

Supplemental table 1. Demographic data of donors, clinical information and assays applied to each tissue/donor are listed.

ID	Location	Age	Gender	Autoimmune Manifestations	Used for
Control1(E)	Axillary	71	M	-	GeoMx, Panel1, Panel2, Panel3, Panel4, Panel5
Control2(F)	Cervical	39	M	-	Panel1, Panel2, Panel3, Panel4
Control3(G)	Inguinal	49	M	-	GeoMx, Panel1, Panel2, Panel3, Panel4, Panel5
Control4(U)	Inguinal	78	M	-	GeoMx, Panel1, Panel3, Panel4, Panel5
SLE1(A)	Inguinal	35	M	ANA (+), anti-SSA-52 (+), anti-SSA-60(+), C4(low), C3(low), isolated hemolysis, IgG=30.1 g/l	GeoMx, Panel1, Panel2, Panel3, Panel4, Panel5
SLE2(B)	Axillary	56	F	ANA (+), anti-nucleosome (borderline), SLE GN class V, IgG=10.7 g/l	Panel1, Panel2, Panel3, Panel4
SLE3(C)	Inguinal	21	M	ANA (+), anti-SSA-60 (+), anti-RNP (+), anti-Sm (+), anti-dsDNA (+), anti-nucleosome (+), C4(low), C3(low), leukopenia-anemia, IgG=47.5 g/l	GeoMx, Panel1, Panel2, Panel3, Panel4, Panel5
SLE4(D)	Inguinal	25	F	ANA (+), anti-SSA-52 (borderline), (+), anti-RNP (+), anti-Sm (+), anti- dsDNA (+), anti-nucleosome (+), C4(low), C3(low), leukopenia, IgG=23.1 g/l	GeoMx, Panel1, Panel2, Panel3, Panel4, Panel5

SLE5(I)	Cervical	21	F	ANA (+), anti-SSA-52 (+), anti-SSA-60(+), anti- dsDNA (+), anti-nucleosome (+), C4(low), C3(low), leukopenia-anemia, SLE GN class IV, IgG=14.78 g/l	GeoMx, Panel1, Panel3, Panel4, Panel5
---------	----------	----	---	---	---------------------------------------

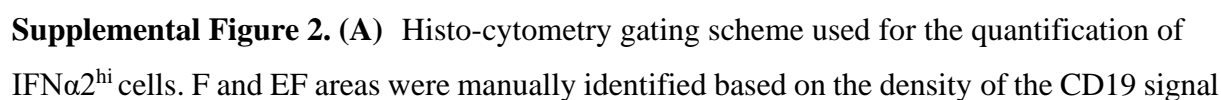
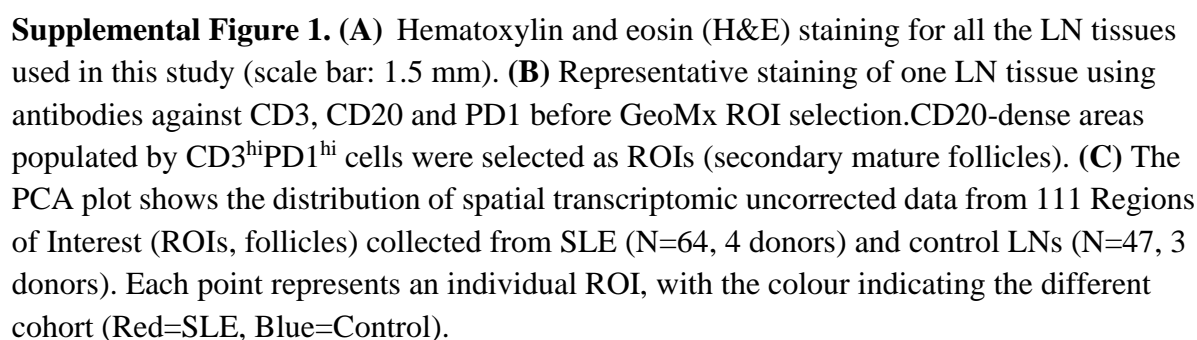
Supplemental table 2. The antibody clones, catalogue numbers and fluorochrome used are shown.

Epitope	Clone	Cat No	Fluorophore
CD4	SP35	790-4423	Opal690
PD-1	NAT 105	ACI 3137	Opal620
Ki67	MIB-1	M7240	Opal780(1), Opal520(2)
CD20	L26	NCL-L-CD20-L26	Opal520
GATA-3	L50-823	760-4897	Opal570
Bcl-6	GI191E/A8	760-4241	Opal480
CD8	C8/144B	M710301-2	Opal780
PAX5	SP34	790-4420	Opal690
GRZb	GrB-7	MON7029C	Opal480
Perforin	5B10	Mob555	Opal570
CD57	NK-1	Mob 163	Opal480
CD14	EPR3653	114R-15	Opal520
CD16	2H7	CD16-L-CE	Opal570
CD11c	EP1347Y	ab52632	Opal780(4), Alexa555(5)
CD19	BT51E	NCL-L-CD19-163	Opal690

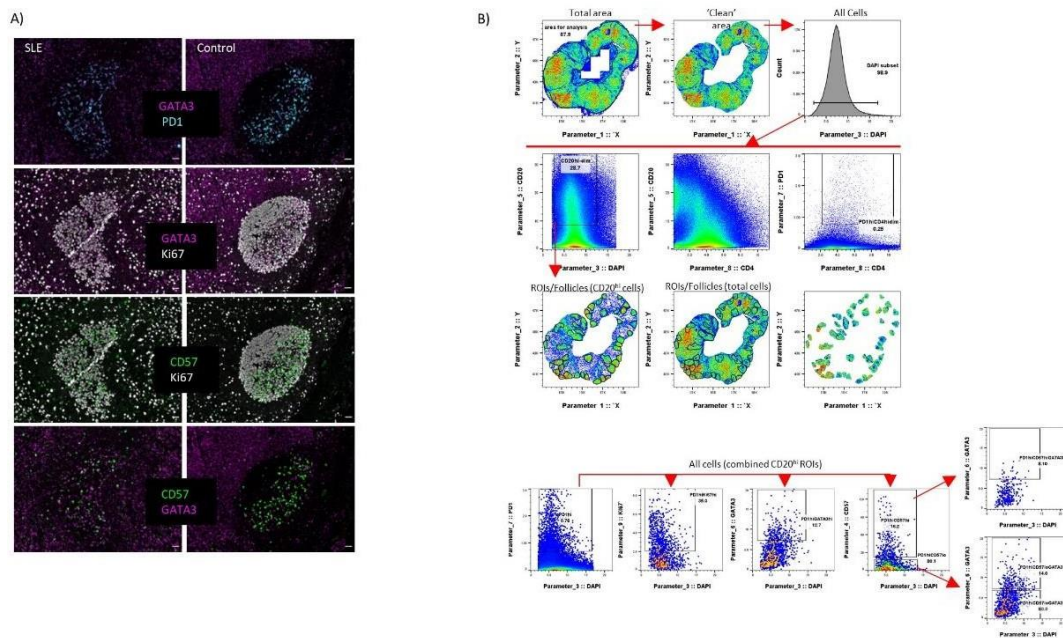
Tbet	MRQ-46	760-4598	Opal480
IFN- α 2	Polyclonal	ab198914	Opal620
FDC	CNA.42	14-99-68-82	Alexa488
CXCL-13	Polyclonal	PA5-28827	Opal780
IL-21	Polyclonal	AHP1845	BV421

Supplemental table 3. The antibody panels and dilutions used are shown.

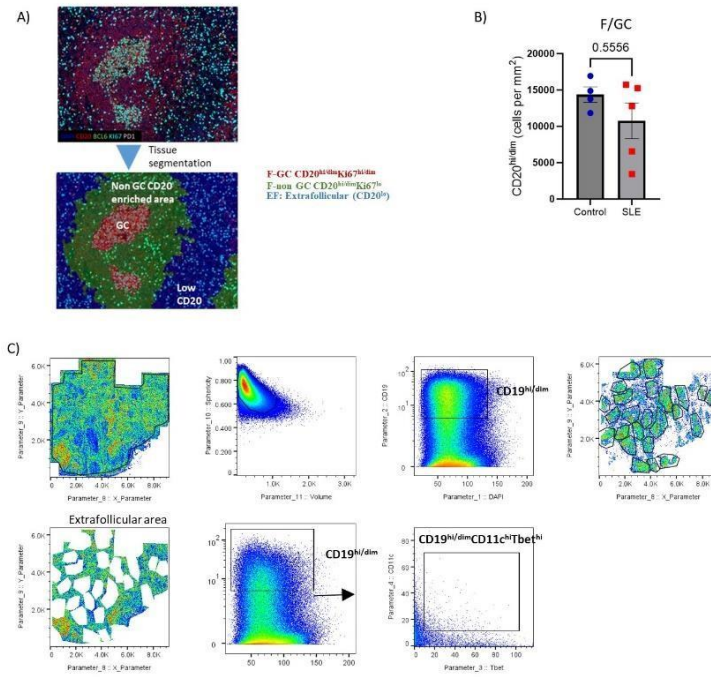
Panel1	Panel2	Panel3	Panel4	Panel5
Bcl-6 (Ready to use)	CD8 (1/100)	CD4 (Ready to use)	CD11c (1/200)	CD20 (1/400)
CD4 (Ready to use)	PD-1 (1/100)	PD-1 (1/100)	CD19 (1/200)	FDC (1/350)
PD-1 (1/100)	Perforin (1/10)	Ki67 (1/300)	Tbet (Ready to use)	IL-21 (1/80)
Ki67 (1/300)	GRZb (1/40)	CD20 (1/400)	IFN- α 2 (1/200)	CXCL-13 (1/300)
CD20 (1/400)	PAX-5 (Ready to use)	GATA-3 (1/10)	CD14 (1/100)	CD11c (1/20)
GATA-3 (1/10)	Ki67 (1/300)	CD57 (1/200)	CD16 (1/100)	
DAPI	DAPI	DAPI	DAPI	SYTO45



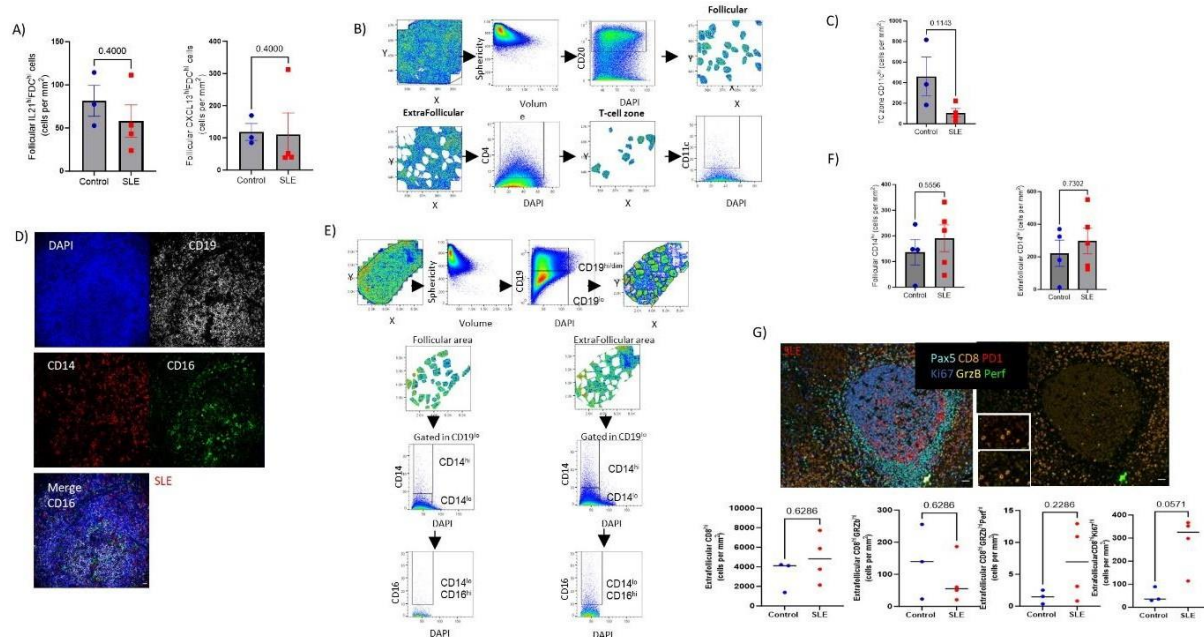
and gated back to the X, Y dot plot. Representative data from a SLE LN are plotted. **(B)** Bar graphs demonstrating the cell densities of extrafollicular (right) and follicular (left) IFN α 2^{hi} cells in SLE (N = 5) and control LNs (N = 4). Each dot/square represents one donor. The p values were calculated using the Mann–Whitney test. Data represent mean \pm SEM. **(C)** Graphs representing the relative correlation of deconvoluted cell subsets proportion (T, B, dendritic cells) from all the ROIs with T (upper) and B (lower) cell related genes. **(D)** Bar graphs demonstrating the quantification of Circularity of follicles (identified as CD19^{hi}/dim areas. Area and solidity of ROIs were calculated using FIJI. Each dot/square represents a different follicle. The p values were calculated using the mixed effects model (MEM). Data represent mean \pm SEM.



Supplemental Figure 3. **(A)** Representative mIF images of GATA3 (magenta), CD57 (green), Ki67 (grey) and PD1 (cyan) from SLE and control LNs (scale bar:20mm). **(B)** Histo-cytometry gating scheme used for the quantification of T_{FH} cell subsets. F and EF areas were manually identified based on the density of the CD20 signal and gated back to the X, Y dot plot. Representative data from a control LN are plotted.



Supplemental Figure 4. (A) Representative example of tissue segmentation into different anatomical categories (F/GC-CD20^{hi/dim}Ki67^{hi/dim}- F/ non-GC-CD20^{hi/dim}Ki67^{lo}-EF CD20^{lo}) using the inForm image analysis software, version 2.4.8 (Akoya). (B) Bar graphs demonstrating the cell densities of F/GC- CD20^{hi/dim} B cells in SLE (N = 5) and control LNs (N = 4). Each dot/square represents one donor. The p values were calculated using the Mann–Whitney test. Data represent mean \pm SEM. (C) Histo-cytometry gating scheme used for the quantification of CD19^{hi/dim}CD11c^{hi}Tbet^{hi} cells. F and EF areas were manually identified based on the density of the CD19 signal and gated back to the X, Y dot plot. Representative data from a SLE LN are plotted.



Supplemental Figure 5. (A) Bar graphs demonstrating the cell densities of follicular $IL21^{hi}FDC^{hi}$ and $CXCL13^{hi}FDC^{hi}$ cells in SLE (N = 4) and control LNs (N = 3). Each dot/square represents one donor. The p values were calculated using the Mann–Whitney test. Data represent mean \pm SEM. (B) Histo-cytometry gating scheme used for the quantification of T-cell zone $CD11c^{hi}$ cells. Real cells were gated based on their sphericity and volume. T-cell zone area was manually identified based on the density of the CD4 signal and gated back to the X, Y dot plot. Representative data from a control LN are plotted. (C) Bar graph demonstrating the cell densities of T-cell zone $CD11c^{hi}$ cells in SLE (N = 4) and control LNs (N = 3). Each dot/square represents one donor. The p values were calculated using the Mann–Whitney test. Data represent mean \pm SEM. (D) Representative mIF images of CD14 (red), CD16 (green) CD19 (grey) and DAPI (blue) from a SLE donor (40X, scale bar: 30 μ m). (E) Histo-cytometry gating scheme used for the quantification of $CD14^{hi}$, $CD14^{lo}CD16^{hi}$ cell subsets. F and EF areas were manually identified based on the density of the CD19 signal and gated back to the X, Y dot plot. Representative data from a SLE LN are plotted. (F) Bar graphs demonstrating the cell densities of follicular (left) and extrafollicular (right) $CD14^{hi}$ cells in SLE (N = 5) and control LNs (N = 4). Each dot/square represents one donor. The p values were calculated using the Mann–Whitney test. Data represent mean \pm SEM (G) Representative examples of PD1 (red), CD8 (orange), GRZb (yellow), Perforin (green), Ki67 (blue) and Pax5 (cyan) staining patterns from a SLE LN (upper panel, scale bar: 20mm). Bar graphs demonstrating the cell densities of extrafollicular $CD8^{hi}$, $CD8^{hi}GRZb^{hi}$, $CD8^{hi}GRZb^{hi}Perf^{hi}$, $CD8^{hi}Ki67^{hi}$ cells in SLE (N = 4)

and control LNs ($N = 3$). Each dot/square represents one donor. The p values were calculated using the Mann–Whitney test. Data represent mean \pm SEM.