Supplemental tables

Supplementary Table 1. Genes upregulated by activin A+IL12 versus beads (FC>2).

gene	FC: [ACTIVIN-IL12 / BEADS]	P-value: ACTIVIN-IL12 vs. BEADS
ABCA2	2.343450135	0.002362364
ADAM19	2.803580385	0.007991968
AFAP1	2.058737222	0.023893541
AHCYL2	2.708628088	0.018692016
AHNAK	2.440297918	0.021009203
ANXA3	6.143350904	0.07550199
APOD	4.7046	0.068916717
ARHGAP31	2.972779067	1.54E-04
ATP2B4	2.221528477	7.80E-04
BBS12	3.970744385	0.062640403
BCYRN1	2.994805614	0.003134124
BMF	2.058931061	0.077258402
C5orf62	2.429442026	3.48E-05
CCL20	2.9472	0.003248621
CD22	2.496985583	0.215917802
CD9	3.770795166	0.053135909
CDH3	2.310390903	0.124062594
CDO1	2.113184632	0.065495457
CLDN1	2.3948	0.056881363
CSF2	2.419008135	0.208412737
CTSL1	4.4882	0.002040349
CTTN	2.08278318	0.001900218
CXCR5	6.65237215	6.03E-05
CYB5R2	2.300346021	0.113056972
CYFIP1	2.622043011	2.97E-04
CYP1B1	2.3645667	0.052112968
DIXDC1	5.020577407	0.001725683
DNAJC12	2.197351775	0.122979027
DOK5	2.4762	0.005339894
DYRK3	2.028701031	2.08E-04
EBI3	2.269816972	0.021297931
FASLG	2.712617508	0.032013959
FES	3.361050328	6.03E-04
FOXP4	2.12645887	0.001010786
FURIN	2.683904846	0.002065868
FUT7	6.381809773	0.002496982
G0S2	4.219453875	0.010307598
GCNT1	3.0932	0.006862705

GPR132	2.009494483	6.01E-05
GZMB	2.967922775	0.022227041
GZMH	4.629574764	6.87E-06
HMSD	2.209647786	0.043805433
IFIT2	3.698113208	0.151644662
IFIT3	3.589535865	0.125697797
IFNG	16.82224551	0.002168453
IL17F	2.106672042	0.305739162
IL18RAP	4.622042528	6.21E-05
IL21	3.689415822	0.029570055
IL23R	7.543309685	1.48E-05
IL24	2.368415825	0.008808211
IL2	3.936564906	0.002781782
IL4I1	2.74551049	0.002019898
IL9	2.981111613	0.377102638
ITGA3	3.845067236	2.33E-05
JUN	2.193922011	1.24E-05
KIAA1671	2.687468816	9.17E-04
KLF7	2.204100145	0.012915117
LAG3	2.098841962	0.011961576
LIF	3.143715094	0.003442403
LMNA	3.080678809	0.029280744
LOC100128420	2.081359972	0.004962183
LOC286442	2.735117319	0.018406427
LPL	5.787974988	0.002729163
LTA	2.016602157	0.044354832
METRNL	2.106004941	0.032694905
MIAT	2.376779685	0.049675981
MIR4746	3.1312	0.216852372
MIR762	3.56182266	0.082064038
MLLT4	2.072467257	0.103036539
MRC2	2.208469055	0.006027432
MUC1	2.017707702	0.009417179
MYO1E	2.313139492	0.062050154
NAPSA	3.516305813	0.01319139
NAPSB	10.66607143	1.82E-04
NCF2	2.003478261	0.067077024
NIPAL4	2.0608	0.013341123
NPDC1	2.897599724	0.006080367
PALLD	2.790146932	9.49E-05
PDCD1	3.512473649	0.00329754
PRG4	3.428571429	0.028950737
PRR5L	9.812661629	1.87E-04

PTK2	2.799674955	3.42E-05
PVR	2.003006227	0.020477767
RAB13	2.443252904	2.76E-04
RASGRP4	2.511781232	0.05544781
RBPJ	2.49313021	0.003054213
RCN3	2.133333333	3.21E-04
RGS16	3.285483528	3.46E-04
RHOU	2.312336416	0.018574666
RORA	2.362512873	0.04175531
SDC4	2.015622513	0.001583463
SEMA7A	2.21884058	0.001886278
SERPINB1	2.106170656	0.002649776
SKIL	2.115481172	0.004192401
SLC27A2	2.099541891	0.00604925
SMAD7	2.07315851	0.001167526
SNHG9	2.000840271	0.023068875
SNORA5B	2.0024	0.218793038
SNORA9	2.019125843	0.013152467
SNORD116-22	2.146805618	0.101903273
SNORD19	2.081740338	0.156440879
SNORD1C	2.060313165	0.200291002
SNORD43	2.136859822	0.177506908
SPR	2.32695005	0.055070797
SSTR3	2.724666771	3.41E-05
STEAP1	2.6302	0.038804306
TBKBP1	2.196003858	0.024298753
TBX21	2.013489861	0.006428995
THEM5	2.039467259	0.002797862
TIAM2	2.5052	1.19E-04
TMCC2	2.262604857	0.002688247
TMPRSS6	2.290715417	0.10153529
TNF	2.13887922	0.04173215
TNFRSF12A	2.348153512	0.031720617
TUBB6	2.506779336	0.003266087
TYMP	2.558848049	5.97E-04

Supplementary Table 2. Genes downregulated by activin A+IL12 versus beads (FC<-2).

gene	FC: [ACTIVIN-IL12 / BEADS]	P-value: ACTIVIN-IL12 vs. BEADS
ACSS1	0.464743422	4.04E-06
AGPAT9	0.363281987	0.029875941
AOAH	0.436423368	0.029072049
ATM	0.493678507	0.00587987
AUH	0.482671806	7.55E-04
B3GALNT1	0.469676623	0.141117557
BATF3	0.408364334	0.010935619
BCL2A1	0.497115852	7.12E-04
C10orf128	0.46152109	0.102708906
C1orf162	0.332269728	6.78E-05
C5orf39	0.377603278	0.028999316
CARD17	0.439753738	0.208565191
CCNI2	0.490027447	0.007111892
CECR1	0.1405456	1.15E-05
CXCR6	0.483002296	0.173892106
CYSLTR2	0.396873213	5.91E-04
EGFL6	0.431673	0.130882851
FAM46C	0.459734845	0.053231101
FBLN5	0.327943074	0.016387211
FCER2	0.343878955	0.028505027
FLJ21408	0.170664095	0.001358903
GAB2	0.246886941	0.009272844
GATA3	0.315950532	6.39E-04
GPR18	0.402170384	0.022509743
GZMA	0.275258239	0.00337507
IL13	0.127714852	2.65E-04
IL8	0.470396413	0.134888016
ITGB7	0.435321006	1.80E-04
LGMN	0.33425345	0.00538803
LIME1	0.426091131	0.022200017
LPAR6	0.494505358	0.004691165
LRRN3	0.392061871	0.002311384
MEOX1	0.328057082	0.00845204
MGC16121	0.379903125	0.087982459
MIR4658	0.498708963	0.298491488
MMP25	0.404853714	0.00681913
MYO3B	0.433087917	9.35E-04
PHLDA1	0.471949197	0.006000014
PIK3CG	0.413781361	0.002829081
PLAU	0.383435583	0.003004312

PRDM1	0.440053328	0.017654848
PTGER2	0.290296353	0.071889013
RAB37	0.376773198	0.011257109
RCBTB2	0.360151447	0.003134647
RGS1	0.357760354	0.151975181
RTP4	0.405677642	0.00370187
SCARB2	0.444132608	0.007395987
SESN3	0.316170754	5.07E-04
SLC35F3	0.468528069	0.020673247
SLC9A3	0.498359585	0.027069683
SMAD3	0.456403336	0.001260405
SNORD121B	0.489650949	0.152261603
SNORD95	0.414329849	0.051992769
SOS1	0.440173805	3.51E-04
SPNS3	0.415432428	0.073382593
ST3GAL5	0.485057862	4.10E-04
TGFBR3	0.482766738	0.002947216
TMEM71	0.488323232	0.005974872
TRANK1	0.458041379	0.025238041
TRIB2	0.492701228	0.037082962

Supplementary Table 3. Flow cytometry panels. Related to Experimental Procedures.

marker	fluorochrome	clone	vendor	diluition
screening, surface				
PD-1	PE	eBioJ105	eBioscience	1:50
CXCR5	BV421	RF8B2	BD Biosciences	1:1000 bulk order
ICOS	PE-Cy7	ISA-3	eBioscience	1:33
fixable viability dye	APC-eFluor 780		eBioscience	1:1000
differentiation, surface				
PD-1	PE	eBioJ105	eBioscience	1:50
CXCR5	BV421	RF8B2	BD Biosciences	1:500 bulk order
ICOS	PE-Cy7	ISA-3	eBioscience	1:33
CCR7	Alexa Fluor 488	G043H7	BioLegend	1:33
CD4	APC		BD Biosciences	1:50
Integrin beta 7	FITC	FIB504	eBioscience	1:33
fixable viability dye	APC-eFluor 780		eBioscience	1:1000
or				
SLAM	PE	A12	BioLegend	1:25
differentiation, intranuclear				
CD4	PerCP-eFluor 710	SK3	eBioscience	1:50
CXCR5	BV421	RF8B2	BD Biosciences	1:500 bulk order
fixable viability dye	APC-eFluor 780		eBioscience	1:1000
BCL6	Alexa Fluor 647	K112-91	BD Biosciences	1:10 bulk order
FOXP3	PE	236A/E7	eBioscience	1:50
differentiation, ICS				
fixable viability dye	APC-eFluor 780		eBioscience	1:1000
IL-21	PE	eBio3A3-N2	eBioscience	1:25
CD40L	PerCP-eFluor 710	24-31	eBioscience	1:25
TNFα	FITC	MAb11	BioLegend	1:50
LTα	PE	359-81-11	BioLegend	1:25
Phosflow on PBMCs				
pSMAD	Purified	D27F4	Cell Signaling Technology	1:400
Goat anti-Rabbit IgG (H+L) Secondary Antibody	Alexa Fluor 647	Polyclonal	Life Technologies	1:500
CD4	PerCP-eFluor 710	SK3	eBioscience	1:50
CD45RA	PE	HI100	eBioscience	1:33
P-MAPK	Alexa Fluor 488	28B10	Cell Signaling Technology	1:50
P-ERK	BV421	20A	BD Biosciences	1:25
Phosflow on tonsils				
pSMAD	Purified	D27F4	Cell Signaling Technology	1:400
Goat anti-Rabbit IgG (H+L) Secondary Antibody	Alexa Fluor 647	Polyclonal	Life Technologies	1:500
CD4	PerCP-eFluor 710	SK3	eBioscience	1:50
CD45RO	FITC	UCHL1	eBioscience	1:33
PD-1	PE	eBioJ105	eBioscience	1:50
CXCR5	BV421	RF8B2	BD Biosciences	1:500 bulk order
NHP sorting				
CD4	APC	RPA-T4	BD Biosciences	1:50
CD45RA	V450	5H9	BD Biosciences	1:25
CD95	PE-Cy7	DX2	eBioscience	1:33
CD28	PE	CD28.2	eBioscience	1:25
CCR7	AlexaFluor 488	G043H7	BioLegend	1:25
fixable viability dye	APC-eFluor 780		eBioscience	1:1000
NHP surface				
CXCR5	PE	MU5UBEE	eBioscience	1:25
ICOS	PerCP-Cy5.5	C398.4A	BioLegend	1:33
PD-1	Brilliant Violet 421	EH12.1	BD Biosciences	1:33
CCR7	Alexa Fluor 488	G043H7	BioLegend	1:25
CD4	APC	RPA-T4	BD Biosciences	1:50
fixable viability dye	APC-eFluor 780		eBioscience	1:1000
mouse surface				
CXCR5 biotin		2G8	BD Biosciences	1:50
Streptavidin	Brilliant Violet 421		BioLegend	1:200
PD-1	APC	J43	eBioscience	1:400
ICOS	PE	7E.17G9	eBioscience	1:200
CD4	FITC	GK1.5	eBioscience	1:400
CCR7	PerCP-Cy5.5	4B12	BioLegend	1:400
fixable viability dye	APC-eFluor 780		eBioscience	1:1000

Supplementary Table 4. Equipment and settings used to acquire microscopy data.

Figure 2a

Microscope	Olympus FV10i
Objective	60x 1.35 NA Immersol 518
Immersion	F
Detector	Internal PMT
Bit range	12
Acquisition software	FV10-ASW 4.2
Pixel scaling [µm x µm]	0.160 x 0.160
Original image size	5747x6644 (stitch of multiple 1024x1024 tiles)
Zoom	1.3x
Confocal aperture	116 µm (1X)

Acquisition settings	Channel 1	Channel 2	Channel 3	Channel 4
Fluorophore	Hoechst	Alexa Fluor 488	Alexa Fluor 568	DyLight 649
Laser wavelength [nm]	405	488	559	635
Laser nominal power [mW]	17.1	11.9	15	9.5
Transmissivity	0.059	0.366	1	1
PMT voltage [V]	585	620	660	708
Emission [nm]	420-460	490-590	570-670	660-760

Figure 2b and Supplementary Figure 2b

Microscope	Olympus FV10i
Objective	60x 1.35 NA Immersol 518
Immersion	F
Detector	Internal PMT
Bit range	12
Acquisition software	FV10-ASW 4.2
Pixel scaling [µm x µm]	0.148 x 0.148
Original image size	3830x3778 (stitch of multiple 1024x1024 tiles)
Zoom	1.4x
Confocal aperture	116 µm (1X)

Acquisition settings	Channel 1	Channel 2	Channel 3	Channel 4
Fluorophore	Hoechst	Alexa Fluor	Alexa Fluor 568	DyLight 649

		488		
Laser wavelength [nm]	405	488	559	635
Laser nominal power [mW]	17.1 mW	11.9 mW	15 mW	9.5 mW
Transmissivity	0.093	0.535	0.775	1
PMT voltage [V]	520	606	615	725
Emission [nm]	420-460	490-590	570-670	660-760

Supplementary Figure 2a

Microscope	ZEISS Axio Scan.Z1
Objective	20x 0.8 NA
Detector	Hamamatsu Orca Flash 4.0 v2
Bit range	16
Acquisition software	ZEN2 blue
Pixel scaling [µm x µm]	0.325 x 0.325
Image size	2920 x 2092 (stitch of multiple tiles)
Light source	HXP 120, 100%

Acquisition settings	Channel 1	Channel 2	Channel 3	Channel 4
Fluorophore	Alexa Fluor 647	Alexa Fluor 568	Alexa Fluor 488	Hoechst
Reflector cube	50 Cy5	43 HE DsRed	38 HE GFP	49 DAPI
Beam splitter [nm]	660	570	495	395
Excitation [nm]	625-655	538-562	450-490	335-383
Emission [nm]	665-715	570-640	500-550	420-470
Exposure time [ms]	300	150	100	3

Supplementary Table 5. Total number of mapped reads for each RNA-seq sample.
Related to Experimental Procedures.

Sample name	Total number of uniquely mapped reads (excluding mitochondrial reads)
ML_DN105_IL12	6211562
ML_DN105_TGFb	6831972
ML_DN105_TGFbplusIL12	6471897
ML_DN105_activin	7923520
ML_DN105_activinplusIL12	16240581
ML_DN105_beadsonly	5933043
ML_DN111_IL12	14086300
ML_DN111_TGFb	7009856
ML_DN111_TGFbplusIL12	8227535
ML_DN111_activin	9555758
ML_DN111_activinplusIL12	13408134
ML_DN111_beadsonly	7722468
ML_DN138_IL12	9691039
ML_DN138_TGFb	8568097
ML_DN138_TGFbplusIL12	7526478
ML_DN138_activin	7758777
ML_DN138_activinplusIL12	11585744
ML_DN138_beadsonly	7718322
ML_DN140_1_beadsonly	9545994
ML_DN140_2_TGFb	8263440
ML_DN140_3_IL12	14255322
ML_DN140_4_TGFbplusIL12	14602957
ML_DN140_5_activin	12786056
ML_DN140_6_activinplusIL12	17163699
ML_DN154_TGFb	12403005
ML_DN154_TGFbplusIL12	7755578
ML_DN154_activin	6616204
ML_DN154_activinplusIL12	6415498

Supplementary Table 6. Tonsil GC Tfh gene set used for GSEA analysis. Related to Experimental Procedures.

GC Tfh versus non	FC>2
Gene	
CXCR5	
CXCL13	
TOX2	
C20ORF100	
ICA1	
PDCD1	
ICA1	
CXCR5	
FAM43A	
PVALB	
SCGB3A1	
TOX2	
ASCL2	
CHI3L2	
CDK5R1	
CEBPA	
GNG4	
CXXC5	
GFOD1	
C3ORF21	
TIGIT	
POU2AF1	
HEYL	
C11ORF75	
CXXC5	
ATP9A	
KIAA1671	
SGPP2	
BCL6	
EGR2	
CDK5R1	
MYB	
LGMN	
CD79A	
KIAA1324	
NFATC1	
MYL6B	
BCAT1	
PASK	
CTLA4	
KCNK5	
PASK	

TOP2A
CTTN
LAG3
ICOS
THADA
LHFPL2
LGMN
NFATC1
MAF
CHI3L2
FABP5L2
TYMS
ID3
TRIB1
BTLA
C14ORF145
SLC9A9
CAV1
SH2D1A
CTTN
SH3TC1
MAGEH1
ST8SIA1
IKZF3
CTLA4
HS.570988
IGFBP4
IKZF3
NMB
TBC1D4
TRIM8
CCDC50
MYH10
UBE2C
PTPN11
BTLA
STK39
UBE2C
BLR1
FAM46C
C8ORF13
ITM2A
FABP5
SPSB1
CTLA4
ODC1

MERTK
FBLN7
CDC20
SERTAD2
TOX
CORO1B
SCD
SHISA2
ST8SIA1
RAB27A
CORO1B
FAM167A
CDCA5
STX11
LRRC1
PTTG1
CD200
KIAA0101
HS.571502
LIMS1
SLC7A5
PON2
FKBP5
NUSAP1
LOC642956
NAB1
C16ORF75
PFKFB3
DUSP6
AIM2
GADD45G
COL6A3
CKS2
HS.390407
FAM179A
PHGDH
NUDT7
NFATC1
CKS2
RNF19A
DUSP2
PAQR4
PPP1CC
CDKL2
SLC25A46
CARHSP1

HES6
H1F0
LIMS1
SRGN
UHRF1
CDCA7
SIRPG
SRGN
PTTG3P
MT1E
CD38
C14ORF72
ASB2
KIFC1
RDH10
LRMP
C17ORF96
SERP2
DDIT4
P2RY11
ITM2A
NUCB2
TMEM2
ACTA2
C16ORF87
SERPINE2
CASP9
FLJ11795
FABP5L2
INPP1
CCNB2
SIRPG
SGCE
MTUS1
GRAMD3
HS.60257
HLA-A29.1
CCNA2
AFF3
RNF19A
LOC440871
NCALD
ANKRD55
ATPGD1
AGMAT
TRIM32

H2AFZ
CPA5
MCM4
MAPK6
KIAA0182
NDFIP2
ANKRD35
UBE2E3
CNIH
CDC45L
SEPN1
LIMS2
NETO2
GLCCI1
FAAH2
RPL39L
SSH2
RPL39L
PHACTR2
ERMP1
PON2
C9ORF16
PTTG1
TNFRSF18
C1ORF198
ANKS1B
SOCS1
LOC729816
FEN1
PYHIN1
PTPN13
QPRT
SEPN1
ASPM
C20ORF55
ACTN1
STMN1
NCALD
SIRPG
MYO5A
DLGAP5
ECOP
FABP5
MEIS3P1
MGC33556
PTPN13

POMT1
LAT
NUSAP1
CNIH
AURKB
SYT11
CNIH
BCAS4
INSIG1
ALPK2
LOC644132
WSB2
RAB11FIP1
NR3C1
TRAF3IP2
GINS2
RFC5
FAM110A
RILPL2
AURKA
IL2RB
ASAP1
COL6A3
GK
TSPAN5
ALDH5A1
TIAM1
CBLB
AURKA
CENPM
ASF1B
ATPGD1
C3ORF37
CLINT1
CCNF
TK1
SMPDL3A
C6ORF105
C7ORF44
PYHIN1
SIPA1L2
JARID2
C1ORF85
NEK2
ORMDL3
PGAM4

CENPA
TSHR
BAZ2B
ATP6V1D
RAB27A
ASAP1
LOC653566
C12ORF35
ZFPM1
TM2D3
RAB37
BCAS4
KIF2C
CEP55
GPR19
F2R
NCAPG
BIRC5
SRPK2
BIK
FBXO33
CKS1B
MAPKAPK3
PTPN2
LBH
PTPN7
UBE2G1
SH3RF3
CDKN3
MCM6
FHL2
TJP2
IFNAR2
VOPP1
LOC728069
IRF4
HMMR
CDK6
FAM164A
HIF1A
P2RX5
CXCR4
TMEM99
FYN
DCUN1D3
HS.542413

BATF
CDT1
LOC399942
GFI1
CDC2
ARHGAP10
PRKCZ
IL6R
TIMP2
LTA
KPNA2
MELK
PPP2R5C
PYHIN1
CASP3
HS.547738
LOC729086
PPP1R16B
POMT1
CENPN
HMMR
BUB1
VWA5A
DLGAP5
HS.538259
FAM160B1
PPP2R5C
TMEM64
MBOAT1
FAM134B
TP53INP1
RBBP8
RYR1
TSHR
GK
AKAP13
TNFRSF18
LOC729086
PCNA
DUSP6
HIST1H2BD
LOC92755
HES4
NAP1L4
PLCH2
GAPDH

HECW2
TRIB2
SAT1
SLC29A1
ZFP91
MTUS1
RACGAP1
MCM2
ALDH5A1
SFXN1