

**Supplementary Table ST1:** Gene ontology enriched biological process (BP), cellular component (CC), Molecular function (MF) and KEGG Pathway analysis for all the five categories.

- 1 - ORA GO for Category 1
- 2 - ORA GO for Category 2
- 3 - ORA GO for Category 3
- 4 - ORA GO for Category 4
- 5 - ORA GO for Category 5

Gene Set	Gene Ontology	Ratio					P Value					FDR					Gene				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
GO:0032395	MHC class II receptor activity	69.52 381	50.41 436	41.47 727	42.94 118	98.64 865	2.12E-07	2.20E-08	1.68E-06	1.46E-06	1.78E-04	0.002569	2.67E-04	0.020374	0.017741	1	4	5	4	4	2
GO:0050776	Regulation of immune response	4.971 45	3.882 294	3.992 587	4.015 402	4.883 596	6.60E-12	3.77E-12	1.61E-12	2.84E-12	6.39E-05	8.01E-08	4.58E-08	1.96E-08	3.45E-08	0.775475	26	35	35	34	9
GO:0002253	Activation of immune response	6.184 234	4.531 628	4.660 368	4.623 816	6.465 735	1.87E-10	6.47E-10	3.61E-10	9.87E-10	8.48E-05	2.27E-06	7.86E-06	4.38E-06	1.20E-05	1	19	24	24	23	7
GO:0002684	Positive regulation of immune system process	4.793 521	4.016 671	4.024 863	4.057 261	4.534 412	5.52E-12	5.86E-14	1.15E-13	1.87E-13	1.13E-04	6.70E-08	7.12E-10	1.40E-09	2.27E-09	1	27	39	38	37	9
GO:0098552	Side of membrane	5.420 255	5.030 955	5.173 88	5.133 301	7.178 176	1.05E-07	7.77E-11	4.27E-11	1.28E-10	4.39E-05	0.001271	9.44E-07	5.19E-07	1.56E-06	0.532659	15	24	24	23	7
hsa04612	Antigen processing and presentation	10.13 433	8.738 739	8.394 231	8.558 824	17.32 143	4.97E-06	1.67E-07	1.02E-06	8.65E-07	8.34E-06	0.001621	5.43E-05	3.33E-04	2.82E-04	0.002719	7	10	9	9	5
GO:0001775	Cell activation	3.775 638	3.247 667	3.106 912	3.055 739	#N/A	2.43E-10	3.28E-12	8.04E-11	3.97E-10	#N/A	2.95E-06	3.98E-08	9.76E-07	4.82E-06	#N/A	29	43	40	38	#N/A

Gene Set	Gene Ontology	Ratio					P Value					FDR					Gene				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
GO:0002250	Adaptive immune response	6.824981	5.278991	5.428962	5.339544	#N/A	4.96E-09	1.44E-09	8.78E-10	3.08E-09	#N/A	6.02E-05	1.75E-05	1.07E-05	3.75E-05	#N/A	15	20	20	19	#N/A
GO:0002429	Immune response-activating cell surface receptor signaling pathway	8.690476	6.721915	6.912879	6.79902	#N/A	1.80E-10	2.01E-11	1.20E-11	5.30E-11	#N/A	2.18E-06	2.44E-07	1.45E-07	6.43E-07	#N/A	15	20	20	19	#N/A
GO:0002521	Leukocyte differentiation	5.957181	4.675526	5.017412	4.545185	#N/A	3.31E-09	8.31E-10	8.04E-11	7.58E-09	#N/A	4.02E-05	1.01E-05	9.77E-07	9.21E-05	#N/A	17	23	24	21	#N/A
GO:0002682	Regulation of immune system process	4.221088	3.456985	3.407062	3.37395	#N/A	1.69E-13	1.18E-14	7.55E-14	3.81E-13	#N/A	2.05E-09	1.43E-10	9.17E-10	4.63E-09	#N/A	34	48	46	44	#N/A
GO:1903037	Regulation of leukocyte cell-cell adhesion	7.292707	6.345864	6.163581	6.005759	#N/A	9.30E-08	5.46E-10	2.61E-09	1.12E-08	#N/A	0.00113	6.63E-06	3.17E-05	1.36E-04	#N/A	12	18	17	16	#N/A
GO:0002694	Regulation of leukocyte activation	6.504307	5.659825	5.605037	5.579675	#N/A	2.66E-10	2.85E-13	9.97E-13	3.04E-12	#N/A	3.23E-06	3.46E-09	1.21E-08	3.69E-08	#N/A	18	27	26	25	#N/A
GO:0002696	Positive regulation of leukocyte activation	6.999041	5.751974	5.567419	5.763916	#N/A	1.45E-07	7.41E-09	3.28E-08	2.00E-08	#N/A	0.001764	9.00E-05	3.98E-04	2.43E-04	#N/A	12	17	16	16	#N/A
GO:0002757	Immune response-activating signal transduction	6.508286	4.885974	5.02478	4.965665	#N/A	8.72E-10	8.81E-10	5.13E-10	1.59E-09	#N/A	1.06E-05	1.07E-05	6.23E-06	1.93E-05	#N/A	17	22	22	21	#N/A

Gene Set	Gene Ontology	Ratio					P Value					FDR					Gene				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
GO:0051249	Regulation of lymphocyte activation	6.469337	6.004689	5.917973	5.860458	#N/A	1.02E-08	1.91E-12	7.59E-12	2.66E-11	#N/A	1.24E-04	2.33E-08	9.22E-08	3.23E-07	#N/A	15	24	23	22	#N/A
GO:0002764	Immune response-regulating signaling pathway	6.450663	4.781569	4.917409	4.869618	#N/A	3.03E-10	5.38E-10	3.06E-10	9.03E-10	#N/A	3.69E-06	6.54E-06	3.72E-06	1.10E-05	#N/A	18	23	23	22	#N/A
GO:0002768	Immune response-regulating cell surface receptor signaling pathway	7.900433	6.110832				6.74E-10	1.11E-10	6.67E-11	2.69E-10	#N/A	8.19E-06	1.35E-06	8.10E-07	3.27E-06	#N/A	15	20	20	19	#N/A
GO:0030097	Hemopoiesis	4.394678	3.569159	3.670555	3.39295	#N/A	2.10E-08	4.63E-09	2.43E-09	8.59E-08	#N/A	2.55E-04	5.62E-05	2.95E-05	0.001043	#N/A	20	28	28	25	#N/A
GO:0030098	lymphocyte differentiation	7.690687	5.651168	5.811712	5.383481	#N/A	9.76E-10	1.24E-09	7.69E-10	1.94E-08	#N/A	1.19E-05	1.50E-05	9.33E-06	2.36E-04	#N/A	15	19	19	17	#N/A
GO:0042110	T cell activation	6.15255	5.57681	5.505833	5.225143	#N/A	7.76E-05	3.94E-08	1.42E-07	2.91E-06	#N/A	7.76E-05	3.94E-08	1.42E-07	2.91E-06	#N/A	16	25	24	22	#N/A
GO:0045321	Leukocyte activation	4.11036	3.406376	3.327991	3.26411	#N/A	7.67E-11	5.11E-12	3.64E-11	2.12E-10	#N/A	9.31E-07	6.20E-08	4.42E-07	2.57E-06	#N/A	28	40	38	36	#N/A
GO:0045580	Regulation of T cell differentiation	13.06839	9.097329				4.82E-09	8.50E-09	6.19E-09	4.18E-09	#N/A	5.85E-05	1.03E-04	7.52E-05	5.08E-05	#N/A	10	12	12	12	#N/A
GO:0045619	Regulation of lymphocyte differentiation	12.87478	8.713594				1.52E-10	8.27E-10	5.72E-10	3.61E-10	#N/A	1.85E-06	1.00E-05	6.94E-06	4.39E-06	#N/A	12	14	14	14	#N/A

Gene Set	Gene Ontology	Ratio					P Value					FDR					Gene				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
GO:0046649	Lymphocyte activation	5.650155	4.83853	4.815473	4.653069	#N/A	9.62E-11	2.70E-13	7.48E-13	1.03E-11	#N/A	1.17E-06	3.28E-09	9.08E-09	1.25E-07	#N/A	21	31	30	28	#N/A
GO:0050778	Positive regulation of immune response	5.169972	3.856056	3.965603	3.953508	#N/A	4.87E-10	1.74E-09	9.21E-10	2.02E-09	#N/A	5.91E-06	2.11E-05	1.12E-05	2.45E-05	#N/A	21	27	27	26	#N/A
GO:0050851	Antigen receptor-mediated signaling pathway	11.3354	9.315698	9.580348	9.335038	#N/A	6.64E-10	4.03E-12	2.56E-12	1.72E-11	#N/A	8.07E-06	4.89E-08	3.10E-08	2.09E-07	#N/A	12	17	17	16	#N/A
GO:0050852	T cell receptor signaling pathway	13.36996	10.57644	10.87691	10.51008	#N/A	6.16E-10	1.25E-11	8.33E-12	6.78E-11	#N/A	7.48E-06	1.52E-07	1.01E-07	8.23E-07	#N/A	11	15	15	14	#N/A
GO:0050863	Regulation of T cell activation	7.408275	6.61172	6.459575	6.335583	#N/A	2.17E-08	2.71E-11	1.29E-10	5.50E-10	#N/A	2.63E-04	3.29E-07	1.57E-06	6.68E-06	#N/A	13	20	19	18	#N/A
GO:0050865	Regulation of cell activation	6.039713	5.255552	5.204677	5.181127	#N/A	8.70E-10	1.63E-12	5.33E-12	1.52E-11	#N/A	1.06E-05	1.98E-08	6.47E-08	1.85E-07	#N/A	18	27	26	25	#N/A
GO:0006955	Immune response	3.260627	2.784743	2.80982	2.797106	#N/A	5.18E-11	2.08E-12	2.29E-12	7.27E-12	#N/A	6.30E-07	2.53E-08	2.78E-08	8.83E-08	#N/A	36	53	52	50	#N/A
GO:0007159	Leukocyte cell-cell adhesion	6.538289	6.005473	5.851026	5.721003	#N/A	3.02E-07	4.48E-10	1.98E-09	7.90E-09	#N/A	0.00367	5.44E-06	2.41E-05	9.59E-05	#N/A	12	19	18	17	#N/A
GO:0022409	Positive regulation of cell-cell adhesion	7.740505	6.531416	6.297157	6.519409	#N/A	1.82E-07	3.44E-09	1.76E-08	1.10E-08	#N/A	0.002206	4.17E-05	2.14E-04	1.34E-04	#N/A	11	16	15	15	#N/A
GO:1903039	Positive regulation of	8.276644	6.721915	6.419102	6.645658	#N/A	3.66E-07	2.37E-08	1.31E-07	8.71E-08	#N/A	0.004446	2.88E-04	0.001588	0.001057	#N/A	10	14	13	13	#N/A

Gene Set	Gene Ontology	Ratio					P Value					FDR					Gene				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	Leukocyte cell-cell adhesion																				
GO:0030217	T cell differentiation	9.068323	6.575787	6.762599	6.067775	#N/A	8.38E-09	9.89E-09	6.75E-09	2.50E-07	#N/A	1.02E-04	1.20E-04	8.19E-05	0.003037	#N/A	12	15	15	13	#N/A
GO:0033077	T cell differentiation in thymus	20.15183	13.15157	13.5252	12.44672	#N/A	5.73E-09	2.58E-08	2.03E-08	2.48E-07	#N/A	6.96E-05	3.14E-04	2.46E-04	0.00301	#N/A	8	9	9	8	#N/A
GO:0048534	Hematopoietic or lymphoid organ development	4.173098	3.389201	3.485485	3.221877	#N/A	4.92E-08	1.42E-08	7.54E-09	2.29E-07	#N/A	5.98E-04	1.72E-04	9.15E-05	0.002781	#N/A	20	28	28	25	#N/A
GO:0050867	Positive regulation of cell activation	6.728111	5.529317	5.351906	5.540797	#N/A	2.22E-07	1.33E-08	5.67E-08	3.48E-08	#N/A	0.0027	1.62E-04	6.89E-04	4.23E-04	#N/A	12	17	16	16	#N/A
GO:0002460	Adaptive immune response based on somatic recombination of immune receptors built from immunoglobulin superfamily domains	7.008449	5.691944	5.853647	5.627372	#N/A	1.67E-06	1.88E-07	1.33E-07	5.91E-07	#N/A	0.020256	0.002284	0.001614	0.007181	#N/A	10	14	14	13	#N/A
GO:0002520	Immune system	3.945733	3.204545	3.295584	3.046338	#N/A	1.23E-07	4.67E-08	2.51E-08	6.48E-07	#N/A	0.001489	5.67E-04	3.05E-04	0.00787	#N/A	20	28	28	25	#N/A

Gene Set	Gene Ontology	Ratio					P Value					FDR					Gene				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	development																				
GO:1903706	Regulation of hemopoiesis	6.255356	4.665597	4.798142	4.967488	#N/A	5.00E-08	6.64E-08	4.30E-08	2.51E-08	#N/A	6.07E-04	8.06E-04	5.23E-04	3.04E-04	#N/A	14	18	18	18	#N/A
GO:0042613	MHC class II protein complex	46.34921	40.33149	34.56439	35.78431	#N/A	1.34E-06	4.07E-09	2.19E-07	1.84E-07	#N/A	0.016331	4.94E-05	0.002657	0.002236	#N/A	4	6	5	5	#N/A
GO:0045785	Positive regulation of cell adhesion	5.3207	4.887107	4.761422	4.929472	#N/A	2.64E-06	1.33E-08	4.84E-08	2.82E-08	#N/A	0.031998	1.62E-04	5.87E-04	3.42E-04	#N/A	12	19	18	18	#N/A
hsa04514	Cell adhesion molecules (CAMs)	6.193201	6.074637	5.984776	6.102124	#N/A	3.92E-05	1.76E-07	6.30E-07	5.09E-07	#N/A	0.012786	5.73E-05	2.05E-04	1.66E-04	#N/A	8	13	12	12	#N/A
hsa04658	Th1 and Th2 cell differentiation	9.693705	8.776733	8.586852	8.755222	#N/A	1.40E-06	8.54E-09	4.70E-08	3.83E-08	#N/A	4.57E-04	2.78E-06	1.53E-05	1.25E-05	#N/A	8	12	11	11	#N/A
hsa04659	Th17 cell differentiation	8.334775	6.917488	6.711898	6.843504	#N/A	4.41E-06	4.45E-07	2.02E-06	1.69E-06	#N/A	0.001439	1.45E-04	6.60E-04	5.52E-04	#N/A	8	11	10	10	#N/A

#N/A – Corresponding GO not available because of no significant under FDR<0.05