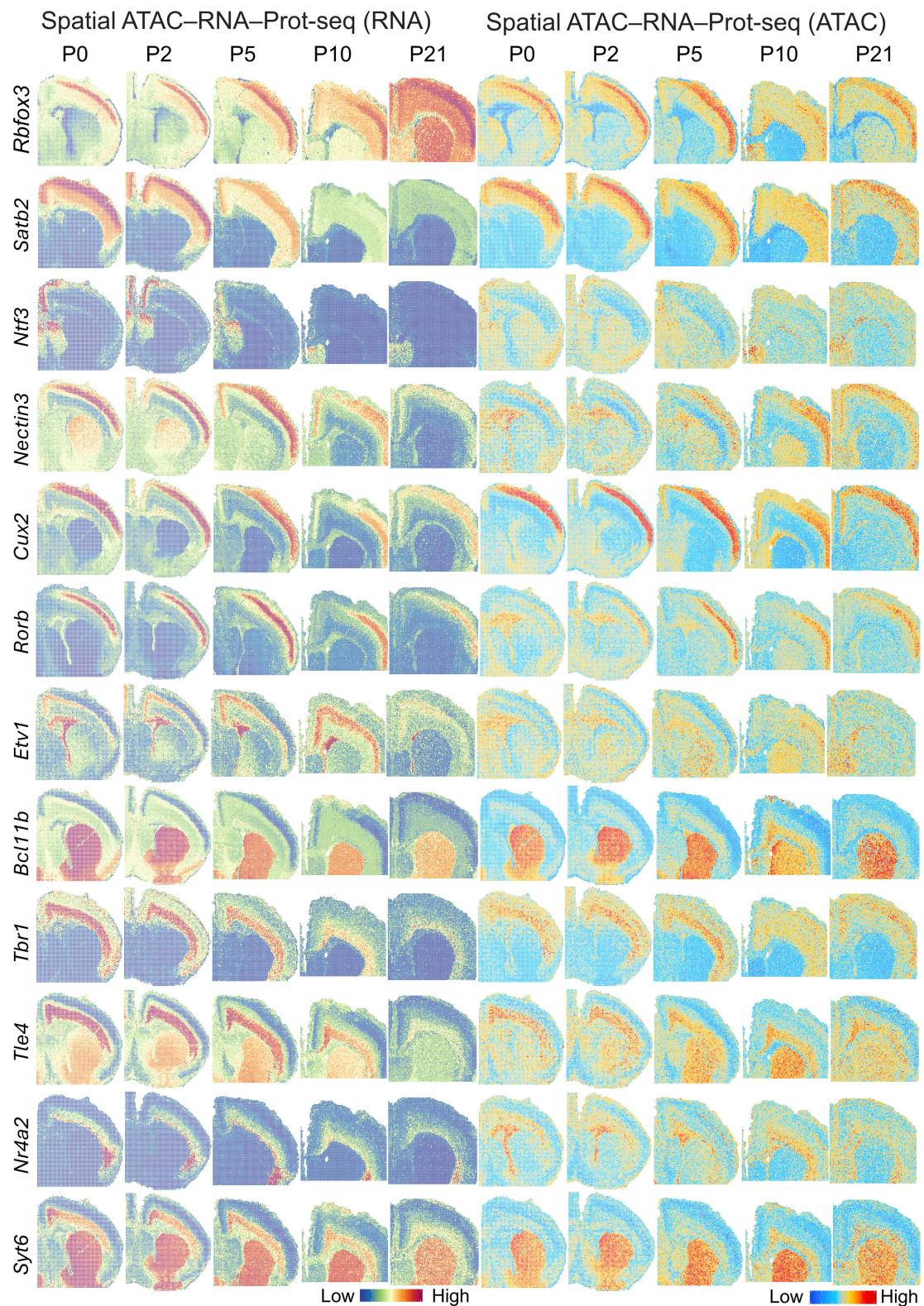
Extended Data Fig. 9 Gene expression of cortical-layer specific markers for postanal mouse brains. Spatial mapping of gene expression and GAS for neuronal marker genes from RNA and ATAC in DBiT ARP-seq.
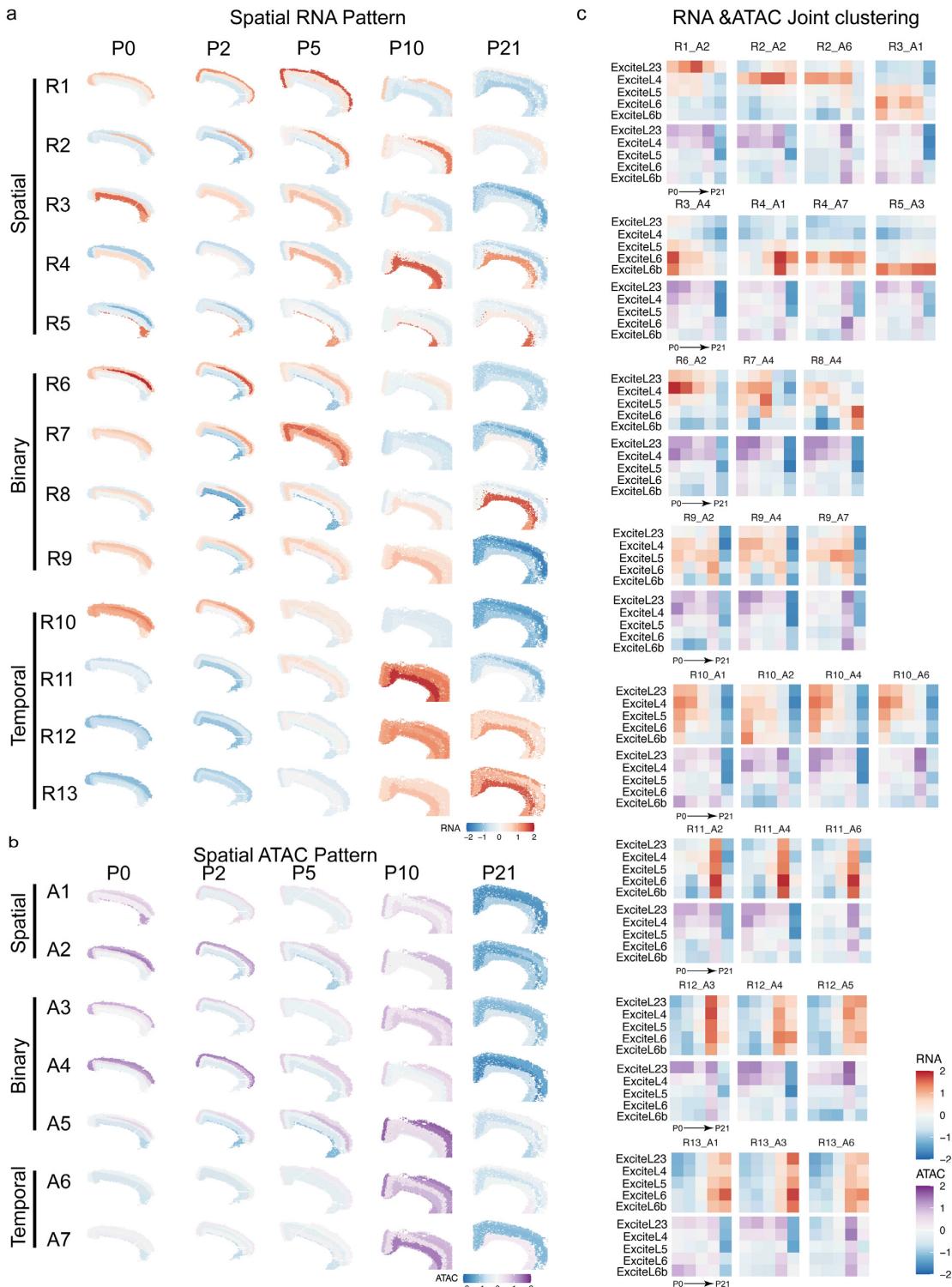
Extended Data Fig. 10 Further analysis of developing mouse brain cortical layers. a-b, Spatial RNA **(a)** and ATAC **(b)** patterns generated from the regression model. **c,** Heatmap for each of the 27 clusters from the RNA & ATAC joint clustering analysis.
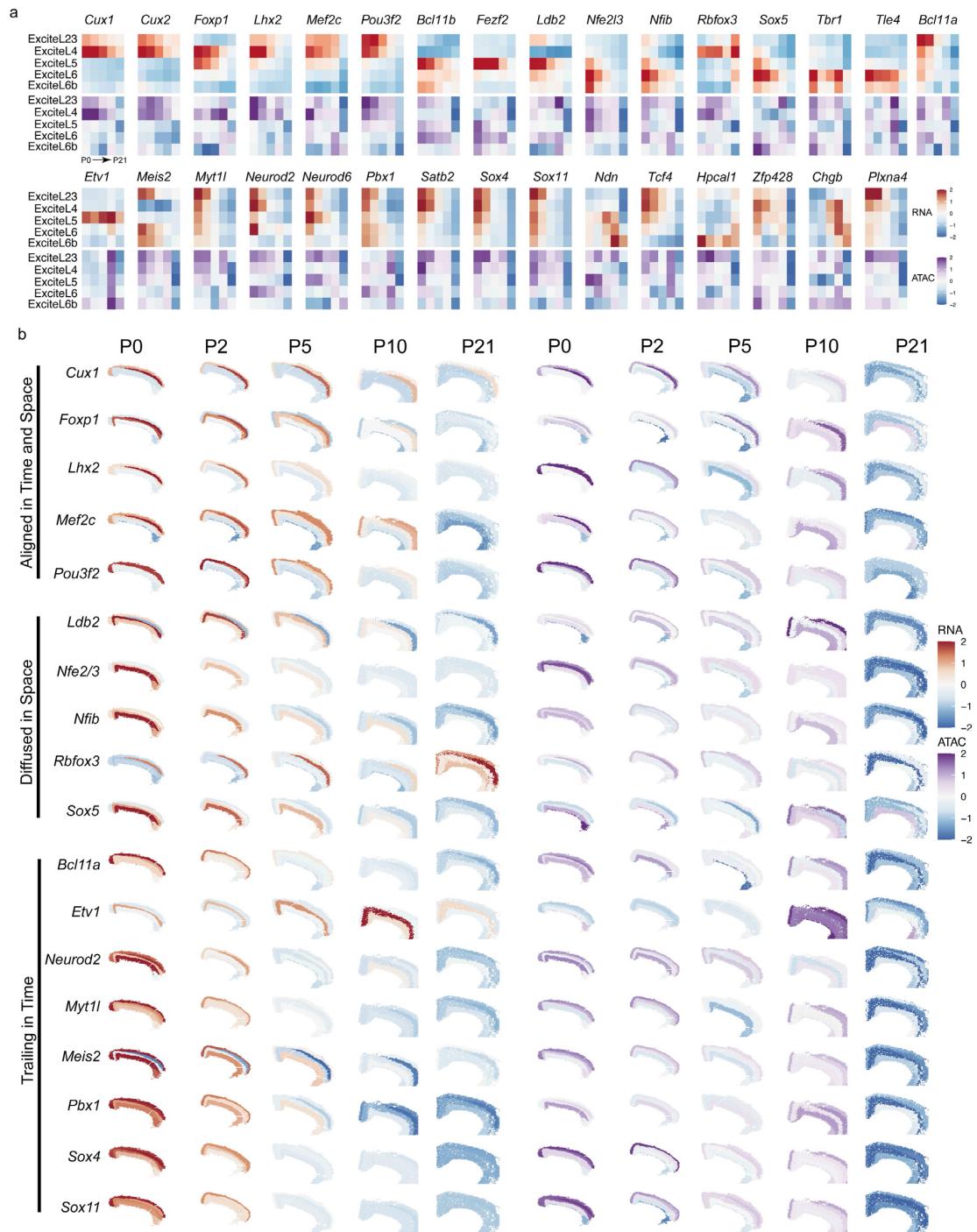
Extended Data Fig. 11 Further analysis of developing mouse brain cortical layers. a, Heatmaps of the RNA gene expression (top) and ATAC GAS (bottom) calculated on the basis of the regression model for specific neuronal genes. **b,** The RNA gene expression and ATAC GAS calculated on the basis of the regression model for specific neuronal genes.

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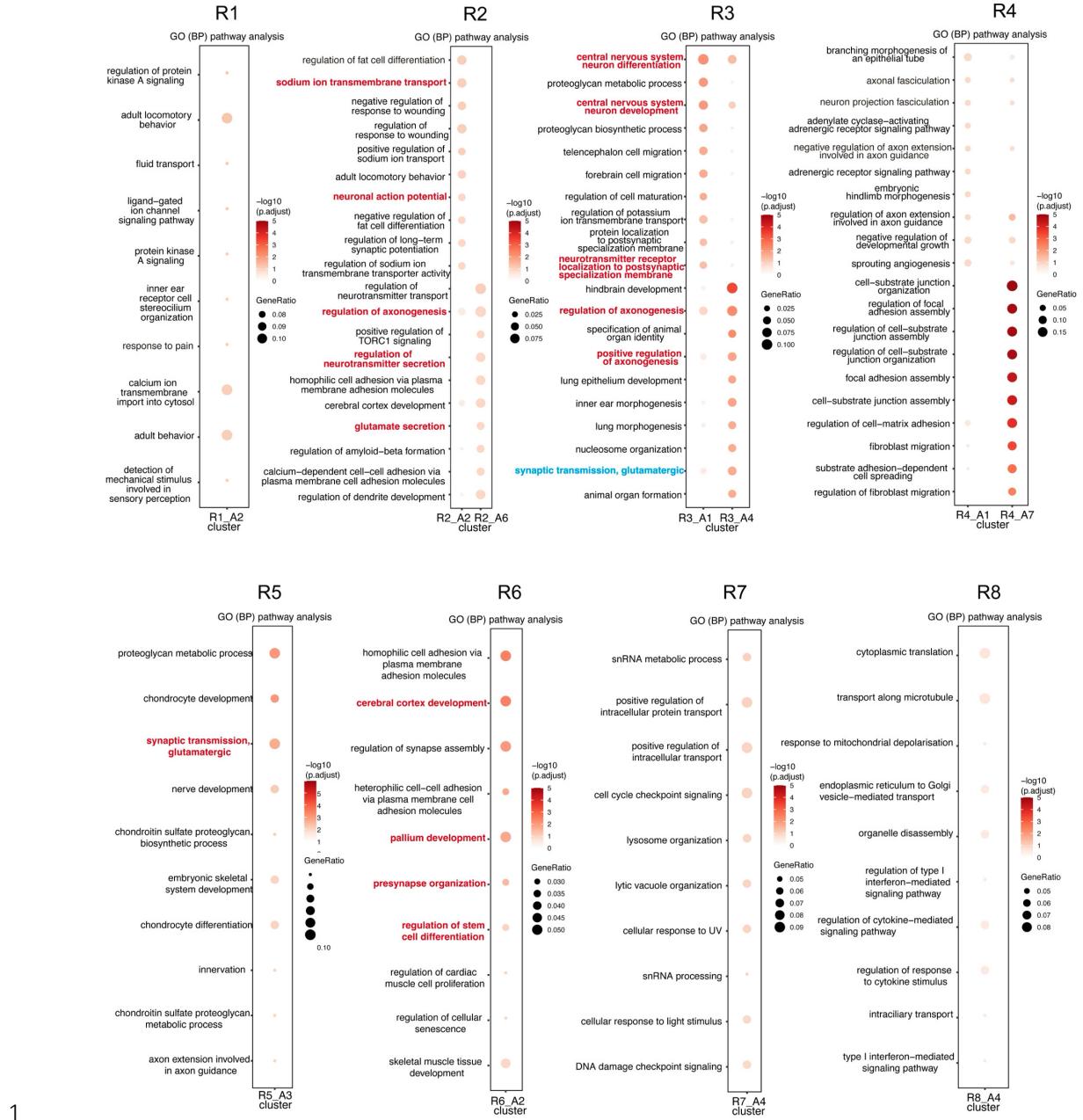
Extended Data Fig. 12 Further analysis of developing mouse brain cortical layers. GO

analysis for each RNA cluster (R1-R8) generated from the regression model.

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2 **Extended Data Fig. 13 Further analysis of developing mouse brain cortical layers.** GO

3 analysis for each RNA cluster (R9-R13) generated from the regression model.

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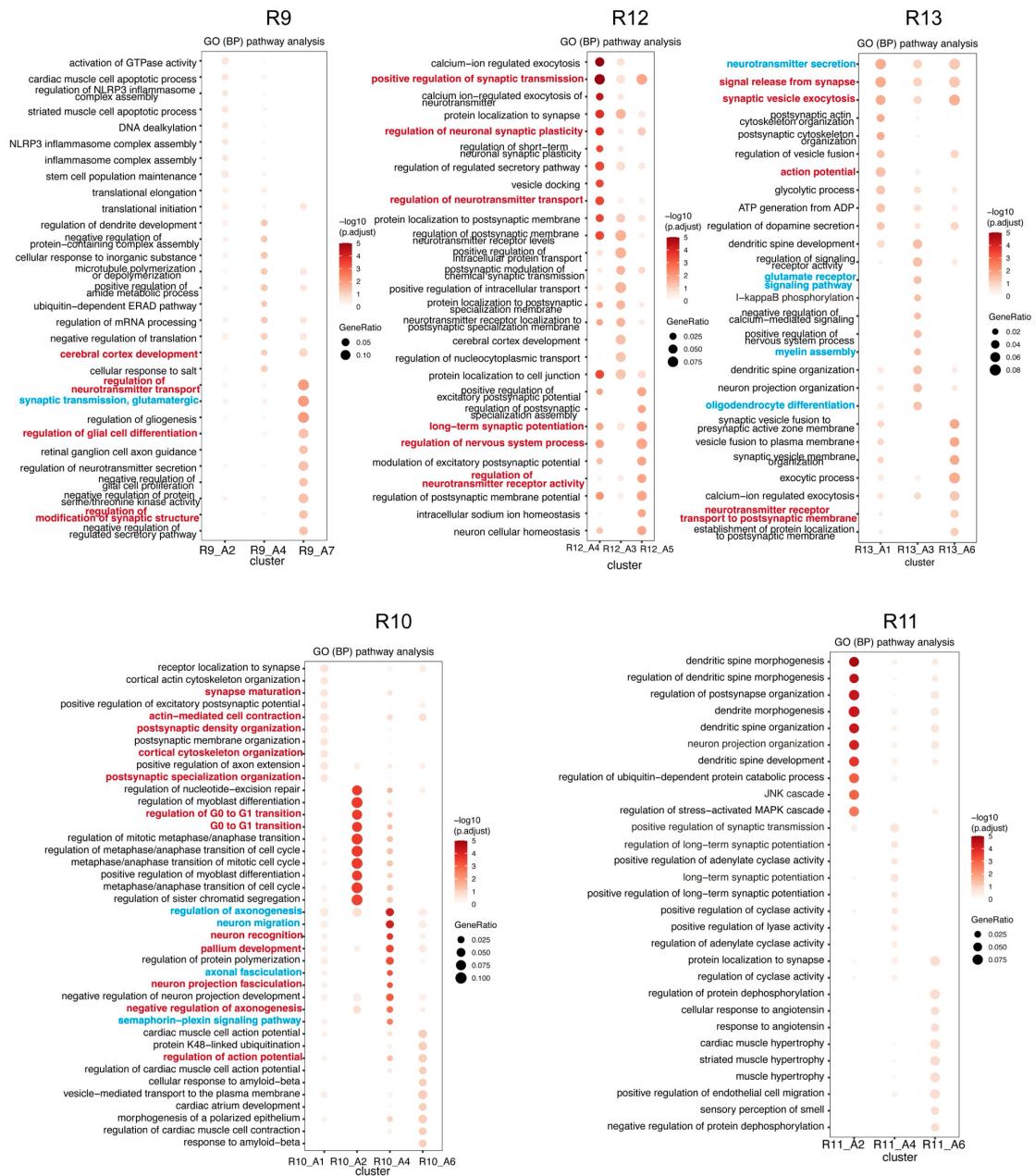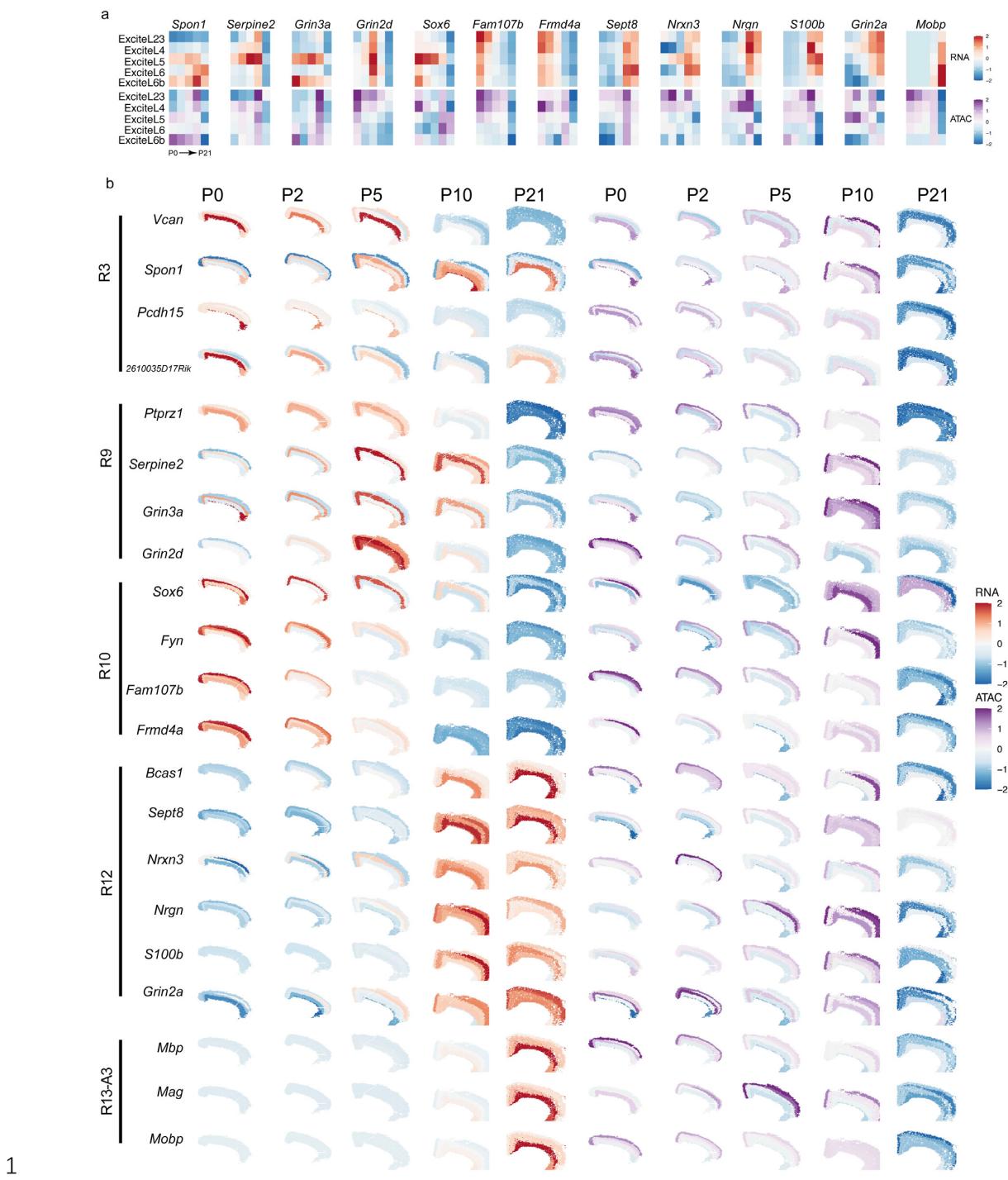
Extended Data Fig. 14 Further analysis of developing mouse brain cortical layers. a, Heatmaps of the RNA gene expression (top) and ATAC GAS (bottom) calculated on the basis of the regression model for myelin related genes. **b,** The RNA gene expression and ATAC GAS calculated on the basis of the regression model for myelin related genes.
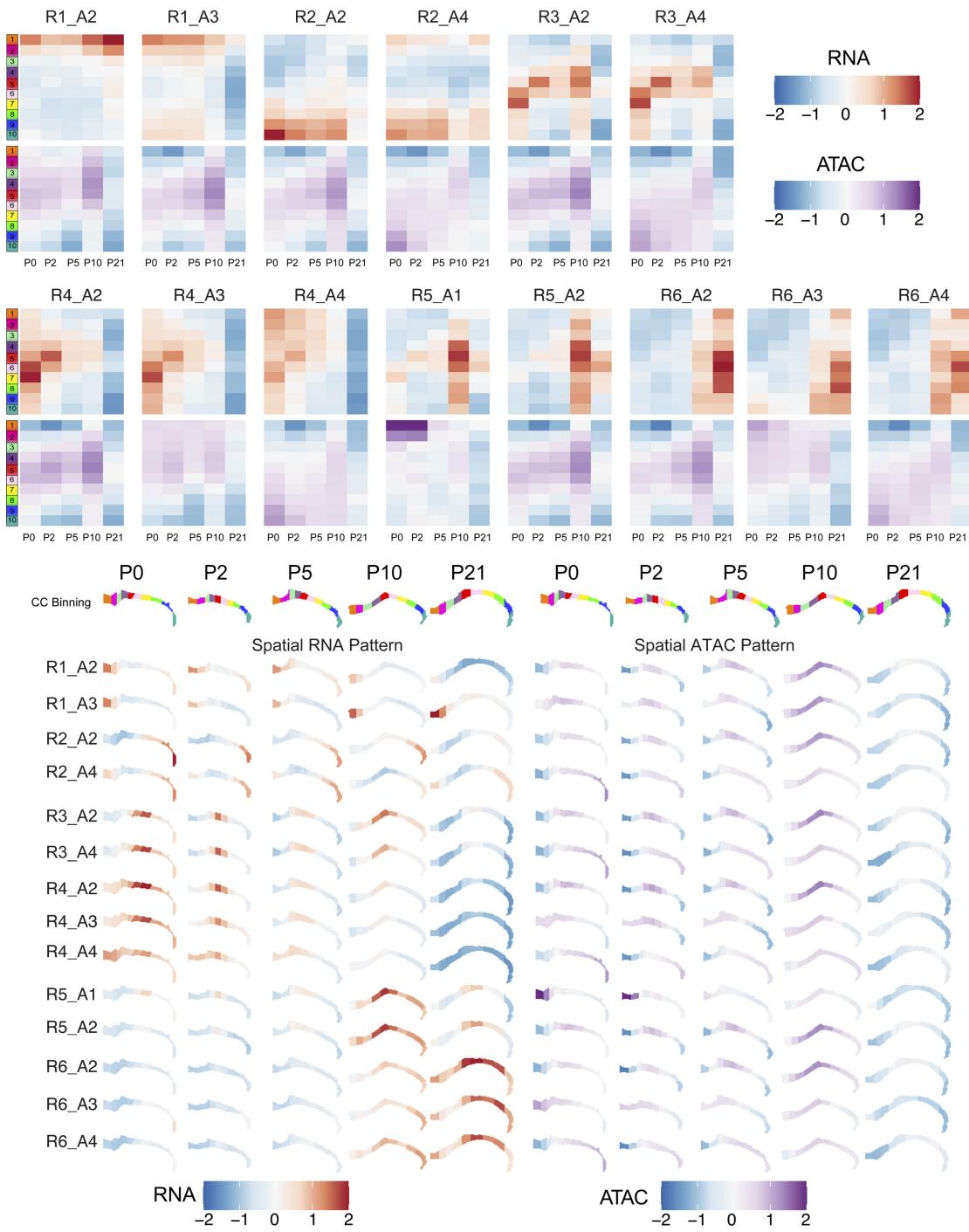
Extended Data Fig. 15 Further analysis of developing mouse brain corpus callosum.
Heatmaps and spatial patterns of the 14 RNA&ATAC joint clustering.

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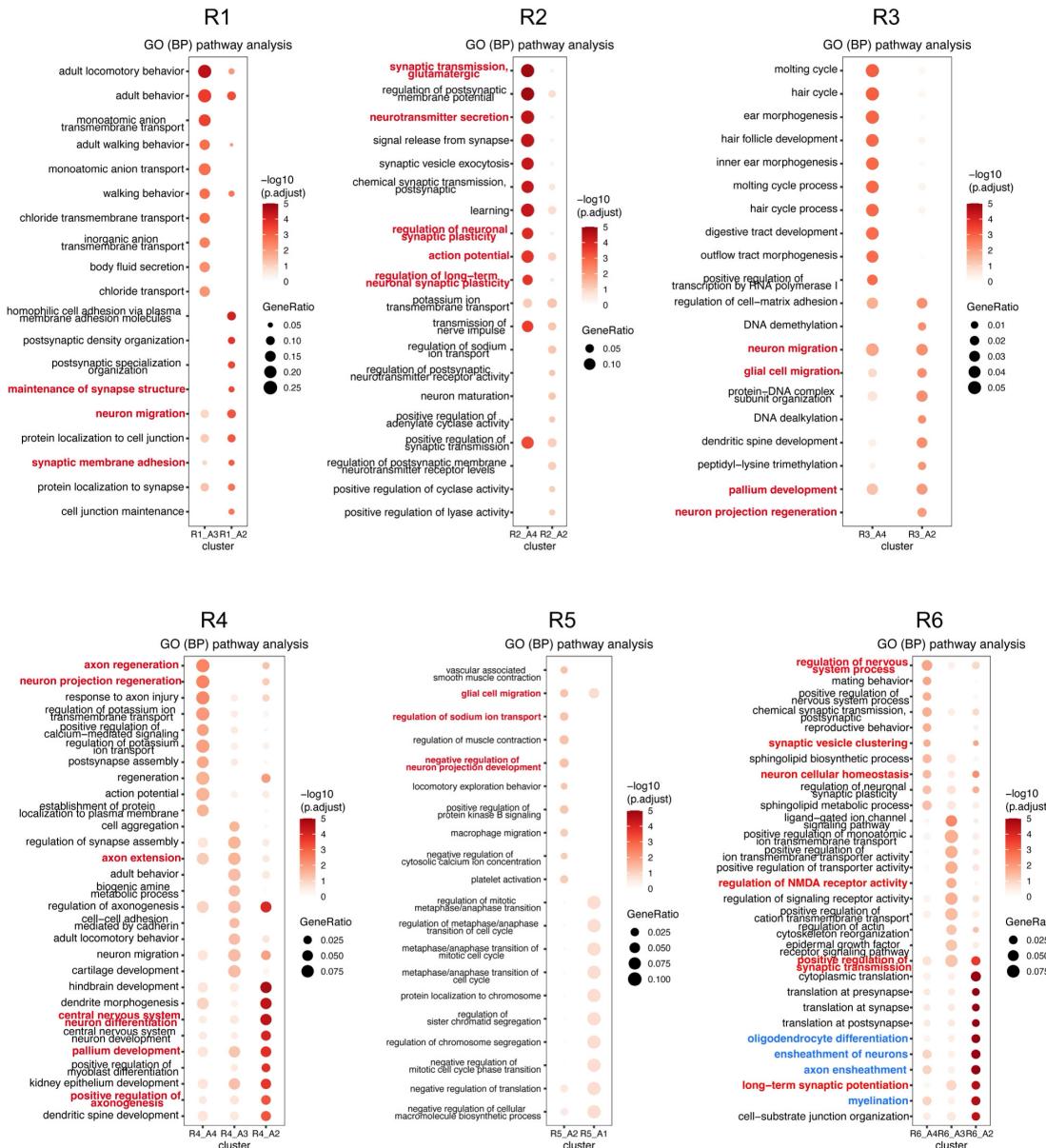
2 **Extended Data Fig. 16 Further analysis of developing mouse brain corpus callosum.** GO

3 analysis for each RNA cluster (R1-R6) generated from the regression model.

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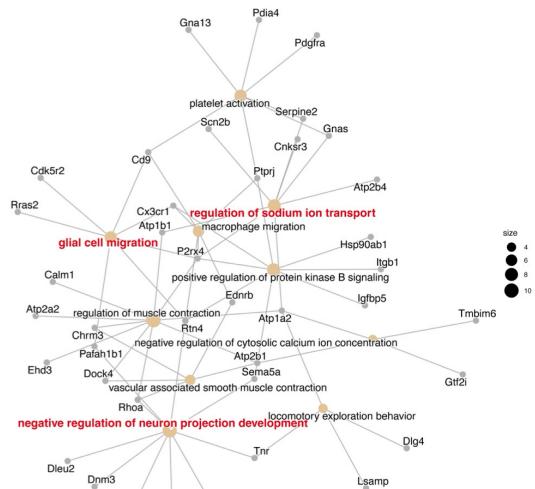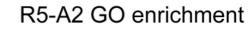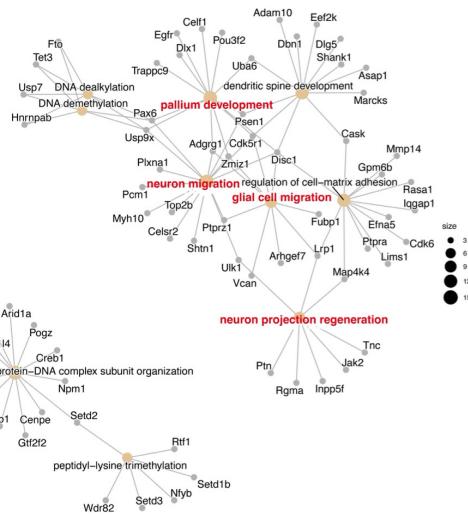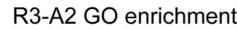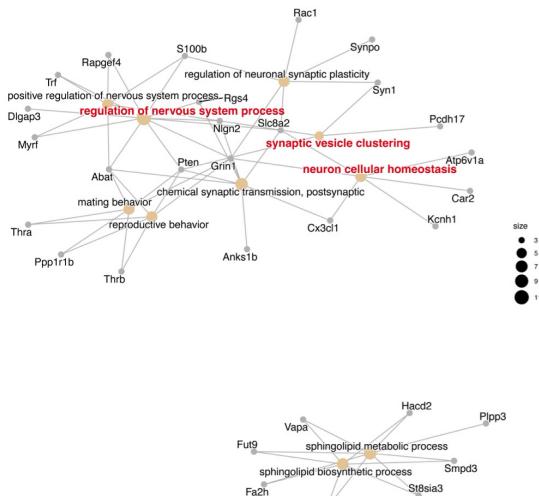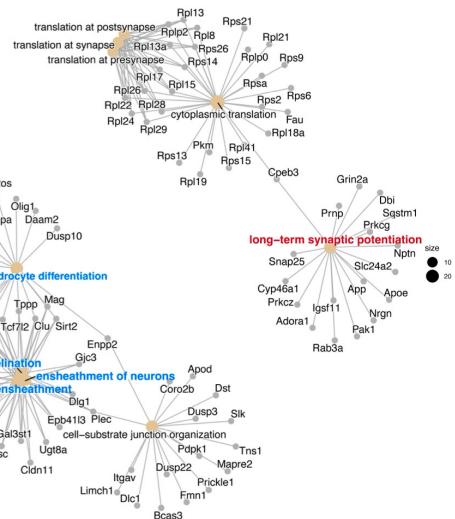
2 **Extended Data Fig. 17 Further analysis of developing mouse brain corpus callosum.** GO

3 enrichment analysis for cluster R3-A2, R5-A2, R6-A4, and R6-A2.

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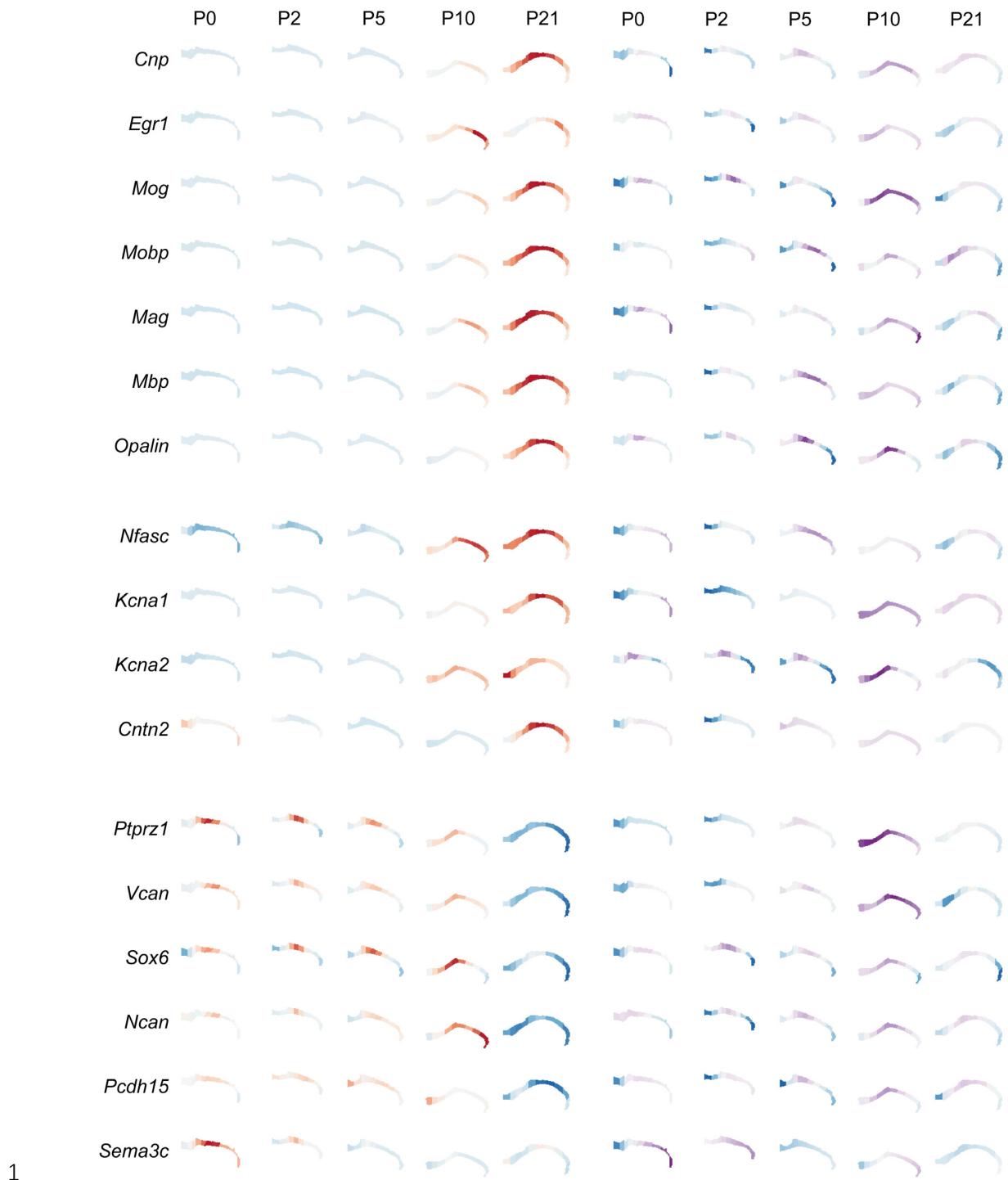
Extended Data Fig. 18 Further analysis of developing mouse brain corpus callosum. The RNA gene expression and ATAC GAS calculated on the basis of the regression model for specific genes.

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2 **Extended Data Fig. 19 Further analysis of developing mouse brain corpus callosum.** The

3 RNA gene expression and ATAC GAS calculated on the basis of the regression model for

4 specific genes.

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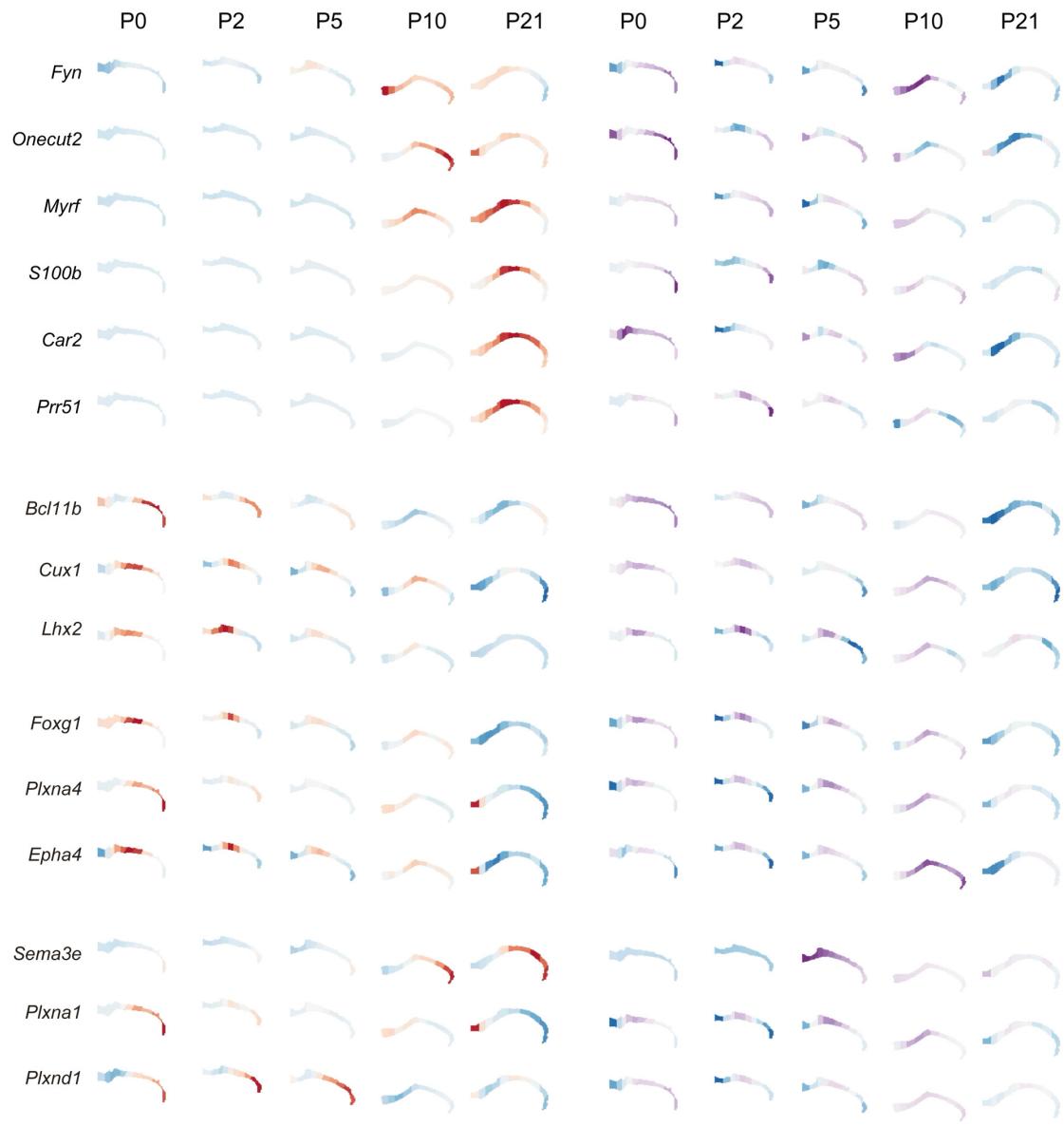
Extended Data Fig. 20 Further analysis of developing mouse brain corpus callosum. The RNA gene expression and ATAC GAS calculated on the basis of the regression model for specific genes.
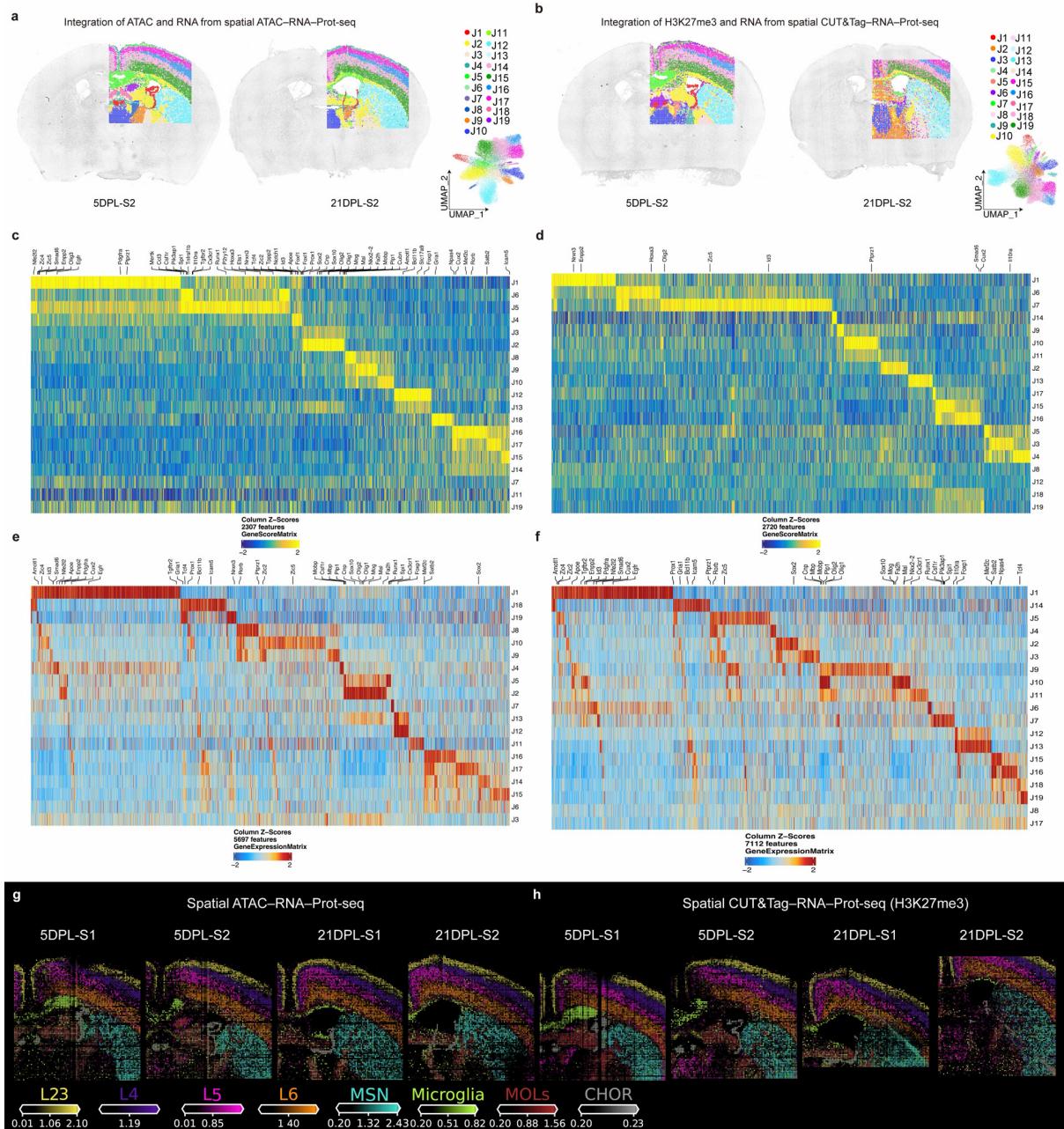
Extended Data Fig. 21 Further analysis of spatial ATAC–RNA–Prot-seq (DBiT ARP-seq) and spatial CUT&Tag–RNA–Prot-seq (DBiT CTRP-seq, targeting H3K27me3) for LPC mouse model brains at 5 DPL and 21 DPL. a, Integration of RNA and ATAC data in DBiT ARP-seq for replicate. **b,** Integration of H3K27me3 and RNA data in DBiT CTRP-seq for replicate. **c,** Marker GASs from each joint cluster in DBiT ARP-seq in **a** and **Fig. 4f. d,** Marker CSSs from each joint cluster in DBiT CTRP-seq in **b** and **Fig. 4g. e**, Marker gene expression from each joint cluster in DBiT ARP-seq in **a** and **Fig. 4f. f**, Marker gene expression from each joint cluster in DBiT CTRP-seq in **b** and **Fig. 4g. g-h,** Cell types predicted by cell2location from all processed LPC mouse model brains in DBiT ARP-seq (**g**) and DBiT CTRP-seq (**h**).
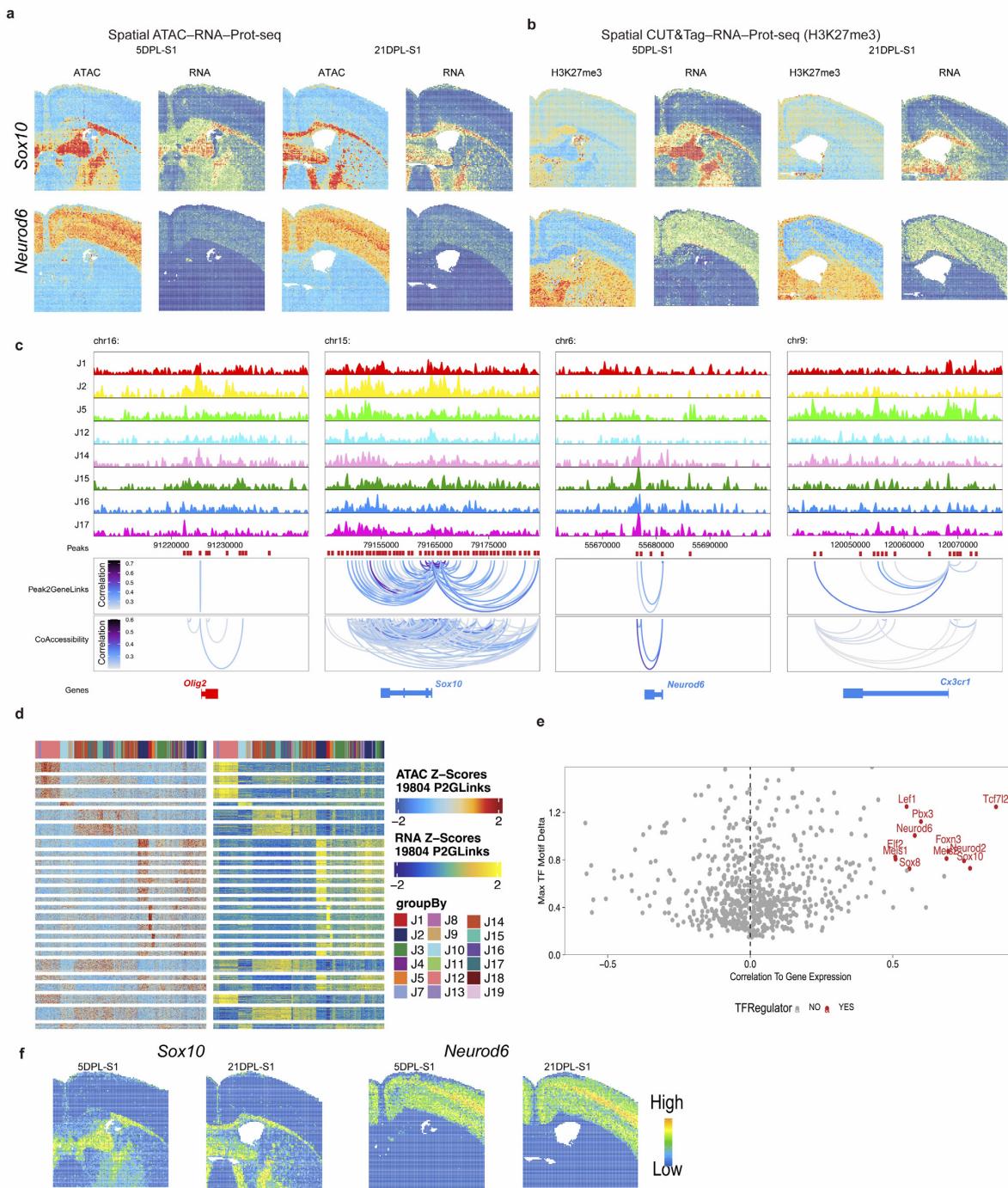
Extended Data Fig. 22 Further analysis of spatial ATAC–RNA–Prot-seq (DBiT ARP-seq) and spatial CUT&Tag–RNA–Prot-seq (DBiT CTRP-seq, targeting H3K27me3) for LPC mouse model brains at 5 DPL and 21 DPL. a-b, Spatial mapping of gene expression and GAS (**a**), or gene expression and CSS (**b**) for *Sox10* and *Neurod6* in both DBiT ARP-seq and DBiT CTRP-seq. **c,** Genome track visualization of marker genes with peak-to-gene links for distal regulatory elements and peak co-accessibility. **d,** Heatmaps of peak-to-gene links in DBiT ARP-seq. **e,** Dot plot showing the identification of positive TF regulators. **f,** Spatial mapping of deviation scores for selected TF motifs from DBiT ARP-seq.
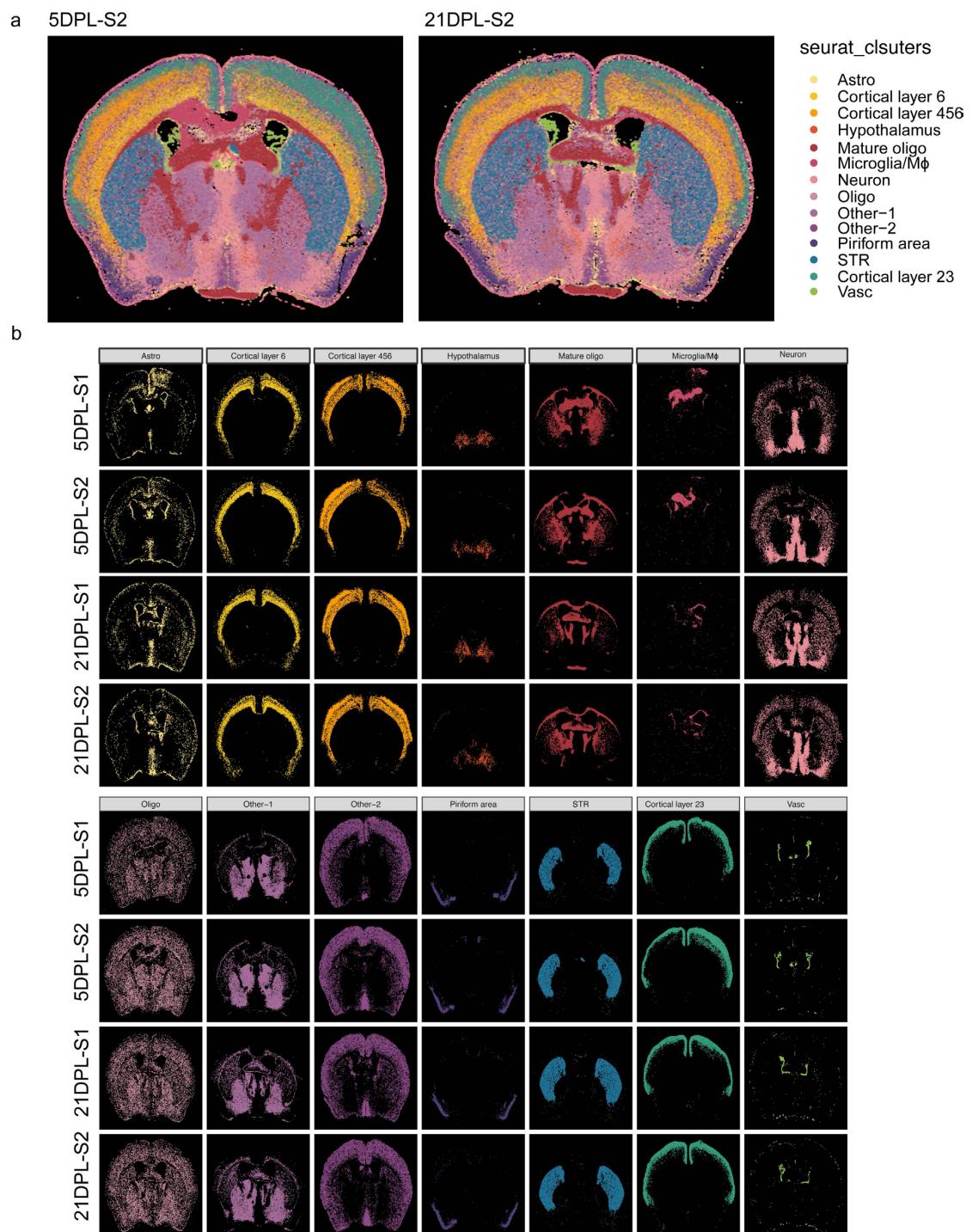
Extended Data Fig. 23 Further analysis for CODEX images of LPC mouse model brains at 5 DPL and 21 DPL. a, Seurat clustering of the CODEX images for replicates. **b,** Spatial map of the cell types from **a**.
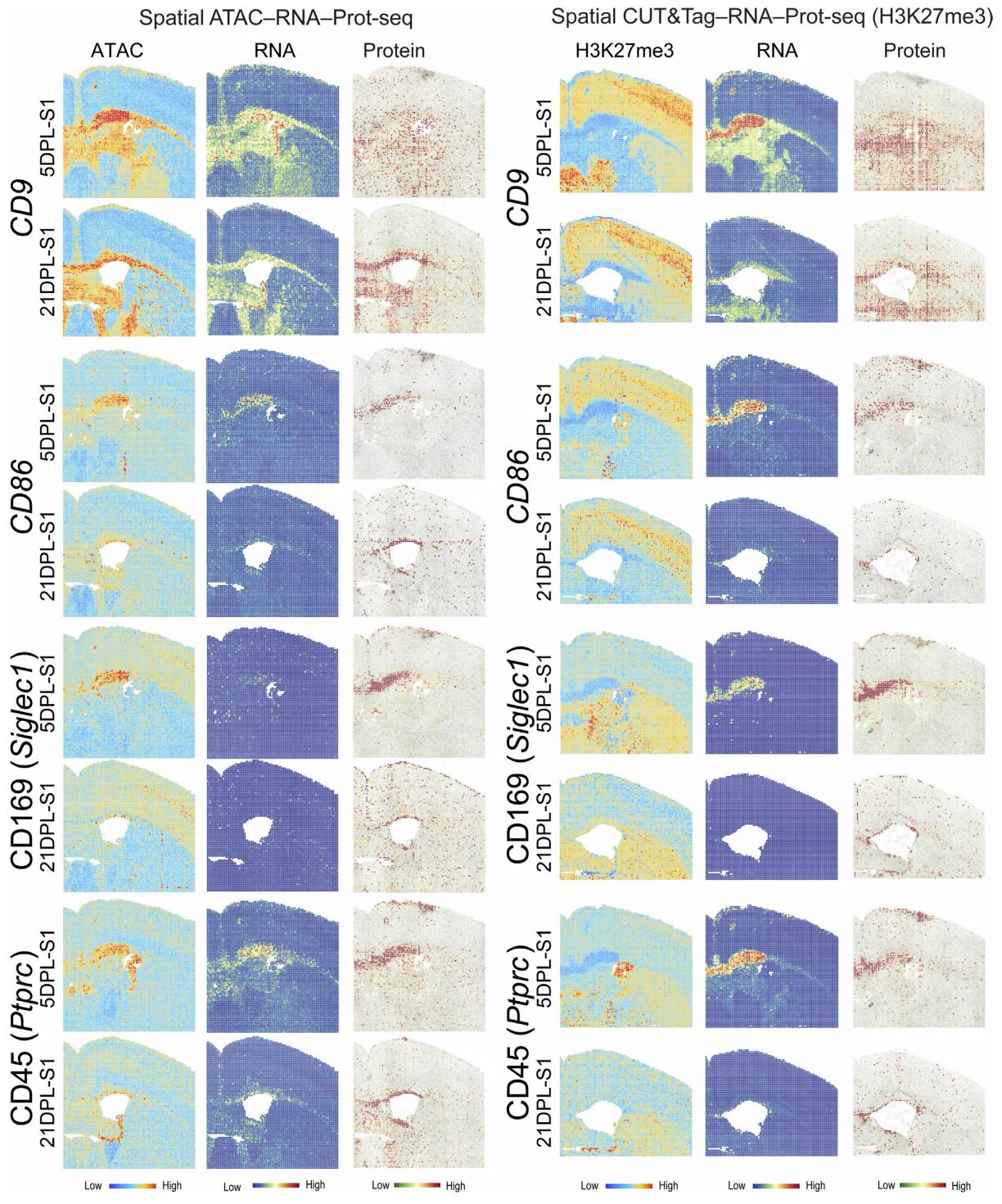
Extended Data Fig. 24 Further analysis of spatial ATAC–RNA–Prot-seq (DBiT ARP-seq) and spatial CUT&Tag–RNA–Prot-seq (DBiT CTRP-seq, targeting H3K27me3) for LPC mouse model brains at 5 DPL and 21 DPL. Spatial mapping of gene expression, GAS, CSS, and ADT protein expression for marker genes in both DBiT ARP-seq and DBiT CTRP-seq.
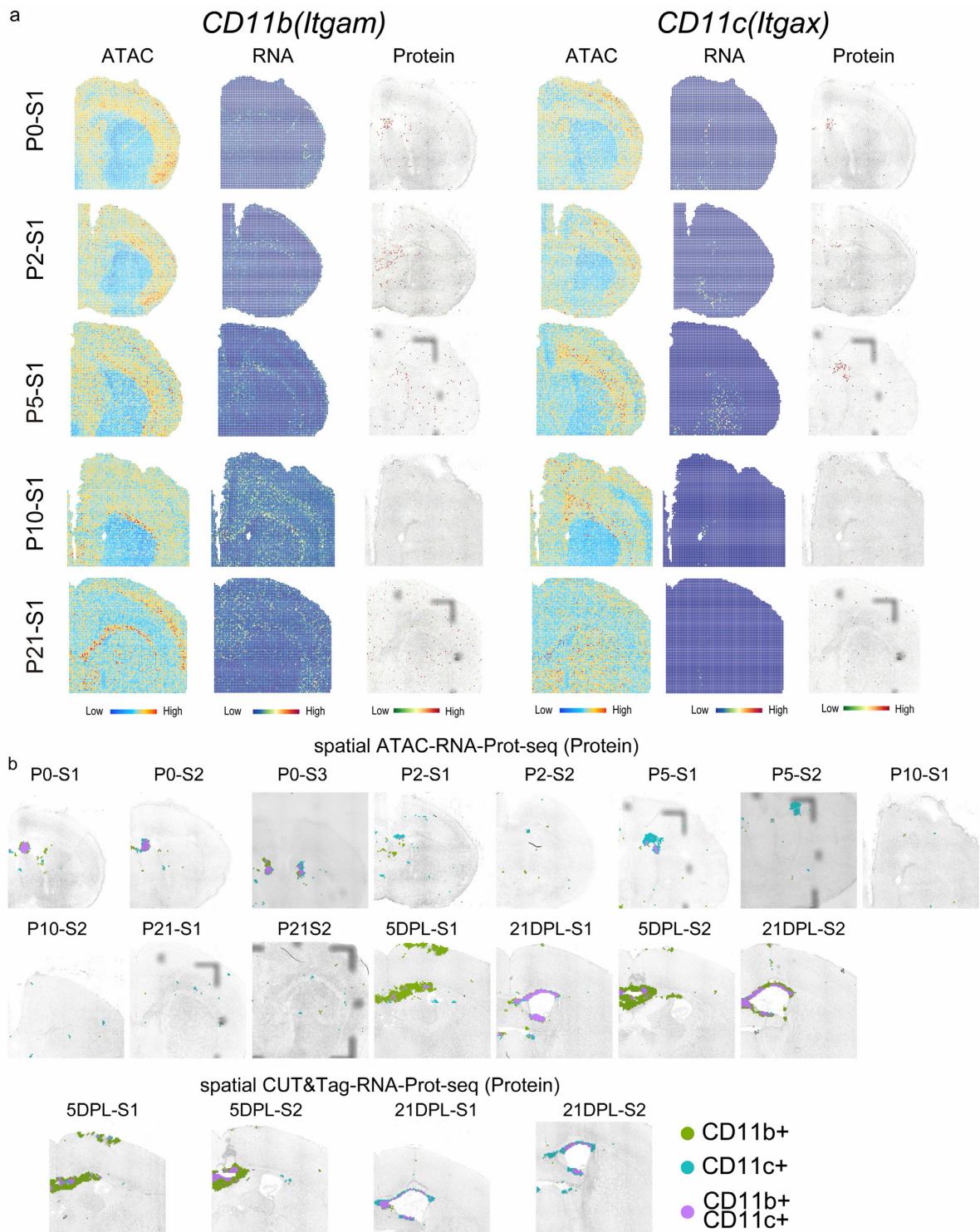
Extended Data Fig. 25 Further analysis for microglia. a, Spatial mapping of gene expression, GAS, and ADT protein expression for *Itgam* (CD11b*)* and *Itgax* (CD11c) in both DBiT ARP-seq and DBiT CTRP-seq. **b,** The ADT protein co-expression of CD11b and CD11c for developing and LPC mouse brains (including the replicate).

Extended Data Table 1. DNA oligos used for transposome assembly, PCR, and
preparation of sequencing library.

RT primer	/5Phos/CATCGGCGTACGACTNNNNNNNNNN/iBiodT/TTTTTTTT TTTTTTTVN
Ligation linker 1	AGTCGTACGCCGATGCGAAACATCGGCCAC
Ligation linker 2	CGAATGCTCTGGCCTCTCAAGCACGTGGAT
PCR Primer 1	CAAGCGTTGGCTTCTCGCATCT
PCR Primer 2	AAGCAGTGGTATCAACGCAGAGT
N501	AATGATACGGCGACCACCGAGATCTACACTAGATCGCTCGTCG GCAGCGTCAGATGTGTATAAGAGACAG
N701	CAAGCAGAAGACGGCATACGAGATTCGCCTTAGTCTCGTGGG CTCGGAGATGTGTATAAGAGACAGCAAGCGTTGGCTTCTCGC ATCT
N702	CAAGCAGAAGACGGCATACGAGATCTAGTACGGTCTCGTGGG CTCGGAGATGTGTATAAGAGACAGCAAGCGTTGGCTTCTCGC ATCT
N703	CAAGCAGAAGACGGCATACGAGATTTCTGCCTGTCTCGTGGG CTCGGAGATGTGTATAAGAGACAGCAAGCGTTGGCTTCTCGC ATCT
N704	CAAGCAGAAGACGGCATACGAGATGCTCAGGAGTCTCGTGGG CTCGGAGATGTGTATAAGAGACAGCAAGCGTTGGCTTCTCGC ATCT
N705	CAAGCAGAAGACGGCATACGAGATAGGAGTCCGTCTCGTGGG CTCGGAGATGTGTATAAGAGACAGCAAGCGTTGGCTTCTCGC ATCT
N706	CAAGCAGAAGACGGCATACGAGATCATGCCTAGTCTCGTGGG CTCGGAGATGTGTATAAGAGACAGCAAGCGTTGGCTTCTCGC ATCT
N707	CAAGCAGAAGACGGCATACGAGATGTAGAGAGGTCTCGTGGG CTCGGAGATGTGTATAAGAGACAGCAAGCGTTGGCTTCTCGC ATCT
Tn5ME-A	5′-TCGTCGGCAGCGTCAGATGTGTATAAGAGACAG-3′
Tn5MErev	5′-/5Phos/CTGTCTCTTATACACATCT-3′
Tn5ME-B	5′-/5Phos/CATCGGCGTACGACTAGATGTGTATAAGAGACAG-3′

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Extended Data Table 2. DNA barcode A sequences.

Barcode A	Sequence
Barcode A-1	/5Phos/AGGCCAGAGCATTCGAACGTGATGTGGCCGATGTTTCG
Barcode A-2	/5Phos/AGGCCAGAGCATTCGAAACATCGGTGGCCGATGTTTCG
Barcode A-3	/5Phos/AGGCCAGAGCATTCGATGCCTAAGTGGCCGATGTTTCG
Barcode A-4	/5Phos/AGGCCAGAGCATTCGAGTGGTCAGTGGCCGATGTTTCG
Barcode A-5	/5Phos/AGGCCAGAGCATTCGACCACTGTGTGGCCGATGTTTCG
Barcode A-6	/5Phos/AGGCCAGAGCATTCGACATTGGCGTGGCCGATGTTTCG
Barcode A-7	/5Phos/AGGCCAGAGCATTCGCAGATCTGGTGGCCGATGTTTCG
Barcode A-8	/5Phos/AGGCCAGAGCATTCGCATCAAGTGTGGCCGATGTTTCG
Barcode A-9	/5Phos/AGGCCAGAGCATTCGCGCTGATCGTGGCCGATGTTTCG
Barcode A-10	/5Phos/AGGCCAGAGCATTCGACAAGCTAGTGGCCGATGTTTCG
Barcode A-11	/5Phos/AGGCCAGAGCATTCGCTGTAGCCGTGGCCGATGTTTCG
Barcode A-12	/5Phos/AGGCCAGAGCATTCGAGTACAAGGTGGCCGATGTTTCG
Barcode A-13	/5Phos/AGGCCAGAGCATTCGAACAACCAGTGGCCGATGTTTCG
Barcode A-14	/5Phos/AGGCCAGAGCATTCGAACCGAGAGTGGCCGATGTTTCG
Barcode A-15	/5Phos/AGGCCAGAGCATTCGAACGCTTAGTGGCCGATGTTTCG
Barcode A-16	/5Phos/AGGCCAGAGCATTCGAAGACGGAGTGGCCGATGTTTCG
Barcode A-17	/5Phos/AGGCCAGAGCATTCGAAGGTACAGTGGCCGATGTTTCG
Barcode A-18	/5Phos/AGGCCAGAGCATTCGACACAGAAGTGGCCGATGTTTCG
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Barcode A-23	/5Phos/AGGCCAGAGCATTCGACTATGCAGTGGCCGATGTTTCG
Barcode A-24	/5Phos/AGGCCAGAGCATTCGAGAGTCAAGTGGCCGATGTTTCG
Barcode A-25	/5Phos/AGGCCAGAGCATTCGAGATCGCAGTGGCCGATGTTTCG
Barcode A-26	/5Phos/AGGCCAGAGCATTCGAGCAGGAAGTGGCCGATGTTTCG
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Barcode A-29	/5Phos/AGGCCAGAGCATTCGATTGAGGAGTGGCCGATGTTTCG
Barcode A-30	/5Phos/AGGCCAGAGCATTCGCAACCACAGTGGCCGATGTTTCG
Barcode A-31	/5Phos/AGGCCAGAGCATTCGGACTAGTAGTGGCCGATGTTTCG
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Barcode A-36	/5Phos/AGGCCAGAGCATTCGCCAGTTCAGTGGCCGATGTTTCG
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Barcode A-40	/5Phos/AGGCCAGAGCATTCGCGAACTTAGTGGCCGATGTTTCG
Barcode A-41	/5Phos/AGGCCAGAGCATTCGCGACTGGAGTGGCCGATGTTTCG
Barcode A-42	/5Phos/AGGCCAGAGCATTCGCGCATACAGTGGCCGATGTTTCG
Barcode A-43	/5Phos/AGGCCAGAGCATTCGCTCAATGAGTGGCCGATGTTTCG
Barcode A-44	/5Phos/AGGCCAGAGCATTCGCTGAGCCAGTGGCCGATGTTTCG
Barcode A-45	/5Phos/AGGCCAGAGCATTCGCTGGCATAGTGGCCGATGTTTCG
Barcode A-46	/5Phos/AGGCCAGAGCATTCGGAATCTGAGTGGCCGATGTTTCG
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Barcode A-55	/5Phos/AGGCCAGAGCATTCGGGGTGCGAAGTGGCCGATGTTTCG
Barcode A-56	/5Phos/AGGCCAGAGCATTCGGTACGCAAGTGGCCGATGTTTCG
Barcode A-57	/5Phos/AGGCCAGAGCATTCGGTCGTAGAGTGGCCGATGTTTCG
Barcode A-58	/5Phos/AGGCCAGAGCATTCGGTCTGTCAGTGGCCGATGTTTCG
Barcode A-59	/5Phos/AGGCCAGAGCATTCGGTGTTCTAGTGGCCGATGTTTCG
Barcode A-60	/5Phos/AGGCCAGAGCATTCGTAGGATGAGTGGCCGATGTTTCG
Barcode A-61	/5Phos/AGGCCAGAGCATTCGTATCAGCAGTGGCCGATGTTTCG
Barcode A-62	/5Phos/AGGCCAGAGCATTCGTCCGTCTAGTGGCCGATGTTTCG
Barcode A-63	/5Phos/AGGCCAGAGCATTCGTCTTCACAGTGGCCGATGTTTCG
Barcode A-64	/5Phos/AGGCCAGAGCATTCGTGAAGAGAGTGGCCGATGTTTCG
Barcode A-65	/5Phos/AGGCCAGAGCATTCGTGGAACAAGTGGCCGATGTTTCG
Barcode A-66	/5Phos/AGGCCAGAGCATTCGTGGCTTCAGTGGCCGATGTTTCG
Barcode A-67	/5Phos/AGGCCAGAGCATTCGTGGTGGTAGTGGCCGATGTTTCG
Barcode A-68	/5Phos/AGGCCAGAGCATTCGTTCACGCAGTGGCCGATGTTTCG
Barcode A-69	/5Phos/AGGCCAGAGCATTCGAACTCACCGTGGCCGATGTTTCG
Barcode A-70	/5Phos/AGGCCAGAGCATTCGAAGAGATCGTGGCCGATGTTTCG
Barcode A-71	/5Phos/AGGCCAGAGCATTCGAAGGACACGTGGCCGATGTTTCG
Barcode A-72	/5Phos/AGGCCAGAGCATTCGAATCCGTCGTGGCCGATGTTTCG

Barcode A-73	/5Phos/AGGCCAGAGCATTCGAATGTTGCGTGGCCGATGTTTCG
Barcode A-74	/5Phos/AGGCCAGAGCATTCGACACGACCGTGGCCGATGTTTCG
Barcode A-75	/5Phos/AGGCCAGAGCATTCGACAGATTCGTGGCCGATGTTTCG
Barcode A-76	/5Phos/AGGCCAGAGCATTCGAGATGTACGTGGCCGATGTTTCG
Barcode A-77	/5Phos/AGGCCAGAGCATTCGAGCACCTCGTGGCCGATGTTTCG
Barcode A-78	/5Phos/AGGCCAGAGCATTCGAGCCATGCGTGGCCGATGTTTCG
Barcode A-79	/5Phos/AGGCCAGAGCATTCGAGGCTAACGTGGCCGATGTTTCG
Barcode A-80	/5Phos/AGGCCAGAGCATTCGATAGCGACGTGGCCGATGTTTCG
Barcode A-81	/5Phos/AGGCCAGAGCATTCGATCATTCCGTGGCCGATGTTTCG
Barcode A-82	/5Phos/AGGCCAGAGCATTCGATTGGCTCGTGGCCGATGTTTCG
Barcode A-83	/5Phos/AGGCCAGAGCATTCGCAAGGAGCGTGGCCGATGTTTCG
Barcode A-84	/5Phos/AGGCCAGAGCATTCGCACCTTACGTGGCCGATGTTTCG
Barcode A-85	/5Phos/AGGCCAGAGCATTCGCCATCCTCGTGGCCGATGTTTCG
Barcode A-86	/5Phos/AGGCCAGAGCATTCGCCGACAACGTGGCCGATGTTTCG
Barcode A-87	/5Phos/AGGCCAGAGCATTCGCCTAATCCGTGGCCGATGTTTCG
Barcode A-88	/5Phos/AGGCCAGAGCATTCGCCTCTATCGTGGCCGATGTTTCG
Barcode A-89	/5Phos/AGGCCAGAGCATTCGCGACACACGTGGCCGATGTTTCG
Barcode A-90	/5Phos/AGGCCAGAGCATTCGCGGATTGCGTGGCCGATGTTTCG
Barcode A-91	/5Phos/AGGCCAGAGCATTCGCTAAGGTCGTGGCCGATGTTTCG
Barcode A-92	/5Phos/AGGCCAGAGCATTCGGAACAGGCGTGGCCGATGTTTCG
Barcode A-93	/5Phos/AGGCCAGAGCATTCGGACAGTGCGTGGCCGATGTTTCG
Barcode A-94	/5Phos/AGGCCAGAGCATTCGGAGTTAGCGTGGCCGATGTTTCG
Barcode A-95	/5Phos/AGGCCAGAGCATTCGGATGAATCGTGGCCGATGTTTCG
Barcode A-96	/5Phos/AGGCCAGAGCATTCGGCCAAGACGTGGCCGATGTTTCG
Barcode A-97	/5Phos/AGGCCAGAGCATTCGCGGAAGAAGTGGCCGATGTTTCG
Barcode A-98	/5Phos/AGGCCAGAGCATTCGGTGACAAGGTGGCCGATGTTTCG
Barcode A-99	/5Phos/AGGCCAGAGCATTCGGAACCAGAGTGGCCGATGTTTCG
Barcode A-100	/5Phos/AGGCCAGAGCATTCGTTGCTGGAGTGGCCGATGTTTCG

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Extended Data Table 3. DNA barcode B sequences.

Barcode B	Sequence
Barcode B-1	CAAGCGTTGGCTTCTCGCATCTAACGTGATATCCACGTGCTTGAG
Barcode B-2	CAAGCGTTGGCTTCTCGCATCTAAACATCGATCCACGTGCTTGAG
Barcode B-3	CAAGCGTTGGCTTCTCGCATCTATGCCTAAATCCACGTGCTTGAG
Barcode B-4	CAAGCGTTGGCTTCTCGCATCTAGTGGTCAATCCACGTGCTTGAG
Barcode B-5	CAAGCGTTGGCTTCTCGCATCTACCACTGTATCCACGTGCTTGAG
Barcode B-6	CAAGCGTTGGCTTCTCGCATCTACATTGGCATCCACGTGCTTGAG
Barcode B-7	CAAGCGTTGGCTTCTCGCATCTCAGATCTGATCCACGTGCTTGAG
Barcode B-8	CAAGCGTTGGCTTCTCGCATCTCATCAAGTATCCACGTGCTTGAG
Barcode B-9	CAAGCGTTGGCTTCTCGCATCTCGCTGATCATCCACGTGCTTGAG
Barcode B-10	CAAGCGTTGGCTTCTCGCATCTACAAGCTAATCCACGTGCTTGAG
Barcode B-11	CAAGCGTTGGCTTCTCGCATCTCTGTAGCCATCCACGTGCTTGAG
Barcode B-12	CAAGCGTTGGCTTCTCGCATCTAGTACAAGATCCACGTGCTTGAG
Barcode B-13	CAAGCGTTGGCTTCTCGCATCTAACAACCAATCCACGTGCTTGAG
Barcode B-14	CAAGCGTTGGCTTCTCGCATCTAACCGAGAATCCACGTGCTTGAG
Barcode B-15	CAAGCGTTGGCTTCTCGCATCTAACGCTTAATCCACGTGCTTGAG
Barcode B-16	CAAGCGTTGGCTTCTCGCATCTAAGACGGAATCCACGTGCTTGAG
Barcode B-17	CAAGCGTTGGCTTCTCGCATCTAAGGTACAATCCACGTGCTTGAG
Barcode B-18	CAAGCGTTGGCTTCTCGCATCTACACAGAAATCCACGTGCTTGAG
Barcode B-19	CAAGCGTTGGCTTCTCGCATCTACAGCAGAATCCACGTGCTTGAG
Barcode B-20	CAAGCGTTGGCTTCTCGCATCTACCTCCAAATCCACGTGCTTGAG
Barcode B-21	CAAGCGTTGGCTTCTCGCATCTACGCTCGAATCCACGTGCTTGAG
Barcode B-22	CAAGCGTTGGCTTCTCGCATCTACGTATCAATCCACGTGCTTGAG
Barcode B-23	CAAGCGTTGGCTTCTCGCATCTACTATGCAATCCACGTGCTTGAG
Barcode B-24	CAAGCGTTGGCTTCTCGCATCTAGAGTCAAATCCACGTGCTTGAG
Barcode B-25	CAAGCGTTGGCTTCTCGCATCTAGATCGCAATCCACGTGCTTGAG
Barcode B-26	CAAGCGTTGGCTTCTCGCATCTAGCAGGAAATCCACGTGCTTGAG
Barcode B-27	CAAGCGTTGGCTTCTCGCATCTAGTCACTAATCCACGTGCTTGAG
Barcode B-28	CAAGCGTTGGCTTCTCGCATCTATCCTGTAATCCACGTGCTTGAG
Barcode B-29	CAAGCGTTGGCTTCTCGCATCTATTGAGGAATCCACGTGCTTGAG
Barcode B-30	CAAGCGTTGGCTTCTCGCATCTCAACCACAATCCACGTGCTTGAG
Barcode B-31	CAAGCGTTGGCTTCTCGCATCTGACTAGTAATCCACGTGCTTGAG
Barcode B-32	CAAGCGTTGGCTTCTCGCATCTCAATGGAAATCCACGTGCTTGAG
Barcode B-33	CAAGCGTTGGCTTCTCGCATCTCACTTCGAATCCACGTGCTTGAG
Barcode B-34	CAAGCGTTGGCTTCTCGCATCTCAGCGTTAATCCACGTGCTTGAG
Barcode B-35	CAAGCGTTGGCTTCTCGCATCTCATACCAAATCCACGTGCTTGAG

Barcode B-36	CAAGCGTTGGCTTCTCGCATCTCCAGTTCAATCCACGTGCTTGAG
Barcode B-37	CAAGCGTTGGCTTCTCGCATCTCCGAAGTAATCCACGTGCTTGAG
Barcode B-38	CAAGCGTTGGCTTCTCGCATCTCCGTGAGAATCCACGTGCTTGAG
Barcode B-39	CAAGCGTTGGCTTCTCGCATCTCCTCCTGAATCCACGTGCTTGAG
Barcode B-40	CAAGCGTTGGCTTCTCGCATCTCGAACTTAATCCACGTGCTTGAG
Barcode B-41	CAAGCGTTGGCTTCTCGCATCTCGACTGGAATCCACGTGCTTGAG
Barcode B-42	CAAGCGTTGGCTTCTCGCATCTCGCATACAATCCACGTGCTTGAG
Barcode B-43	CAAGCGTTGGCTTCTCGCATCTCTCAATGAATCCACGTGCTTGAG
Barcode B-44	CAAGCGTTGGCTTCTCGCATCTCTGAGCCAATCCACGTGCTTGAG
Barcode B-45	CAAGCGTTGGCTTCTCGCATCTCTGGCATAATCCACGTGCTTGAG
Barcode B-46	CAAGCGTTGGCTTCTCGCATCTGAATCTGAATCCACGTGCTTGAG
Barcode B-47	CAAGCGTTGGCTTCTCGCATCTCAAGACTAATCCACGTGCTTGAG
Barcode B-48	CAAGCGTTGGCTTCTCGCATCTGAGCTGAAATCCACGTGCTTGAG
Barcode B-49	CAAGCGTTGGCTTCTCGCATCTGATAGACAATCCACGTGCTTGAG
Barcode B-50	CAAGCGTTGGCTTCTCGCATCTGCCACATAATCCACGTGCTTGAG
Barcode B-51	CAAGCGTTGGCTTCTCGCATCTGCGAGTAAATCCACGTGCTTGAG
Barcode B-52	CAAGCGTTGGCTTCTCGCATCTGCTAACGAATCCACGTGCTTGAG
Barcode B-53	CAAGCGTTGGCTTCTCGCATCTGCTCGGTAATCCACGTGCTTGAG
Barcode B-54	CAAGCGTTGGCTTCTCGCATCTGGAGAACAATCCACGTGCTTGAG
Barcode B-55	CAAGCGTTGGCTTCTCGCATCTGGTGCGAAATCCACGTGCTTGAG
Barcode B-56	CAAGCGTTGGCTTCTCGCATCTGTACGCAAATCCACGTGCTTGAG
Barcode B-57	CAAGCGTTGGCTTCTCGCATCTGTCGTAGAATCCACGTGCTTGAG
Barcode B-58	CAAGCGTTGGCTTCTCGCATCTGTCTGTCAATCCACGTGCTTGAG
Barcode B-59	CAAGCGTTGGCTTCTCGCATCTGTGTTCTAATCCACGTGCTTGAG
Barcode B-60	CAAGCGTTGGCTTCTCGCATCTTAGGATGAATCCACGTGCTTGAG
Barcode B-61	CAAGCGTTGGCTTCTCGCATCTTATCAGCAATCCACGTGCTTGAG
Barcode B-62	CAAGCGTTGGCTTCTCGCATCTTCCGTCTAATCCACGTGCTTGAG
Barcode B-63	CAAGCGTTGGCTTCTCGCATCTTCTTCACAATCCACGTGCTTGAG
Barcode B-64	CAAGCGTTGGCTTCTCGCATCTTGAAGAGAATCCACGTGCTTGAG
Barcode B-65	CAAGCGTTGGCTTCTCGCATCTTGGAACAAATCCACGTGCTTGAG
Barcode B-66	CAAGCGTTGGCTTCTCGCATCTTGGCTTCAATCCACGTGCTTGAG
Barcode B-67	CAAGCGTTGGCTTCTCGCATCTTGGTGGTAATCCACGTGCTTGAG
Barcode B-68	CAAGCGTTGGCTTCTCGCATCTTTCACGCAATCCACGTGCTTGAG
Barcode B-69	CAAGCGTTGGCTTCTCGCATCTAACTCACCATCCACGTGCTTGAG
Barcode B-70	CAAGCGTTGGCTTCTCGCATCTAAGAGATCATCCACGTGCTTGAG
Barcode B-71	CAAGCGTTGGCTTCTCGCATCTAAGGACACATCCACGTGCTTGAG
Barcode B-72	CAAGCGTTGGCTTCTCGCATCTAATCCGTCATCCACGTGCTTGAG

Barcode B-73	CAAGCGTTGGCTTCTCGCATCTAATGTTGCATCCACGTGCTTGAG
Barcode B-74	CAAGCGTTGGCTTCTCGCATCTACACGACCATCCACGTGCTTGAG
Barcode B-75	CAAGCGTTGGCTTCTCGCATCTACAGATTCATCCACGTGCTTGAG
Barcode B-76	CAAGCGTTGGCTTCTCGCATCTAGATGTACATCCACGTGCTTGAG
Barcode B-77	CAAGCGTTGGCTTCTCGCATCTAGCACCTCATCCACGTGCTTGAG
Barcode B-78	CAAGCGTTGGCTTCTCGCATCTAGCCATGCATCCACGTGCTTGAG
Barcode B-79	CAAGCGTTGGCTTCTCGCATCTAGGCTAACATCCACGTGCTTGAG
Barcode B-80	CAAGCGTTGGCTTCTCGCATCTATAGCGACATCCACGTGCTTGAG
Barcode B-81	CAAGCGTTGGCTTCTCGCATCTATCATTCCATCCACGTGCTTGAG
Barcode B-82	CAAGCGTTGGCTTCTCGCATCTATTGGCTCATCCACGTGCTTGAG
Barcode B-83	CAAGCGTTGGCTTCTCGCATCTCAAGGAGCATCCACGTGCTTGAG
Barcode B-84	CAAGCGTTGGCTTCTCGCATCTCACCTTACATCCACGTGCTTGAG
Barcode B-85	CAAGCGTTGGCTTCTCGCATCTCCATCCTCATCCACGTGCTTGAG
Barcode B-86	CAAGCGTTGGCTTCTCGCATCTCCGACAACATCCACGTGCTTGAG
Barcode B-87	CAAGCGTTGGCTTCTCGCATCTCCTAATCCATCCACGTGCTTGAG
Barcode B-88	CAAGCGTTGGCTTCTCGCATCTCCTCTATCATCCACGTGCTTGAG
Barcode B-89	CAAGCGTTGGCTTCTCGCATCTCGACACACATCCACGTGCTTGAG
Barcode B-90	CAAGCGTTGGCTTCTCGCATCTCGGATTGCATCCACGTGCTTGAG
Barcode B-91	CAAGCGTTGGCTTCTCGCATCTCTAAGGTCATCCACGTGCTTGAG
Barcode B-92	CAAGCGTTGGCTTCTCGCATCTGAACAGGCATCCACGTGCTTGAG
Barcode B-93	CAAGCGTTGGCTTCTCGCATCTGACAGTGCATCCACGTGCTTGAG
Barcode B-94	CAAGCGTTGGCTTCTCGCATCTGAGTTAGCATCCACGTGCTTGAG
Barcode B-95	CAAGCGTTGGCTTCTCGCATCTGATGAATCATCCACGTGCTTGAG
Barcode B-96	CAAGCGTTGGCTTCTCGCATCTGCCAAGACATCCACGTGCTTGAG
Barcode B-97	CAAGCGTTGGCTTCTCGCATCTCGGAAGAAATCCACGTGCTTGAG
Barcode B-98	CAAGCGTTGGCTTCTCGCATCTGTGACAAGATCCACGTGCTTGAG
Barcode B-99	CAAGCGTTGGCTTCTCGCATCTGAACCAGAATCCACGTGCTTGAG
Barcode B-100	CAAGCGTTGGCTTCTCGCATCTTTGCTGGAATCCACGTGCTTGAG

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2

Extended Data Table 4. Mouse Universal cocktail applied in this study.

DNA_ID	Name	Barcode sequence
A0001	anti-mouse CD4	AACAAGACCCTTGAG
A0002	anti-mouse CD8a	TACCCGTAATAGCGT
A0003	anti-mouse CD366 (Tim-3)	ATTGGCACTCAGATG
A0004	anti-mouse CD279 (PD-1)	GAAAGTCAAAGCACT
A0013	anti-mouse Ly-6C	AAGTCGTGAGGCATG
A0014	anti-mouse/human CD11b	TGAAGGCTCATTTGT
A0015	anti-mouse Ly-6G	ACATTGACGCAACTA
A0070	anti-human/mouse CD49f	TTCCGAGGATGATCT
A0073	anti-mouse/human CD44	TGGCTTCAGGTCCTA
A0074	anti-mouse CD54	ATAACCGACACAGTG
A0075	anti-mouse CD90.2	CCGATCAGCCGTTTA
A0077	anti-mouse CD73	ACACTTAACGTCTGG
A0078	anti-mouse CD49d	CGCTTGGACGCTTAA
A0079	anti-mouse CD200 (OX2)	TCAATTCCGGTAGTC
A0090	Mouse IgG1, κ isotype Ctrl	GCCGGACGACATTAA
A0091	Mouse IgG2a, κ isotype Ctrl	CTCCTACCTAAACTG
A0092	Mouse IgG2b, κ isotype Ctrl	ATATGTATCACGCGA
A0093	anti-mouse CD19	ATCAGCCATGTCAGT
A0095	Rat IgG2b, κ Isotype Ctrl	GATTCTTGACGACCT
A0096	anti-mouse CD45	TGGCTATGGAGCAGA
A0097	anti-mouse CD25	ACCATGAGACACAGT
A0103	anti-mouse/human CD45R/B220	CCTACACCTCATAAT
A0104	anti-mouse CD102	GATATTCAGTGCGAC
A0105	anti-mouse CD115 (CSF-1R)	TTCCGTTGTTGTGAG
A0106	anti-mouse CD11c	GTTATGGACGCTTGC
A0107	anti-mouse CD21/CD35 (CR2/CR1)	GGATAATTTCGATCC
A0108	anti-mouse CD23	TCTCTTGGAAGATGA
A0110	anti-mouse CD43	TTGGAGGGTTGTGCT
A0111	anti-mouse CD5	CAGCTCAGTGTGTTG
A0112	anti-mouse CD62L	TGGGCCTAAGTCATC
A0113	anti-mouse CD93 (AA4.1, early B lineage)	GGTATTTCCTGTGGT
A0114	anti-mouse F4/80	TTAACTTCAGCCCGT
A0115	anti-mouse FcεRIα	AGTCACCTCGAAGCT
A0117	anti-mouse I-A/I-E	GGTCACCAGTATGAT

A0118	anti-mouse NK-1.1	GTAACATTACTCGTC
A0119	anti-mouse Siglec H	CCGCACCTACATTAG
A0120	anti-mouse TCR β chain	TCCTATGGGACTCAG
A0121	anti-mouse TCR γ/δ	AACCCAAATAGCTGA
A0122	anti-mouse TER-119/Erythroid Cells	GCGCGTTTGTGCTAT
A0130	anti-mouse Ly-6A/E (Sca-1)	TTCCTTTCCTACGCA
A0157	anti-mouse CD45.2	CACCGTCATTCAACC
A0182	anti-mouse CD3	GTATGTCCGCTCGAT
A0190	anti-mouse CD274 (B7-H1, PD-L1)	TCGATTCCACCAACT
A0191	anti-mouse/rat/human CD27	CAAGGTATGTCACTG
A0192	anti-mouse CD20	TCCACTCCCTGTATA
A0193	anti-mouse CD357 (GITR)	GGCACTCTGTAACAT
A0194	anti-mouse CD137	TCCCTGTATAGATGA
A0195	anti-mouse CD134 (OX-40)	CTCACCTACCTATGG
A0197	anti-mouse CD69	TTGTATTCCGCCATT
A0198	anti-mouse CD127 (IL-7Rα)	GTGTGAGGCACTCTT
A0200	anti-mouse CD86	CTGGATTTGTGTATC
A0201	anti-mouse CD103	TTCATTAGCCCGCTG
A0202	anti-mouse CD64 (FcγRI)	AGCAATTAACGGGAG
A0203	anti-mouse CD150 (SLAM)	CAACGCCTAGAAACC
A0212	anti-mouse CD24	TATATCTTTGCCGCA
A0214	anti-human/mouse integrin β7	TCCTTGGATGTACCG
A0226	anti-mouse CD106	CGTTCCTACCTACCT
A0230	anti-mouse CD8b (Ly-3)	TTCCCTCTATGGAGC
A0236	Rat IgG1, κ isotype Ctrl	ATCAGATGCCCTCAT
A0237	Rat IgG1, λ Isotype Ctrl	GGGAGCGATTCAACT
A0238	Rat IgG2a, κ Isotype Ctrl	AAGTCAGGTTCGTTT
A0240	Rat IgG2c, κ Isotype Ctrl	TCCAGGCTAGTCATT
A0241	Armenian Hamster IgG Isotype Ctrl	CCTGTCATTAAGACT
A0250	anti-mouse/human KLRG1 (MAFA)	GTAGTAGGCTAGACC
A0378	anti-mouse CD223 (LAG-3)	ATTCCGTCCCTAAGG
A0417	anti-mouse CD163	GAGCAAGATTAAGAC
A0421	anti-mouse CD49b	CGCGTTAGTAGAGTC
A0422	anti-mouse CD172a (SIRPα)	GATTCCCTTGTAGCA
A0429	anti-mouse CD48	AGAACCGCCGTAGTT
A0431	anti-mouse CD170 (Siglec-F)	TCAATCTCCGTCGCT
A0440	anti-mouse CD169/Siglec-1	ATTGACGACAGTCAT

A0441	anti-mouse CD71	ACCGACCAGTAGACA
A0443	anti-mouse CD41	ACTTGGATGGACACT
A0450	anti-mouse IgM	AGCTACGCATTCAAT
A0551	anti-mouse CD301a	TGTATTTACTCACCG
A0552	anti-mouse CD304 (Neuropilin-1)	CCAGCTCATTCAACG
A0555	anti-mouse CD36	TTTGCCGCTACGACA
A0557	anti-mouse CD38	CGTATCCGTCTCCTA
A0558	anti-mouse CD55 (DAF)	ATTGTTGTCAGACCA
A0559	anti-mouse CD63	ATCCGACACGTATTA
A0560	anti-mouse CD68	CTTTCTTTCACGGGA
A0561	anti-mouse CD79b (Igβ)	TAACTCAGTGCGAGT
A0562	anti-mouse CD83	TCTCAGGCTTCCTAG
A0563	anti-mouse CX3CR1	CACTCTCAGTCCTAT
A0566	anti-mouse CD301b	CTTGCCTTGCGATTT
A0567	anti-mouse Tim-4	TGCTGGAGGGTATTC
A0568	anti-mouse/rat XCR1	TCCATTACCCACGTT
A0570	anti-mouse/rat CD29	ACGCATTCCTTGTGT
A0571	anti-mouse IgD	TCATATCCGTTGTCC
A0595	anti-mouse CD11a	AGAGTCTCCCTTTAG
A0807	anti-mouse CD200R (OX2R)	ATTCTTTCCCTCTGT
A0809	anti-mouse CD200R3	ATCAACTTGGAGCAG
A0810	anti-mouse CD138 (Syndecan-1)	GCGTTTGTATGTACT
A0811	anti-mouse CD317 (BST2, PDCA-1)	TGTGGTAGCCCTTGT
A0813	anti-mouse CD9	TAGCAGTCACTCCTA
A0825	anti-mouse CD371 (CLEC12A)	GCGAGAAATCTGCAT
A0827	anti-mouse CD22	AGGTCCTCTCTGGAT
A0837	anti-mouse IL-33Rα (IL1RL1, ST2)	GCGATGGAGCATGTT
A0839	anti-mouse Ly49H	CCAGTAGGCTTATTA
A0841	anti-mouse Ly49D	TATATCCCTCAACGC
A0842	anti-mouse Ly-49A	AATTCCGTCAGATGA
A0846	anti-mouse CD185 (CXCR5)	ACGTAGTCACCTAGT
A0850	anti-mouse CD49a	CCATTCATTTGTGGC
A0851	anti-mouse CD1d (CD1.1, Ly-38)	CAACTTGGCCGAATC
A0852	anti-mouse CD226 (DNAM-1)	ACGCAGTATTTCCGA
A0854	anti-mouse CD199 (CCR9)	CCCTCTGGTATGGTT
A0877	anti-mouse JAML	GTTATGGTTCGTGTT
A0881	anti-mouse CD272 (BTLA)	TGACCCTATTGAGAA

A0882	anti-mouse PIR-A/B	TGTAGAGTCAGACCT
A0883	anti-mouse CD26 (DPP-4)	ATGGCCTGTCATAAT
A0885	anti-mouse CD270 (HVEM)	GATCCGTGTTGCCTA
A0892	anti-mouse CD2	TTGCCGTGTGTTTAA
A0893	anti-mouse CD120b (TNF R Type II/p75)	GAAGCTGTATCCGAA
A0903	anti-mouse CD40	ATTTGTATGCTGGAG
A0904	anti-mouse CD31	GCTGTAGTATCATGT
A0905	anti-mouse CD107a (LAMP-1)	AAATCTGTGCCGTAC
A0910	anti-mouse/rat CD61	TTCTTTACCCGCCTG
A0915	anti-mouse VISTA (PD-1H)	ACATTCCCTTGCCT
A0926	anti-mouse CD186 (CXCR6)	TGTCAGGTTGTATTC
A0927	anti-mouse CD159a (NKG2AB6)	GTGTTTGTGTTCCTG
A0930	anti-mouse Ly108	CGATTCTTTGCGAGT
A1006	anti-mouse CD160	GCGTATGTCAGTACC
A1007	anti-mouse CD85k (gp49 Receptor)	ATGTCAACTCTGGGA
A1008	anti-mouse CD51	GGAGTCAGGGTATTA
A1009	anti-mouse CD94	CACAGTTGTCCGTGT
A1010	anti-mouse CD205 (DEC-205)	CATATTGGCCGTAGT
A1011	anti-mouse CD155 (PVR)	TAGCTTGGGATTAAG
A1064	anti-mouse/rat CD81	TTGTCACCAACTTCC
	MBP	TAGTACGGATCCAGT
	MOG	GGTACTGAACTTTAG
	NEUN	CGAGTGCACCTTGAG
	PDGFRα	CTTGATCGTTGACGA
	SATB2	GACAAATTGTCAGTT
	TBR1	AATCGAATTGGCATA
	CUX2/1	AAACTAAGATGACGG
	CTIP2	TTAAGATCAGGAATC

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2

Extended Data Table 5. Human Universal cocktail applied in this study.

ID	Name	Barcode sequence
ADT_A0006	Hu.CD86	GTCTTTGTCAGTGCA
ADT_A0007	Hu.CD274	GTTGTCCGACAATAC
ADT_A0020	Hu.CD270	TGATAGAAACAGACC
ADT_A0023	Hu.CD155	ATCACATCGTTGCCA
ADT_A0024	Hu.CD112	AACCTTCCGTCTAAG
ADT_A0026	Hu.CD47	GCATTCTGTCACCTA
ADT_A0029	Hu.CD48	CTACGACGTAGAAGA
ADT_A0031	Hu.CD40	CTCAGATGGAGTATG
ADT_A0032	Hu.CD154	GCTAGATAGATGCAA
ADT_A0033	Hu.CD52	CTTTGTACGAGCAAA
ADT_A0034	Hu.CD3_UCHT1	CTCATTGTAACTCCT
ADT_A0046	Hu.CD8	GCGCAACTTGATGAT
ADT_A0047	Hu.CD56	TCCTTTCCTGATAGG
ADT_A0050	Hu.CD19	CTGGGCAATTACTCG
ADT_A0052	Hu.CD33	TAACTCAGGGCCTAT
ADT_A0053	Hu.CD11c	TACGCCTATAACTTG
ADT_A0058	Hu.HLA.ABC	TATGCGAGGCTTATC
ADT_A0063	Hu.CD45RA	TCAATCCTTCCGCTT
ADT_A0064	Hu.CD123	CTTCACTCTGTCAGG
ADT_A0066	Hu.CD7	TGGATTCCCGGACTT
ADT_A0070	HuMs.CD49f	TTCCGAGGATGATCT
ADT_A0071	Hu.CD194	AGCTTACCTGCACGA
ADT_A0072	Hu.CD4_RPA.T4	TGTTCCCGCTCAACT
ADT_A0073	HuMs.CD44	TGGCTTCAGGTCCTA
ADT_A0081	Hu.CD14_M5E2	TCTCAGACCTCCGTA
ADT_A0083	Hu.CD16	AAGTTCACTCTTTGC
ADT_A0085	Hu.CD25	TTTGTCCTGTACGCC
ADT_A0087	Hu.CD45RO	CTCCGAATCATGTTG
ADT_A0088	Hu.CD279	ACAGCGCCGTATTTA
ADT_A0089	Hu.TIGIT	TTGCTTACCGCCAGA
ADT_A0090	Isotype_MOPC.21	GCCGGACGACATTAA
ADT_A0091	Isotype_MOPC.173	CTCCTACCTAAACTG
ADT_A0092	Isotype_MPC.11	ATATGTATCACGCGA
ADT_A0095	Isotype_RTK4530	GATTCTTGACGACCT
ADT_A0100	Hu.CD20_2H7	TTCTGGGTCCCTAGA

ADT_A0101	Hu.CD335	ACAATTTGAACAGCG
ADT_A0124	Hu.CD31	ACCTTTATGCCACGG
ADT_A0127	Hu.Podoplanin	GGTTACTCGTTGTGT
ADT_A0134	Hu.CD146	CCTTGGATAACATCA
ADT_A0136	Hu.IgM	TAGCGAGCCCGTATA
ADT_A0138	Hu.CD5	CATTAACGGGATGCC
ADT_A0140	Hu.CD183	GCGATGGTAGATTAT
ADT_A0141	Hu.CD195	CCAAAGTAAGAGCCA
ADT_A0142	Hu.CD32	GCTTCCGAATTACCG
ADT_A0143	Hu.CD196	GATCCCTTTGTCACT
ADT_A0144	Hu.CD185	AATTCAACCGTCGCC
ADT_A0145	Hu.CD103	GACCTCATTGTGAAT
ADT_A0146	Hu.CD69	GTCTCTTGGCTTAAA
ADT_A0147	Hu.CD62L	GTCCTGCAACTTGA
ADT_A0149	Hu.CD161	GTACGCAGTCCTTCT
ADT_A0151	Hu.CD152	ATGGTTCACGTAATC
ADT_A0152	Hu.CD223	CATTTGTCTGCCGGT
ADT_A0153	Hu.KLRG1	CTTATTTCCTGCCCT
ADT_A0154	Hu.CD27	GCACTCCTGCATGTA
ADT_A0155	Hu.CD107a	CAGCCCACTGCAATA
ADT_A0156	Hu.CD95	CCAGCTCATTAGAGC
ADT_A0158	Hu.CD134	AACCCACCGTTGTTA
ADT_A0159	Hu.HLA.DR	AATAGCGAGCAAGTA
ADT_A0160	Hu.CD1c	GAGCTACTTCACTCG
ADT_A0161	Hu.CD11b	GACAAGTGATCTGCA
ADT_A0162	Hu.CD64	AAGTATGCCCTACGA
ADT_A0163	Hu.CD141	GGATAACCGCGCTTT
ADT_A0165	Hu.CD314	CGTGTTTGTTCCTCA
ADT_A0167	Hu.CD35	ACTTCCGTCGATCTT
ADT_A0168	Hu.CD57	AACTCCCTATGGAGG
ADT_A0170	Hu.CD272	GTTATTGGACTAAGG
ADT_A0171	HuMsRt.CD278	CGCGCACCCATTAAA
ADT_A0172	Hu.CD275_B7.RP1	GTTAGTGTTAGCTTG
ADT_A0174	Hu.CD58	GTTCCTATGGACGAC
ADT_A0176	Hu.CD39	TTACCTGGTATCCGT
ADT_A0179	Hu.CX3CR1	AGTATCGTCTCTGGG
ADT_A0180	Hu.CD24	AGATTCCTTCGTGTT

ADT_A0181	Hu.CD21	AACCTAGTAGTTCGG
ADT_A0185	Hu.CD11a	TATATCCTTGTGAGC
ADT_A0187	Hu.CD79b	ATTCTTCAACCGAAG
ADT_A0189	Hu.CD244	TCGCTTGGATGGTAG
ADT_A0206	Hu.CD169	TACTCAGCGTGTTTG
ADT_A0214	HuMs.integrin.b7	TCCTTGGATGTACCG
ADT_A0215	Hu.CD268	CGAAGTCGATCCGTA
ADT_A0216	Hu.CD42b	TCCTAGTACCGAAGT
ADT_A0217	Hu.CD54	CTGATAGACTTGAGT
ADT_A0218	Hu.CD62P	CCTTCCGTATCCCTT
ADT_A0219	Hu.CD119	TGTGTATTCCCTTGT
ADT_A0224	Hu.TCR.AB	CGTAACGTAGAGCGA
ADT_A0236	Isotype_RTK2071	ATCAGATGCCCTCAT
ADT_A0237	Isotype_G0114F7	GGGAGCGATTCAACT
ADT_A0238	Isotype_RTK2758	AAGTCAGGTTCGTTT
ADT_A0240	Isotype_RTK4174	TCCAGGCTAGTCATT
ADT_A0241	Isotype_HTK888	CCTGTCATTAAGACT
ADT_A0242	Hu.CD192	GAGTTCCCTTACCTG
ADT_A0246	Hu.CD122	TCATTTCCTCCGATT
ADT_A0247	Hu.CD267	AGTGATGGAGCGAAC
ADT_A0352	Hu.FceRIa	CTCGTTTCCGTATCG
ADT_A0353	Hu.CD41	ACGTTGTGGCCTTGT
ADT_A0355	Hu.CD137	CAGTAAGTTCGGGAC
ADT_A0357	Hu.CD43	GATTAACCAGCTCAT
ADT_A0358	Hu.CD163	GCTTCTCCTTCCTTA
ADT_A0359	Hu.CD83	CCACTCATTTCCGGT
ADT_A0364	Hu.CD13	TTTCAACGCCCTTTC
ADT_A0367	Hu.CD2	TACGATTGTCAGGG
ADT_A0368	Hu.CD226_11A8	TCTCAGTGTTTGTGG
ADT_A0369	Hu.CD29	GTATTCCCTCAGTCA
ADT_A0370	Hu.CD303	GAGATGTCCGAATTT
ADT_A0371	Hu.CD49b	GCTTCTTCAGTATG
ADT_A0372	Hu.CD61	AGGTTGGAGTAGACT
ADT_A0373	Hu.CD81	GTATCCTTCCTTGGC
ADT_A0383	Hu.CD55	GCTCATTACCCATTA
ADT_A0384	Hu.IgD	CAGTCTCCGTAGAGT
ADT_A0385	Hu.CD18	TATTGGGACACTTCT

ADT_A0386	Hu.CD28	TGAGAACGACCCTAA
ADT_A0389	Hu.CD38_HIT2	TGTACCCGCTTGTGA
ADT_A0390	Hu.CD127	GTGTGTTGTCCTATG
ADT_A0391	Hu.CD45_HI30	TGCAATTACCCGGAT
ADT_A0393	Hu.CD22	GGGTTGTTGTCTTTG
ADT_A0394	Hu.CD71	CCGTGTTCCTCATTA
ADT_A0396	Hu.CD26	GGTGGCTAGATAATG
ADT_A0398	Hu.CD115	AATCACGGTCCTTGT
ADT_A0404	Hu.CD63	GAGATGTCTGCAACT
ADT_A0406	Hu.CD304	GGACTAAGTTTCGTT
ADT_A0407	Hu.CD36	TTCTTTGCCTTGCCA
ADT_A0408	Hu.CD172a	CGTGTTAACTTGAG
ADT_A0419	Hu.CD72	CAGTCGTGGTAGATA
ADT_A0420	Hu.CD158	TATCAACCAACGCTT
ADT_A0446	Hu.CD93	GCGCTACTTCCTTGA
ADT_A0447	Hu.CD200	CACGTAGACCTTTGC
ADT_A0575	Hu.CD49a	ACTGATGGACTCAGA
ADT_A0576	Hu.CD49d	CCATTCAACTTCCGG
ADT_A0577	Hu.CD73	CAGTTCCTCAGTTCG
ADT_A0579	Hu.CD9	GAGTCACCAATCTGC
ADT_A0581	Hu.TCR.Va7.2	TACGAGCAGTATTCA
ADT_A0582	Hu.TCR.Vd2	TCAGTCAGATGGTAT
ADT_A0586	Hu.CD354	TAGCCGTTTCCTTTG
ADT_A0590	Hu.CD305_LAIR1	ATTTCCATTCCCTGT
ADT_A0591	Hu.LOX.1	ACCCTTTACCGAATA
ADT_A0599	Hu.CD158e1	GGACGCTTTCCTTGA
ADT_A0817	Hu.CD109	CACTTAACTCTGGGT
ADT_A0822	Hu.CD142	CACTGCCGTCGATTA
ADT_A0830	Hu.CD319	AGTATGCCATGTCTT
ADT_A0845	Hu.CD99	ACCCGTCCCTAAGAA
ADT_A0853	Hu.CLEC12A	CATTAGAGTCTGCCA
ADT_A0861	Hu.CD151	CTTACCTAGTCATTC
ADT_A0864	Hu.CD352	AGTTTCCACTCAGGC
ADT_A0866	Hu.CLEC1B	TGCCAGTATCACGTA
ADT_A0867	Hu.CD94	CTTTCCGGTCCTACA
ADT_A0868	Hu.IgE	GGATGTACCGCGTAT
ADT_A0870	Hu.CD150	GTCATTGTATGTCTG

ADT_A0871	Hu.CD162	ATATGTCAGAGCACC
ADT_A0872	Hu.CD84	CTCCCTAGTTCCTTT
ADT_A0894	Hu.Ig.LightChain.k	AGCTCAGCCAGTATG
ADT_A0896	Hu.CD85j	CCTTGTGAGGCTATG
ADT_A0897	Hu.CD23	TCTGTATAACCGTCT
ADT_A0898	Hu.Ig.LightChain.l	CAGCCAGTAAGTCAC
ADT_A0902	Hu.CD328	CTTAGCATTTCACTG
ADT_A0912	Hu.GPR56	GCCTAGTTTCCGTTT
ADT_A0920	Hu.CD82	TCCCACTTCCGCTTT
ADT_A0923	Hu.NKp80	TATAGTTCCTCTGTG
ADT_A0931	Hu.CD131	CTGCATGAGACCAAA
ADT_A0935	Hu.CD74	CTGTAGCATTTCCCT
ADT_A0940	Hu.CD116	ATGGACAGTTCGTGT
ADT_A0941	Hu.CD37	ACAGTCACTGGGCAA
ADT_A0944	Hu.CD101	CTACTTCCCTGTCAA
ADT_A1018	Hu.HLA.DR.DP.DQ	AGCTACGAGCAGTAG
ADT_A1046	Hu.CD88	GCCGCATGAGAAACA

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Extended Data Table 6. Chemicals and reagents.

Name	Catalog number	Vender
Formaldehyde solution	PI28906	Thermo Fisher Scientific
HEPES pH 7.5	BBH-75-250	Boston BioProducts
Glycine	50046	Sigma-Aldrich
NaCl	AM9760G	Thermo Fisher Scientific
Digitonin	G9441	Promega
MgCl$_2$	AM9530G	Thermo Fisher Scientific
Spermidine	S0266	Sigma-Aldrich
EDTA-free Protease Inhibitor Cocktail	11873580001	Millipore Sigma
NP40	11332473001	Sigma-Aldrich
EDTA Solution pH 8.0	AB00502	AmericanBio
Bovine Serum Albumin (BSA)	A8806	Sigma-Aldrich
Anti-H3K27me3 antibody	9733	Cell Signaling Technology
Secondary antibody (Guinea Pig anti-Rabbit IgG)	ABIN101961	Antibodies-Online
pA-Tn5 Transposase – unloaded	C01070002	Diagenode
Triton X-100	T8787	Sigma-Aldrich
T4 DNA Ligase	M0202L	New England Biolabs
T4 DNA Ligase Reaction Buffer	B0202S	New England Biolabs
NEBuffer 3.1	B7203S	New England Biolabs
DPBS	14190144	Thermo Fisher Scientific
Proteinase K	EO0491	Thermo Fisher Scientific
Ampure XP beads	A63880	Beckman Coulter
NEBNext High-Fidelity 2X PCR Master Mix	M0541L	New England Biolabs
SYBR Green I Nucleic Acid Gel Stain	S7563	Thermo Fisher Scientific
DNA Clean & Concentrator-5	D4014	Zymo Research
Tn5 Transposase - unloaded	C01070010	Diagenode
Tagmentation Buffer (2x)	C01019043	Diagenode
Sodium dodecyl sulfate	71736	Sigma-Aldrich
Maxima H Minus Reverse Transcriptase (200 U/L)	EP0751	Thermo Fisher Scientific
dNTP mix	R0192	Thermo Fisher Scientific
SUPERased In RNase Inhibitor	AM2694	Thermo Fisher Scientific

Ampure XP beads	A63880	Beckman Coulter
Dynabeads MyOne C1	65001	Thermo Fisher Scientific
RNase Inhibitor	Y9240L	Enzymatics
Kapa Hotstart HiFi ReadyMix	KK2601	Kapa Biosystems
Nextera XT DNA Preparation Kit	FC-131-1024	Illumina
PDGFRα	ab234965	abcam
OLIG2	ab220796	abcam
APC	ab239828	abcam
MBP	ab230378	abcam
IBA1	ab220815	abcam
GFAP	ab218309	abcam
CTIP2	ab269367	abcam
CUX1+Cux2	ab309140	abcam
TBR1	ab239000	abcam
NeuN	ab209898	abcam
MOG	ab255266	abcam
Satb2	ab212177	abcam
CD31	4250001	Akoya
CD4	4250016	Akoya
CD8a	4250017	Akoya
CD19	4250014	Akoya
CD45R/B220	4450006	Akoya
CD11c	4550108	Akoya
Ki67	4250019	Akoya
CD11b	4450015	Akoya
Ly6g	4550110	Akoya
CD3	4550109	Akoya
CD169	4550100	Akoya
Mouse Universal Cocktail	199901	BioLegend
Human Universal Cocktail	399907	BioLegend

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1 **Extended Data Table 7.** The gene list of each cluster generated from the regression model for
2 mouse brain cortical layers.
3 **Extended Data Table 8.** The gene list of each cluster generated from the regression model for
4 mouse brain corpus callosum.
5 **Extended Data Video 1.** Video output from TRIC-DISCO, replicate #1.
6 **Extended Data Video 2.** Video output from TRIC-DISCO, replicate #2.
7 **Extended Data Video 3.** Video output from TRIC-DISCO, replicate #3.
8