Chemokine Receptors

Key References

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Overview

Chemokines are a family of low molecular weight secreted proteins that act as leukocyte specific chemoattractants, although they may have additional immunological and non-immunological activities. The greater than 40 known chemokines can be grouped into subfamilies based on structural and genetic considerations. All chemokines (except for lymphotactin) have at least four cysteines in nearly invariant positions. In one major subfamily (CXC or α), the two conserved cysteines in the N-terminal domain are separated by a single amino acid, while in the other major subfamily (CC or β) these two cysteines are adjacent. The other two subfamilies, named C (or γ) and CX3C, are comparatively minor, having only two and one known member(s) in man, respectively. C chemokines are characterized by a single cysteine in the N-terminal domain, and the CX3C chemokine (known as 'fractalkine') has three amino acids interposed between its two amino terminal cysteines.

The genes that encode chemokines tend to cluster with a large cluster of CXC chemokine genes mapping to human chromosome 4q13 and a cluster of CC chemokine genes found on 17q11.1-12. With the rapid pace of discovery of novel chemokines over the course of the last few years, there have been a significant number of reports identifying the same gene, which is typically assigned a different name by the individual investigators. Recently, a standard nomenclature system has been developed and approved by the IUIS/WHO nomenclature committee. In this scheme, the chemokines are named CCL1-28 (C-C chemokine members), CXCL1-16 (CXC chemokine members), CX_3CL1 (fractalkine) and XCL1 and 2 (lymphotactin and SCM-1β).

The basis for leukocyte-specific chemoattraction lies in restricted expression of chemokine receptors (CKR) that are seven transmembrane spanning (7TM) G protein-coupled receptors. So far, six CXC and 11 CC chemokine receptors have been cloned and designated CXCR1-6 and CCR1-11, respectively. In addition, one C and one CX_3C chemokine receptor subtypes have been cloned. Three non-signaling mammalian 7TM chemokine binding proteins have also been identified: the Duffy Antigen Receptor for Chemokines (DARC) that binds both CC and CXC chemokines with high affinity and serves as the receptor for *Plasmodium vivax*, D6 and CCX CKR. These molecules are thought to function as decoy receptors or chemokine scavengers, negatively regulating chemokine action. Like chemokine genes, chemokine receptor genes also tend to cluster, with a major locus occurring at 3p21.31-32. Most chemokine receptors are coupled through pertussis toxin-sensitive $G\alpha_i$ proteins, although there is considerable evidence for additional $G\alpha_q$ coupling in many cases. In addition to the mammalian host chemokine system, many mammalian DNA viruses have also been identified that encode chemokines, functional 7TM chemokine receptors and chemokine receptor-like proteins, presumably pirated from their hosts. Secreted viral chemokine binding proteins with unique structures have also been identified. Finally, some viral proteins function as chemokine mimics. The most notable example is the envelope glycoprotein gp120 of HIV that is able to bind one or more chemokine receptors as an essential step in the cell entry process.

A conundrum in chemokine physiology is the fact that when most chemokine receptors are expressed in heterologous cells, they are found to bind several chemokines with high affinities (K_d <5 nM). Similarly, many individual chemokines bind to multiple receptors. This ligand/receptor promiscuity has led to the suggestion that individual chemokines or individual receptors might not play unique roles in leukocyte physiology or disease. There are however a select number of chemokine receptors that are now recognized to bind a single dedicated ligand. These primarily represent receptors and ligands mediating 'homeostatic' functions related to lymphoid organ development and cell population. There is growing evidence that a large number of chemokines may, however, function outside of the simple trafficking paradigm. While classical characterization of chemokine function has centered around cell migration, a large number of chemokines (of all subfamilies) appear to be highly expressed and trigger complex signaling in cells and tissue microenvironments where migration is not a relevant or necessary functionality, and the signaling initiated is peripheral to the migratory phenotype. In addition, chemokine redundancy predicted by *in vitro* binding patterns appears not to be relevant *in vivo*. Mice engineered by targeted gene disruption to lack single chemokines or receptors have profoundly abnormal phenotypes indicating that chemokines cannot compensate completely for each other. The basis for this specificity is likely to lie in the spatio-temporal patterns of expression that appear to be unique for each chemokine, in addition to a high degree of divergence in signaling cascades stimulated following receptor ligation.

Chemokine Receptors

Receptor	CXCR1	CXCR2	CXCR3	CXCR4
Alternate Names	IL-8RA, IL-8R Type 1	IL-8RB, IL-8R Type 2	—	LESTR, HUMSTR, Fusin
Structural Information	350 aa (human)	360 aa (human)	368 aa (human)	352 aa (human)
Selective Agonists	IL-8 **(I1645)**, GCP-2	IL-8 **(I1645)**, GRO-α **(G0657)**, GRO-β **(G7909)**, GRO-γ **(G7784)**, NAP-2 **(N214)**, GCP-2, ENA-78 **(E9769)**	IP-10 **(I3400)**, MIG **(M252)**, I-TAC **(I5528)**, vMIP-II	SDF-1α (PBSF) **(S190)**, (Co-receptor with CD4, for gp120 from T-cell- tropic HIV-1), vMIP-II
Signal Transduction Mechanisms	G_i (PI hydrolysis, PI3K), (cAMP modulation)	G_i (PI hydrolysis, PI3K), (cAMP modulation)	G_i (PI hydrolysis, PI3K), (cAMP modulation)	G_i (PI hydrolysis, PI3K), (cAMP modulation)
Radioligands of Choice	[^{125}I]-IL-8	[^{125}I]-GRO-α	[^{125}I]-IP-10	[^{125}I]-SDF-1α
Tissue Expression	Neutrophils, T cells, eosinophils, NK, other leukocytes and endothelial cells	Leukocytes, endothelial cells	Activated T cells, NK cells, monocytes	Peripheral blood leukocytes, spleen, thymus, spinal cord, heart, placenta, lung, liver, skeletal muscle, kidney, pancreas, cerebellum, cerebral cortex and medulla, microglia, astrocytes, coronary artery and umbilical cord endothelial cells
Physiological Function	Cell migration	Migration, angiogenesis	Cell migration	Hemopoiesis, vascularization of intestinal tract, cardiac ventricular septum formation, CD4- HIV-2 and -HIV-1 X4 strain co-receptor function
Disease Relevance	Pulmonary inflammation	Inflammation, tumor growth arthritis	Autoimmune disease	WHIM syndrome

Footnotes

Chemokine Receptors

Receptor	CXCR5	CXCR6	CCR1	CCR2	CCR3
Alternate Names	BLR-1, MDR15	Bonzo, STRL33	—	—	—
Structural Information	372 aa (human)	340 aa (human)	355 aa (human)	374 aa (human)	355 aa (human)
Selective Agonists	BCA-1 **(B2929)**, CD4 for gp120 from T-cell-tropic HIV-1)	CXCL16	MIP-1α **(M6292** (h), **M6167** (m)**)**, MCP-2, MCP-3 **(M8543)**, MCP-4 **(M246)**, RANTES **(R6267** (h), **R2274** (m)**)**, HCC-1 **(H0656)**, HCC-2, HCC-4, MIP-3, muMCP-5 **(M263)**, vMIP-II	MCP-1 **(M6667** (h), M208 (r)**)**, MCP-2, MCP-3 **(M8543)**, MCP-4 **(M246)**, HCC-4, vMIP-II	Eotaxin **(E7127** (h), **E9008** (m)**)**, Eotaxin-2, Eotaxin-3, RANTES, MCP-2, MCP-3 **(M8543)**, MCP-4 **(M246)**, HCC-2, vMIP-II
Signal Transduction Mechanisms	G_i (PI hydrolysis, PI3K), (cAMP modulation)	G_i (PI hydrolysis, PI3K), (cAMP modulation)	G_i (PI hydrolysis, PI3K), (cAMP modulation)	G_i (PI hydrolysis, PI3K), (cAMP modulation)	G_i (PI hydrolysis, PI3K), (cAMP modulation)
Radioligands of Choice	[^{125}I]-BCA-1	[^{125}I]-CXCL16	[^{125}I]-MIP-1α	[^{125}I]-MCP-1	[^{125}I]-Eotaxin
Tissue Expression	Naïve T cells, B cells, endothelial cells, osteoclasts	Lymphoid, activated T cells	Hematopoietic cells	Monocytes, T cells, neuronal	Eosinophils, Th0, Th2 cells, mast cells, basophils, microglia
Physiological Function	Cell migration and adhesion	Receptor for SIV, HIV-2, m-tropic HIV-1	Cell migration, neuronal signaling	Migration, adhesion	Migration, HIV-1-CD4 co-receptor activity
Disease Relevance	Inflammation, germinal center and follicular organization	HIV, inflammation	Autoimmune (renal, hepatic), inflammation	Inflammation, HIV atherosclerosis, dermatoses pulmonary fibrosis	Eosinophilic inflammation in gut, asthma, atopic dermatitis

Abbreviations
(Text in parentheses describes currenty accepted, standardized nomenclature for the chemokine system)
BCA-1: B-Lymphocyte Chemoattractant (CXCL13)
ENA-78: Epithelial Neutrophil Activating Peptide-78 (CXCL5)
Eotaxin: (CCL11)
GCP-2: Granulocyte Chemotactic Protein-2 (CXCL6)
GRO-α: Growth-Related Oncogene α (CXCL1)
GRO-β: Growth-Related Oncogene β (CXCL2)
GRO-γ: Growth-Related Oncogene γ (CXCL3)
HCC-1/CKβ1/MCIF: Hemofiltrate CC chemokine-1 (CCL14)
HCC-2/MIP-5/Lkn-1: Hemofiltrate CC chemokine-2 (CCL15)
HCC-4/LCC-1/CKβ12: Hemofiltrate CC chemokine-4 (CCL16)
IL-8: Interleukin-8 (CXCL8)
IP-10: Interferon-γ-Inducible Protein-10 (CXCL10)
MIG: Monokine induced by interferon-γ (CXCL9)
MCP-1: Monocyte Chemotactic Protein-1 (CCL2)
MCP-2: Monocyte Chemotactic Protein-2 (CCL8)
MCP-3: Monocyte Chemotactic Protein-3 (CCL7)
MCP-4: Monocyte Chemotactic Protein-4 (CCL13)
muMCP-5: (CCL12)
MIP-1α: Macrophage Inflammatory Protein-1α (CCL3)
MIP-3/Ckβ-8: Macrophage Inflammatory Protein-3 (CCL23)
NAP-2: Neutrophil Activating Peptide-2 (CXCL7)
I-TAC: IFN-Inducible T-cell α-chemoattractant (CXCL11)
RANTES: Regulated upon Activation Normal T Expressed and Secreted (CCL5)
SDF-1α: Stromal Cell-Derived Factor 1α (CXCL12)
WHIM: Warts, hypogammaglobulinemia, infections and myelokathexis

Footnotes

Chemokine Receptors

Receptor	CCR_4	CCR_5	CCR_6	CCR_7
Alternate Names	—	—	GPR-CY4, CKRL-3, STRL-22	EBI1, BLR2
Structural Information	360 aa (human)	352 aa (human)	374 aa (human)	378 aa (human)
Selective Agonists	TARC, MDC **(M251)**, vMIP-II	MIP-1α **(M6292** (h), **M6167** (m)**)**, MIP-1β **(M6417)** (h), **M6542)** (m)**)**, RANTES **(R6267** (h), **R2274** (m)**)**, (Co-receptor with CD4 for gp120 from M cell- tropic HIV-1), CCF18, HCC-1 **(H0656)**, HCC-4, vMIP-II	MIP-3α **(M249)**, (LARC, Exodus-1) 6Ckine **(C0845)**	MIP-3β **(M3552)**, (ELC, Exodus-3),
Signal Transduction	G_i (PI hydrolysis, PI3K), (cAMP modulation)	G_i (PI hydrolysis, PI3K), (cAMP modulation)	G_i (cAMP modulation), (PI hydrolysis, PI3K)	G_i (PI hydrolysis, PI3K)
Radioligands of Choice	$[^{125}I]$-TARC	$[^{125}I]$-MIP-1β	$[^{125}I]$-MIP-3α	$[^{125}I]$-MIP-3β
Tissue Expression	CD4+ lymphocytes, NK cells thymus, CLA+ T cells, platelets, monocytes, spleen, brain and coronary artery endothelial cells	Pro-myelocytic cells, macrophages, T cells, neuronal progenitor cells	Spleen, lymph node, appendix, fetal liver, T and B cells	Lymphoid tissue, T and B cells
Physiological Function	Migration, HIV-2 binding, CNS neuronal survival	Hematopoietic cell expansion m-tropic HIV-1-CD4 co-receptor function	Migration	T and B cell homing, migration, upregulated by EBV in B cells and HSV 6 and 7 in T cells
Disease Relevance	Allergic inflammation modulate susceptibility to endotoxic shock in mice	HIV infection	Homing of T cells in psoriasis, allergic asthma; pancreatic cancer cell invasion	Herpes virus, autoimmunity

Chemokine Receptors

Receptor	CCR8	CCR_9	CCR_{10}	XCR_1
Alternate Names	GPR-CY6, TER1, CKR-L1	GPR-9-6	GPR2	GPR5
Structural Information	355 aa (human)	348 aa (human)	360 aa (human)	332 aa (human)
Selective Agonists	I309 **(I152)**, vMIP-II, vMIP-I	TECK/CK β15 **(T9569)** (h), **T9444** (m)**)**	CTACK/Eskine **(C8365)**, MEC, vMIP-II	Lymphotactin/XCL1 **(L9788** (h), **(L6516)** (m)**)**, vMIP-II
Signal Transduction Mechanisms	G_i (PI hydrolysis, PI3K)	G_i (PI hydrolysis, PI3K)	G_i (PI hydrolysis, PI3K)	G_i (PI hydrolysis, PI3K)
Radioligands of Choice	[^{125}I]-I309	[^{125}I]-TECK	[^{125}I]-CTACK/ESkine	[^{125}I]-lymphotactin/XCL1
Tissue Expression	Monocytes, Th2 cells, granulocytes	Thymus, some in lymph nodes and spleen	Testis, small intestine fetal lung and kidney, widespread expression,	Lymphoid
Physiological Function	Cell migration, Anti-apoptosis of thymic cells, CD4-HIV-1 co-receptor	Cell migration CD4-HIV co-receptor	T cell migration	Migration
Disease Relevance	Allergic inflammation	Gut inflammation, HIV	Lymphocyte homing to skin	Not known

Abbreviations
(Text in parentheses describes currenty accepted, standardized nomenclature for the chemokine system)
CCF18: MIP-1γ (Ccl 9)
CTACK/ESkine: Cutaneous T cell-attracting chemokine (CCL27)
ELC/MIP-3b/exodus 3: (CCL19)
HCC-1/CKb1/MCIF: Hemofiltrate CC chemokine-1 (CCL14)
HCC-4/LCC-1/CKb12: Hemofiltrate CC chemokine-4 (CCL16)
I309: (CCL1)
MDC: Macrophage-derived Chemokine (CCL22)
MEC: (CCL28)
MIP-1α: Macrophage Inflammatory Protein-1α (CCL3)
MIP-1β: Macrophage Inflammatory Protein-1β (CCL4)
MIP-3α: Macrophage Inflammatory Protein-3α (CCL20)
MIP-3β: Macrophage Inflammatory Protein-3β (CCL19)
RANTES: Regulated upon Activation Normal T Expressed and Secreted (CCL5)
SDF-1α: Stromal Cell-Derived Factor 1α (CXCL12)
6-Ckine/SLC/exodus-2: (CCL21)
TARC: Thymus Activation-Regulated Chemokine (CCL17)
TECK/CK β 15: Thymus-expressed chemokine (CCL25)
h: human
m: mouse

Footnotes

Chemokine Receptors

Receptor	CX_3CR1	DARC	D6	CCX-CKR
Alternate Names	V28 Fractalkine receptor	Duffy antigen	—	—
Structural Information	355 aa (human)	338 aa (human)	Not known	350 aa (human)
Selective Agonists	CX_3C chemokine Fractalkine (Chemokine domain: **F1300** (h), **F2302** (m), **F8551** (r); Extracellular domain: **F135** (h), **F7551** (m), **F8676** (r))	IL-8 **(I1645)**, GRO-α **(G0657)**, NAP-2 **(N214)**, MCP-1 **(M6667** (h), **M208** (r)**)**, RANTES **(R6267** (h), **R2274** (m)**)**, plasmodium vivax, plasmodium knowlesi	MCP-1 **(M6667** (h), **M208** (r)**)**, MCP-2, MCP-3 **(M8543)**, MCP-4 **(M246)**, mMCP-5 **(M263)**, HCC-1 **(H0656)**, MIP-1α **(M6292** (h), **M6167** (m)**)**, MIP-1β **(M6417** (h), **(M6542** (m)**)** RANTES **(R6267** (h), R2274 (m)**)**, Eotaxin **(E7127** (h), **E9008** (m)**)**	TECK/CK-β 15 **(T9444** (m), **(T9569** (m)**)**, 6Ckine/SLC **(C0845)**, MIP-3β **(M3552)**
Signal Transduction Mechanisms	G_i (cAMP modulation)	None	None	None
Radioligands of Choice	[^{125}I]-Fractalkine	[^{125}I]-IL-8 [^{125}I]-RANTES	[^{125}I]-MIP-1β	[^{125}I]-TECK [^{125}I]-MIP-3β
Tissue Expression	Lymphoid, cardiovascular, smooth muscle and neuronal	Adult kidney, spleen, and fetal liver postcapillary venules, erythroid cells	Placenta, fetal liver, lung, endothelial cells of afferent lymphatics in dermis, tonsilar lymphatic sinuses, lymphatics in mucosa of small and large intestine and appendix, some malignant vascular tumors	Heart, lower expression in lung, pancreas, spleen, small intestine
Physiological Function	Cell adhesion, migration and HIV, co-receptor function with CD4, chemokines, anti-apoptotic	Non-specific receptor for chemokines, *Plasmodium vivax* and *P. knowlesi*	Receptor for C-C type chemokines	Migration
Disease Relevance	Atherogenesis, cardiovascular disease	Duffy negative phenotype more resistant to malaria infection	Not known	Not known

Footnotes

Chemokine Receptors

Receptor	ECRF3 (Herpesvirus saimiri)	US28 (Cytomegalovirus)	KSHV receptor	U12/UL33 family
Alternate Names	—	—	ORF-74	—
Structural Information	321 aa (Herpesvirus saimiri)	354 aa (human cytomegalovirus)	342 aa (Kaposi's sarcoma-associated herpesvirus/human herpesvirus 8)	333 aa (U12; Human herpesvirus-7) 412 aah (UL33; hCMV – orphan receptor)
Selective Agonists	IL-8 **(I1645)**, GRO-α **(G0657)**, NAP-2 **(N214)**	MIP-1α **(M6292** (h), **M6167** (m)**)**, MIP-1β **(M6417** (h), **M6542** (m)**)**, MCP-1 **(M6667** (h), **M208** (r)**)**, RANTES **(R6267** (h), **R2274** (m)**)**, Fractalkine: (Chemokine domain: **(F1300** (h), **F2302** (m), **F8551** (r)**)**; Extracellular domain: **(F135** (h), **F7551** (m), **F8676** (r)**)**, Eotaxin **(E7127** (h), **E9008** (m)**)**, MCP-3 **(M8543)**, vMIP-II	IL-8 **(I1645)**, NAP-2 **(N214)**, GRO-α **(G0657)**, ENA-78 **(E9769)**, SDF-1α (PBSF) **(S190, S5816** (m)**)**, RANTES **(R6267** (h), **R2274** (m)**)**, I309 **(I152)**, vMIP-II	MIP-1α **(M6292** (h), **M6167** (m)**)**, MIP-1β **(M6417** (h), **M6542** (m)**)**, RANTES **(R6267** (h), **R2274** (m)**)**, MIP-3β **(M3552)**; HHV-7 encoded U12 only)
Signal Transduction Mechanisms	G_i (cAMP modulation) $G_{q/11}$ (increase IP_3/DAG)	?G_i (cAMP modulation) $G_{q/11}$ (increase IP_3/DAG)	G_i (cAMP modulation) (PI hydrolysis)	G_i (PI hydrolysis)
Radioligands of Choice	[^{125}I]-IL-8	[^{125}I]-MIP-1α	[^{125}I]-IL-8	[^{125}I]-MIP-1α [^{125}I]-RANTES
Tissue Expression	Adult kidney, spleen, and fetal liver postcapillary venules, erythroid cells	Placenta, fetal liver, lung, endothelial cells of afferent lymphatics in dermis, tonsilar lymphatic sinuses, lymphatics in mucosa of small and large intestine and appendix, some malignant vascular tumors	Leukocyte, smooth muscle cell, endothelial cell infection	Monocytes, macrophages, CD4 T cells, smooth muscle cell migration, dendritic cells, oligodendrocytes, epithelium
Physiological Function	Non-specific receptor for chemokines, *Plasmodium vivax* and *P. knowlesi*	Receptor for C-C type chemokines	Modulates cell migration, affects cell cycling and signal transduction, angioproliferative	Constitutive cell signal transduction, cell cycling
Disease Relevance	Duffy negative phenotype, more resistant to malaria infection	Latent infection, immune-suppression after organ transplantation	Herpes virus inflammation, vascular disease Kaposi's sarcoma, neoplasia	Herpes virus; AIDS progression, vascular disease (sclerosis, restenosis)

Footnotes

Chemokine Receptors

Receptor	U51 family (HHV-6, and -7), (UL78 (HCMV)
Alternate Names	—
Structural Information	301 aa, (431 aa UL78)
Selective Agonists	RANTES **(R6267** (h), **R2274** (m)**)**, Eotaxin **(E7127** (h), **E9008** (m)**)**, MCP-1 **(M6667** (h), **M208** (r)**)**, MCP-3 **(M8543)**, MCP-4 **(M246)**, VMIP-II
Signal Transduction Mechanisms	Not known
Radioligands of Choice	[^{125}I]-RANTES, [^{125}I]-Eotaxin
Tissue Expression	Lymphoid, dendritic and oligodendritic cells, smooth muscle, epithelium
Physiological Function	Immune modulatory; proliferative
Disease Relevance	Herpes virus

Abbreviations
(Text in parentheses describes currenty accepted, standardized nomenclature for the chemokine system)
BCA-1: B-Lymphocyte Chemoattractant (CXCL13)
CCF18: MIP-1γ (Ccl 9)
6-Ckine/SLC/exodus-2: (CCL21)
CTACK/ESkine: Cutaneous T cell-attracting chemokine (CCL27)
ELC/MIP-3b/exodus 3: (CCL19)
ENA-78: Epithelial Neutrophil Activating Peptide-78 (CXCL5)
Eotaxin: (CCL11)
Fractalkine: (CX_3CL1)
GCP-2: Granulocyte Chemotactic Protein-2 (CXCL6)
GRO-α: Growth-Related Oncogene α (CXCL1)
GRO-β: Growth-Related Oncogene β (CXCL2)
GRO-γ: Growth-Related Oncogene γ (CXCL3)
HCC-1: Hemofiltrate CC chemokine-1
HCC-1/CKβ1/MCIF: Hemofiltrate CC chemokine-1 (CCL14)
HCC-2/MIP-5/Lkn-1: Hemofiltrate CC chemokine-2 (CCL15)
HCC-4/LCC-1/CKβ12: Hemofiltrate CC chemokine-4 (CCL16)
I309: (CCL1)
IL-8: Interleukin-8 (CXCL8)
IP-10: Interferon-γ-Inducible Protein-10 (CXCL10)
I-TAC: IFN-Inducible T-cell α-chemoattractant (CXCL11)
MCP-1: Monocyte Chemotactic Protein-1 (CCL2)
MCP-2: Monocyte Chemotactic Protein-2 (CCL8)
MCP-3: Monocyte Chemotactic Protein-3 (CCL7)
MCP-4: Monocyte Chemotactic Protein-4 (CCL13)
mMCP-5: (CCL12)
MDC: Macrophage-derived Chemokine (CCL22)
MEC: (CCL28)
MIG: Monokine induced by interferon-γ (CXCL9)
MIP-1α: Macrophage Inflammatory Protein-1α (CCL3)
MIP-1β: Macrophage Inflammatory Protein-1β (CCL4)
MIP-3α: Macrophage Inflammatory Protein-3α (CCL20)
MIP-3β: Macrophage Inflammatory Protein-3β (CCL19)
MIP-3/Ckβ-8: Macrophage Inflammatory Protein-3 (CCL23)
vMIP-II: Viral macrophage inflammatory protein II
MIP-1α: Macrophage Inflammatory Protein-1α (CCL3)
MIP-1β: Macrophage Inflammatory Protein-1β (CCL4)
NAP-2: Neutrophil Activating Peptide-2 (CXCL7)
RANTES: Regulated upon Activation Normal T Expressed and Secreted (CCL5)
SDF-1a: Stromal Cell-Derived Factor 1α (CXCL12)
TARC: Thymus Activation-Regulated Chemokine (CCL17)
TECK/CK β 15: Thymus-expressed chemokine (CCL25)
h: human
m: mouse
r: rat

Footnotes