

Supplementary Table 1: Public CITE-seq data summary

Dataset	Tissue	URL
10X_pbmc_10k	PBMC	https://support.10xgenomics.com/single-cell-gene-expression/datasets/3.0.0/pbmc_10k_protein_v3
10X_pbmc_1k	PBMC	https://www.10xgenomics.com/resources/datasets/1-k-pbm-cs-from-a-healthy-donor-gene-expression-and-cell-surface-protein-3-standard-3-0-0
10X_pbmc_5k_v3	PBMC	https://www.10xgenomics.com/datasets/5k-human-pbmcs-3-v3-1-chromium-controller-3-1-standard
10X_pbmc_5k_nextgem	PBMC	https://www.10xgenomics.com/resources/datasets/5-k-peripheral-blood-mononuclear-cells-pbm-cs-from-a-healthy-donor-with-cell-surface-proteins-next-gem-3-1-standard-3-1-0
10X_malt_10k	MALT	https://www.10xgenomics.com/resources/datasets/10-k-cells-from-a-malt-tumor-gene-expression-and-cell-surface-protein-3-standard-3-0-0
stuart_2019	Bone Marrow	https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE128639
granja_2019_bmmc	Bone Marrow	https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE139369
granja_2019_pbmc	PBMC	https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE139369
hao_2020	PBMC	https://atlas.fredhutch.org/nygc/multimodal-pbmc/
kotliarov_2020	PBMC	https://nih.figshare.com/articles/dataset/CITE-seq_protein-mRNA_single_cell_data_from_high_and_low_vaccine_responders_to_reproduce_Figs_4-6_and_associated_Extended_Data_Figs_/11349761
witkowski_2020	Bone Marrow	https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE153358
triana_2021	Bone Marrow	https://figshare.com/projects/Single-cell_proteo-genomic_reference_maps_of_the_human_hematopoietic_system/94469
buus_2021_T	Only keep T cells	https://figshare.com/collections/Improving_oligo-conjugated_antibody_signal_in_multimodal_single-cell_analysis/5018987
Nettersheim_2022	PBMC (Titration)	https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE213282
Stephenson_2021	PBMC (COVID-19)	https://www.ebi.ac.uk/biostudies/arrayexpress/studies/E-MTAB-10026

*PBMC: Peripheral Blood Mononuclear Cells; MALT: Mucosa-Associated Lymphoid Tissue.

Supplementary Table 2: Manual gating strategy.

Cell Type	Gating Strategy
B	CD3 ⁻ CD19 ⁺
CD4 T	CD3 ⁺ CD19 ⁻ CD4 ⁺ CD8 ⁻
CD8 T	CD3 ⁺ CD19 ⁻ CD4 ⁻ CD8 ⁺
DC	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁻ HLA-DR ⁺ CD56 ⁻ CD16 ⁻
NK	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁻ HLA-DR ⁻ CD56 ⁺
Monocytes	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁺
naïve B	CD3 ⁻ CD19 ⁺ CD27 ⁻
memory B	CD3 ⁻ CD19 ⁺ CD27 ⁺
naive CD4	CD3 ⁺ CD19 ⁻ CD4 ⁺ CD8 ⁻ CD25 ⁻ CD45RA ⁺ CD45RO ⁻
memory CD4	CD3 ⁺ CD19 ⁻ CD4 ⁺ CD8 ⁻ CD25 ⁻ CD45RA ⁻ CD45RO ⁺
Treg	CD3 ⁺ CD19 ⁻ CD4 ⁺ CD8 ⁻ CD25 ⁺ CD127 ⁻
naive CD8	CD3 ⁺ CD19 ⁻ CD4 ⁻ CD8 ⁺ CD45RA ⁺ CD45RO ⁻
memory CD8	CD3 ⁺ CD19 ⁻ CD4 ⁻ CD8 ⁺ CD45RA ⁻ CD45RO ⁺
plasmacytoid DC	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁻ HLA-DR ⁺ CD56 ⁻ CD16 ⁻ CD123 ⁺ CD11c ⁻
myeloid DC	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁻ HLA-DR ⁺ CD56 ⁻ CD16 ⁻ CD123 ⁻ CD11c ⁺
CD16 ⁺ NK	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁻ HLA-DR ⁻ CD56 ⁺ CD16 ⁺
CD16 ⁻ NK	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁻ HLA-DR ⁻ CD56 ⁺ CD16 ⁻
classical monocyte	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁺ CD16 ⁻
intermediate monocyte	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁺ CD16 ⁺
non-classical CD16 ⁺ monocyte	CD3 ⁻ CD19 ⁻ CD20 ⁻ CD14 ⁻ HLA-DR ⁺ CD56 ⁻ CD16 ⁺