Knops Blood Group System

Number of antigens 9

Polymorphic	Sl^a, McC^b, Vil, KCAM in Blacks
Low prevalence	Kn^b, McC^b, Sl3, Vil in non Blacks
High prevalence	Sl^a, KCAM in non Blacks and Kn^a, McC^a, Yk^a in all populations

Terminology

ISBT symbol (number)	KN (022)
CD number	CD35
Obsolete name	ISBT Collection 205
History	Reported in 1970, and named in honor of the first patient who made anti-Kn^a. Knops was established as a system in 1992, when the antigens were found to be located on complement receptor 1 (CR1).

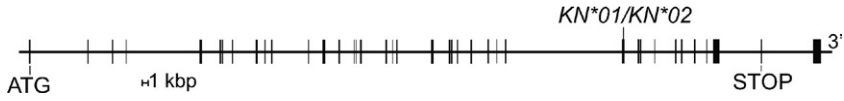
Expression

Soluble form	Present in low levels in plasma
Other blood cells	Granulocytes, B cells, a subset of T cells, monocytes, macrophages, neutrophils, eosinophils
Tissues	Glomerular podocytes, follicular dendritic cells in spleen and lymph nodes, peripheral nerve fibers

Gene

Chromosome	1q32.2
Name	*KN (CR1)*
Organization	Distributed over 130 to 160 kbp of gDNA: *CR1*1* has 39 exons; *CR1*2* has 47 exons; *CR1*3* has 30 exons; and *CR1*4* has 31 exons[1,2]
Product	Complement receptor type 1 (CR1; CD35)

The Blood Group Antigen (3/e). DOI: http://dx.doi.org/10.1016/B978-0-12-415849-8.00024-7



Database accession numbers

GenBank	NM_000573; Y00816 (mRNA)
Entrez Gene ID	1378

Molecular bases of Knops phenotypes

The reference allele is *KN*01* or *KN*A* (accession number Y00816), which encodes Kn[a] (KN1), KN3, KN4, KN5, KN8, KN9. Differences from this reference allele, and the amino acids affected, are given.

Allele encodes	Allele name	Exon	Nucleotide[†]	Restriction enzyme	Amino acid	Ethnicity (prevalence)
Kn(a–b+) or KN:–1,2	*KN*02* or *KN*B*	29	4681G>A	*Nde*I+	Val1561Met	Caucasians (Several), Blacks (Few)
Yk(a–) or KN:–5	*KN*01.–05*	26	4223C>T		Thr1408Met	Caucasians (Several), Blacks (Few)
McC(a–b+) or KN:–3,6	*KN*01.06*	29	4768A>G		Lys1590Glu	Blacks (Common), Caucasians (Few)
Sl(a–)Vil+ or KN:–4,7	*KN*01.07*	29	4801A>G		Arg1601Gly	Blacks (Common), Caucasians (Rare)
Sl3– or KN:–8	*KN*01.–08*	29	4828T>A		Ser1610Thr^	Caucasian (Rare)
KCAM– or KN:–9	*KN*01.–09*	29	4843A>G		Ile1615Val	Blacks (Common), Caucasians (Several)

[†]Nucleotides are numbered from the initiation codon (AUG), so may differ from some earlier publications by –27 nucleotides.
^Arg1601 and Ser1610 are required for Sl3 expression.

An allele found in Brazilians (*KN**4619A>G)[3] has not been associated with an antigen.

Amino acid sequence of the *CR1*1* product[4]

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MGASSPRSPE PVGPPAPGLP FCCGGSLLAV VVLLALPVAW GQCNAPEWLP     50
FARPTNLTDE FEFPIGTYLN YECRPGYSGR PFSIICLKNS VWTGAKDRCR    100
RKSCRNPPDP VNGMVHVIKG IQFGSQIKYS CTKGYRLIGS SSATCIISGD    150
TVIWDNETPI CDRIPCGLPP TITNGDFIST NRENFHYGSV VTYRCNPGSG    200
GRKVFELVGE PSIYCTSNDD QVGIWSGPAP QCIIPNKCTP PNVENGILVS    250
DNRSLFSLNE VVEFRCQPGF VMKGPRRVKC QALNKWEPEL PSCSRVCQPP    300
PDVLHAERTQ RDKDNFSPGQ EVFYSCEPGY DLRGAASMRC TPQGDWSPAA    350
PTCEVKSCDD FMGQLLNGRV LFPVNLQLGA KVDFVCDEGF QLKGSSASYC    400
VLAGMESLWN SSVPVCEQIF CPSPPVIPNG RHTGKPLEVF PFGKAVNYTC    450
DPHPDRGTSF DLIGESTIRC TSDPQGNGVW SSPAPRCGIL GHCQAPDHFL    500
FAKLKTQTNA SDFPIGTSLK YECRPEYYGR PFSITCLDNL VWSSPKDVCK    550
RKSCKTPPDP VNGMVHVITD IQVGSRINYS CTTGHRLIGH SSAECILSGN    600
AAHWSTKPPI CQRIPCGLPP TIANGDFIST NRENFHYGSV VTYRCNPGSG    650
GRKVFELVGE PSIYCTSNDD QVGIWSGPAP QCIIPNKCTP PNVENGILVS    700
DNRSLFSLNE VVEFRCQPGF VMKGPRRVKC QALNKWEPEL PSCSRVCQPP    750
PDVLHAERTQ RDKDNFSPGQ EVFYSCEPGY DLRGAASMRC TPQGDWSPAA    800
PTCEVKSCDD FMGQLLNGRV LFPVNLQLGA KVDFVCDEGF QLKGSSASYC    850
VLAGMESLWN SSVPVCEQIF CPSPPVIPNG RHTGKPLEVF PFGKAVNYTC    900
DPHPDRGTSF DLIGESTIRC TSDPQGNGVW SSPAPRCGIL GHCQAPDHFL    950
FAKLKTQTNA SDFPIGTSLK YECRPEYYGR PFSITCLDNL VWSSPKDVCK   1000
RKSCKTPPDP VNGMVHVITD IQVGSRINYS CTTGHRLIGH SSAECILSGN   1050
TAHWSTKPPI CQRIPCGLPP TIANGDFIST NRENFHYGSV VTYRCNLGSR   1100
GRKVFELVGE PSIYCTSNDD QVGIWSGPAP QCIIPNKCTP PNVENGILVS   1150
DNRSLFSLNE VVEFRCQPGF VMKGPRRVKC QALNKWEPEL PSCSRVCQPP   1200
PEILHGEHTP SHQDNFSPGQ EVFYSCEPGY DLRGAASLHC TPQGDWSPEA   1250
PRCAVKSCDD FLGQLPHGRV LFPLNLQLGA KVSFVCDEGF RLKGSSVSHC   1300
VLVGMRSLWN NSVPVCEHIF CPNPPAILNG RHTGTPSGDI PYGKEISYTC   1350
DPHPDRGMTF NLIGESTIRC TSDPHGNGVW SSPAPRCELS VRAGHCKTPE   1400
QFPFASPTIP INDFEFPVGT SLNYECRPGY FGKMFSISCL ENLVWSSVED   1450
NCRRKSCGPP PEPFNGMVHI NTDTQFGSTV NYSCNEGFRL IGSPSTTCLV   1500
SGNNVTWDKK APICEIISCE PPPTISNGDF YSNNRTSFHN GTVVTYQCHT   1550
GPDGEQLFEL VGERSIYCTS KDDQVGVWSS PPPRCISTNK CTAPEVENAI   1600
RVPGNRSFFS LTEIIRFRCQ PGFVMVGSHT VQCQTNGRWG PKLPHCSRVC   1650
QPPPEILHGE HTLSHQDNFS PGQEVFYSCE PSYDLRGAAS LHCTPQGDWS   1700
PEAPRCTVKS CDDFLGQLPH GRVLLPLNLQ LGAKVSFVCD EGFRLKGRSA   1750
SHCVLAGMKA LWNSSVPVCE QIFCPNPPAI LNGRHTGTPF GDIPYGKEIS   1800
YACDTHPDRG MTFNLIGESS IRCTSDPQGN GVWSSPAPRC ELSVPAACPH   1850
PPKIQNGHYI GGHVSLYLPG MTISYTCDPG YLLVGKGFIF CTDQGIWSQL   1900
DHYCKEVNCS FPLFMNGISK ELEMKKVYHY GDYVTLKCED GYTLEGSPWS   1950
QCQADDRWDP PLAKCTSRAH DALIVGTLSG TIFFILLIIF LSWIILKHRK   2000
GNNAHENPKE VAIHLHSQGG SSVHPRTLQT  NEENSRVLP             2039
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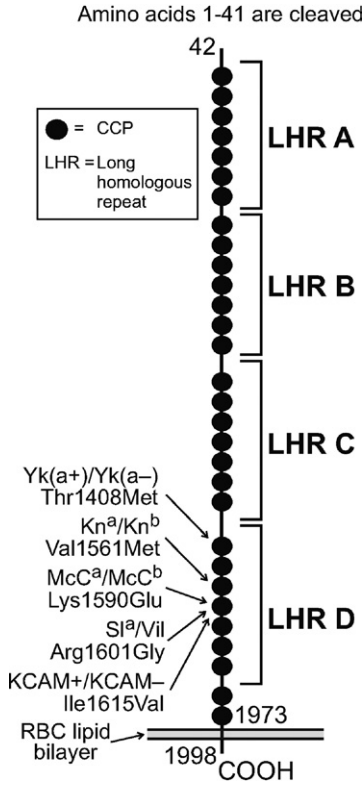
Signal peptide: 41 amino acid residues.

Carrier molecule[4]

The *CR1*1* product (hereafter called "CR1") has 30 complement control protein (CCP) repeats, each comprising about 60 amino acids with sequence homology [also called short consensus repeats (SCRs)]. Each CCP has four cysteine residues, and is maintained in a folded conformation by two disulfide bonds. Seven CCPs comprise one long homologous repeat (LHR) domain. The other allotypes have a similar structure.



M_r (SDS-PAGE)	A allotype (*CR*1–1*) 220,000; B allotype (*CR*1–2*) 250,000; C allotype (*CR*1–3*) 190,000; D allotype (*CR*1–4*) 280,000 under non-reducing conditions
CHO: N-glycan	25 sites: probably 6–8 occupied
CHO: O-glycan	No sites
Cysteine residues	Four per CCP
Copies per RBC	20–1,500[5]

Function

CR1 binds C3b and C4b, and has an inhibitory effect on complement activation by classical and alternative pathways, protecting RBCs from autohemolysis. Erythrocyte CR1 is important in processing immune complexes by binding them for transport to the liver and spleen for removal from the circulation.
CR1 binds particles coated with C3b and C4b, thereby mediating phagocytosis by neutrophils and monocytes. The presence of CR1 on other blood cells and tissues suggests it has multiple roles in the immune response, e.g., activation of B lymphocytes.

Disease association

Knops antigens (CR1 copy number) are depressed in: SLE, CHAD, PNH, hemolytic anemia, insulin-dependent diabetes mellitus, AIDS, some malignant tumors, any condition with increased clearance of immune complexes. Low levels of CR1 on RBCs may result in deposition of immune complexes on blood vessel walls, with subsequent damage to the walls.
CR1 is a ligand for the rosetting of *Plasmodium falciparum* infected RBCs to uninfected RBCs[6].
Almost 75% of HIV-1+ patients have an *in vivo* CR1 cleavage fragment of M_r 160,000, suggesting that RBC CR1 may have a role in HIV infection. This compares with 6.5% of healthy donors, and 13.5% of patients with immune complex diseases[7].

Phenotypes (% occurrence)

Phenotype	Caucasians	Blacks
Kn(a+b–)	94.5	99.9
Kn(a–b+)	>1	0
Kn(a+b+)	3.5	0.1
McC(a+)	98	94
Sl(a+)	98	60
Yk(a+)	92	98
KCAM+	98	20

Null: Some RBCs (e.g., Helgeson) type as Kn(a–b–), McC(a–), Sl(a–), Yk(a–), and KCAM– because these RBCs have low copy numbers of CR1 (approximately 10% of normal)[5].

Comments

The CR1 copy number per RBC may be decreased in stored samples.

References

[1] Moulds, J.M., 2010. The Knops blood-group system: a review. Immunohematology 26, 2–7.

[2] Vik, D.P., Wong, W.W., 1993. Structure of the gene for the F allele of complement receptor type 1 and sequence of the coding region unique to the S allele. J Immunol 151, 6214–6224.

[3] Covas, D.T., et al., 2007. Knops blood group haplotypes among distinct Brazilian populations. Transfusion 47, 147–153.

[4] Cohen, J.H., et al., 1999. The C3b/C4b receptor (CR1, CD35) on erythrocytes: methods for study of the polymorphisms. Mol Immunol 36, 819–825.

[5] Moulds, J.M., et al., 1992. Antiglobulin testing for CR1-related (Knops/McCoy/Swain-Langley/York) blood group antigens: negative and weak reactions are caused by variable expression of CR1. Vox Sang 62, 230–235.

[6] Moulds, J.M., et al., 2001. Molecular identification of Knops blood group polymorphisms found in long homologous region D of complement receptor 1. Blood 97, 2879–2885.

[7] Moulds, J.M., et al., 1995. HIV-1 patients exhibit a novel cleavage fragment of the Knops (CR1) protein [abstract]. Transfusion 35 (Suppl.), 59S.

Kn^a Antigen

Terminology

ISBT symbol (number)	KN1 (022001 or 22.1)
Obsolete names	Knops; COST4; 205004
History	Named after the Kn(a–) patient who made anti-Kn^a. The three Kn(a–) siblings in the original paper (1970) were later shown to have the Helgeson phenotype.

Occurrence

Caucasians	94.5%
Blacks	99.9%

Antithetical antigen

Kn^b (**KN2**)

Expression

Cord RBCs	Weakened
Altered	Weak on dominant Lu(a–b–) RBCs and weak on RBCs from patients with diseases causing RBC CR1 deficiency, e.g., autoimmune diseases

Molecular basis associated with Kn^a antigen[1]

Amino acid	Val1561 in CCP 24 (LHR-D)
Nucleotide	G at bp 4681 (previously reported as 4708) in exon 29

Effect of enzymes and chemicals on Kn^a antigen on intact RBCs

Ficin/Papain	Weakened (especially ficin)
Trypsin	Sensitive
α-Chymotrypsin	Sensitive
DTT 200 mM/50 mM	Sensitive/resistant (thus sensitive to WARM™ and ZZAP)
Acid	Resistant

In vitro characteristics of alloanti-Kn^a

Immunoglobulin class	IgG
Optimal technique	IAT

Clinical significance of alloanti-Kn^a

Transfusion reaction	No
HDFN	No

Comments

Anti-Kn^a is frequently found in multispecific sera.
Disease processes causing RBC CR1 deficiency can lead to "false" negative Kn^a typing. Variable results in tests on different samples from the same patient have been described[2].

References

[1] Moulds, J.M., et al., 2001. Molecular identification of Knops blood group polymorphisms found in long homologous region D of complement receptor 1. Blood 97, 2879–2885.
[2] Rolih, S., 1990. A review: antibodies with high-titer, low avidity characteristics. Immunohematology 6, 59–67.

Kn^b Antigen

Terminology

ISBT symbol (number)	KN2 (022002 or 22.2)
Obsolete names	COST5; 205005
History	Identified in 1980 when it was found to be antithetical to Kn^a.

Occurrence

Caucasians	3.5%
Blacks	<0.01%

Antithetical antigen

Kn^{a} (**KN1**)

Expression

Cord RBCs	Weak
Altered	Weak on RBCs from patients with diseases causing RBC CR1 deficiency, e.g., autoimmune diseases

Molecular basis associated with Kn^{b} antigen[1]

Amino acid	Met1561 in CCP 24 (LHR-D)
Nucleotide	A at bp 4681 (previously reported as 4708) in exon 29

Effect of enzymes and chemicals on Kn^{b} antigen on intact RBCs

Ficin/Papain	Weakened (especially ficin)
Trypsin	Sensitive
α-Chymotrypsin	Sensitive
DTT 200 mM/50 mM	Presumed sensitive/resistant (thus presumed sensitive to WARM™ and ZZAP)

In vitro characteristics of alloanti-Kn^{b}

Immunoglobulin class	IgG
Optimal technique	IAT

Clinical significance of alloanti-Kn^{b}

No data available. Only one example of anti-Kn^{b}, in a serum containing anti-Kp^{a}, has been reported[2].

Comments

Disease processes causing RBC CR1 deficiency can lead to "false" negative Kn^{b} typing. Variable results in tests on different samples from the same patient have been described[3].

References

[1] Moulds, J.M., et al., 2001. Molecular identification of Knops blood group polymorphisms found in long homologous region D of complement receptor 1. Blood 97, 2879–2885.

[2] Mallan, M.T., et al., 1980. The Hall serum: detecting Kn^{b}, the antithetical allele to Kn^{a} [abstract]. Transfusion 20, 630–631.

[3] Rolih, S., 1990. A review: antibodies with high-titer, low avidity characteristics. Immunohematology 6, 59–67.

McC^a Antigen

Terminology

ISBT symbol (number)	KN3 (022003 or 22.3)
Obsolete names	McCoy; COST6; 205006
History	Identified in 1978 and named after the patient who made the first anti-McC^a. Associated with Kn^a because 53% of McC(a–) RBCs were also Kn(a–).

Occurrence

Caucasians	98%
Blacks	94%

Antithetical antigen

McC^b (**KN6**)

Expression

Cord RBCs	Weak
Altered	Weak on dominant Lu(a–b–) RBCs and weak on RBCs from patients with diseases causing RBC CR1 deficiency, e.g., autoimmune diseases

Molecular basis associated with McC^a antigen[1]

Amino acid	Lys1590 in CCP 25 (LHR-D)
Nucleotide	A at bp 4768 (previously reported as 4795) in exon 29

Effect of enzymes and chemicals on McC^a antigen on intact RBCs

Ficin/Papain	Weakened (especially ficin)
Trypsin	Sensitive
α-Chymotrypsin	Sensitive
DTT 200 mM/50 mM	Sensitive/resistant (thus sensitive to WARM™ and ZZAP)
Acid	Resistant

In vitro characteristics of alloanti-McC^a

Immunoglobulin class	IgG
Optimal technique	IAT

Clinical significance of alloanti-McC^a

Transfusion reaction	No
HDFN	No

Comments

Disease processes causing RBC CR1 deficiency can lead to "false" negative typing. Variable results in tests on different samples from the same patient have been described.

Reference

[1] Moulds, J.M., et al., 2001. Molecular identification of Knops blood group polymorphisms found in long homologous region D of complement receptor 1. Blood 97, 2879–2885.

Sl^a Antigen

Terminology

ISBT symbol (number)	KN4 (022004 or 22.4)
Obsolete names	Sl1; Swain-Langley; 205007; COST7; M^{c}C^c
History	Reported in 1980 and named after the first two antibody producers: Swain and Langley.

Occurrence

Caucasians	98%
Blacks	50 to 60%; 30% in West Africa

Antithetical antigen

Vil (Sl2; **KN7**)

Expression

Cord RBCs	Weak
Altered	Weak on dominant Lu(a–b–) RBCs, and weak on RBCs from patients with diseases causing RBC CR1 deficiency, e.g., autoimmune diseases

Molecular basis associated with Sl^a antigen[1]

Amino acid	Arg1601 in CCP 25 (LHR-D)
Nucleotide	A at bp 4801 (previously reported as 4828) in exon 29

See Sl3 [**KN8**].

Effect of enzymes and chemicals on Sl^a antigen on intact RBCs

Ficin/Papain	Weakened (especially ficin)
Trypsin	Sensitive
α-Chymotrypsin	Sensitive
DTT 200 mM/50 mM	Sensitive/resistant (thus sensitive to WARM™ and ZZAP)
Acid	Resistant

In vitro characteristics of alloanti-Sl^a

Immunoglobulin class	IgG
Optimal technique	IAT

Clinical significance of alloanti-Sl^a

Transfusion reaction	No
HDFN	No

Comments

Sl^a has been subdivided, see Sl3 [**KN8**][2].
Anti-Sl^a is a common specificity produced by Blacks, and initially may be confused with anti-Fy3 because most Fy(a–b–) RBCs are also likely to be Sl(a–).
Disease processes causing RBC CR1 deficiency can lead to "false" negative typing. Variable results in tests on different samples from the same patient have been described.

References

[1] Moulds, J.M., et al., 2001. Molecular identification of Knops blood group polymorphisms found in long homologous region D of complement receptor 1. Blood 97, 2879–2885.
[2] Moulds, J.M., et al., 2002. Expansion of the Knops blood group system and subdivision of Sl^a. Transfusion 42, 251–256.

Yk^a Antigen

Terminology

ISBT symbol (number)	KN5 (022005 or 22.5)
Obsolete names	York; COST3; 205003
History	Briefly described in 1969, and initially thought to be anti-Cs^a because the serum was non-reactive with two Cs(a–) RBC samples. Named in 1975 after the first producer of the antibody, Mrs. York.

Occurrence

Caucasians	92%
Blacks	98%

Expression

Cord RBCs	Weak
Altered	Weak on dominant Lu(a–b–) RBCs and weak on RBCs from patients with diseases causing RBC CR1 deficiency, e.g., autoimmune diseases

Molecular basis associated with Yk^a antigen[1]

Amino acid	Thr1408 in CCP 22 (LHR-D)
Nucleotide	C at bp 4223 in exon 26
Yk(a–)	Met1408 and T at bp 4223

Effect of enzymes and chemicals on Yk^a antigen on intact RBCs

Ficin/Papain	Weakened (especially ficin)
Trypsin	Sensitive
α-Chymotrypsin	Sensitive
DTT 200 mM/50 mM	Sensitive/resistant (thus sensitive to WARM™ and ZZAP)
Acid	Resistant

In vitro characteristics of alloanti-Yk^a

Immunoglobulin class	IgG
Optimal technique	IAT

Clinical significance of alloanti-Yk^a

Transfusion reaction	No
HDFN	No

Comments

Approximately 12% of Caucasian Yk(a–) RBCs and 16% of Black Yk(a–) RBCs are Cs(a–)[2].

Disease processes causing RBC CR1 deficiency can lead to "false" negative typing. Variable results in tests on different samples from the same patient have been described.

References

[1] Veldhuisen, B., et al., 2011. Molecular analysis of the York antigen of the Knops blood group system. Transfusion 51, 1389–1396.

[2] Rolih, S., 1990. A review: antibodies with high-titer, low avidity characteristics. Immunohematology 6, 59–67.

McC^b Antigen

Terminology

ISBT symbol (number)	KN6 (022006 or 22.6)
History	Identified in 1983; antibody recognized an antigen antithetical to McC^a on RBCs of Blacks. Confirmed by molecular analysis and became a Knops system antigen in 2000.

Occurrence

Caucasians	<0.1%
Blacks	45%

Antithetical antigen

McC^a (**KN3**)

Expression

Cord RBCs	Weak
Altered	Weak on RBCs from patients with diseases causing RBC CR1 deficiency, e.g., autoimmune diseases

Molecular basis associated with McC^b antigen[1]

Amino acid	Glu1590 in CCP 25 (LHR-D)
Nucleotide	G at bp 4768 (previously reported as 4795) in exon 29

Effect of enzymes and chemicals on McC^b antigen on intact RBCs

Ficin/Papain	Variable
Trypsin	Presumed sensitive
α-Chymotrypsin	Presumed sensitive
DTT 200 mM/50 mM	Presumed sensitive/resistant (thus presumed sensitive to WARM™ and ZZAP)

In vitro characteristics of alloanti-McC^b

Immunoglobulin class	IgG
Optimal technique	IAT

Clinical significance of alloanti-McC^b

No data but unlikely to be significant.

Comments

Disease processes causing RBC CR1 deficiency can lead to "false" negative typing. Variable results in tests on different samples from the same patient have been described.

Reference

[1] Moulds, J.M., et al., 2001. Molecular identification of Knops blood group polymorphisms found in long homologous region D of complement receptor 1. Blood 97, 2879–2885.

Vil Antigen

Terminology

ISBT symbol (number)	KN7 (022007 or 22.7)
Obsolete names	Villien; McC^d
History	Reported in 1980, and named after the first patient who made the antibody before the antithetical relationship to Sl^a was established. Joined the Knops system in 2000 after molecular analysis confirmed the relationship with Sl^a.

Occurrence

Caucasians	<0.01%
Blacks	80%

Antithetical antigen

Sl^a (Sl1; **KN4**)

Expression

Cord RBCs	Weak
Altered	Weak on RBCs from patients with diseases causing RBC CR1 deficiency, e.g., autoimmune diseases

Molecular basis associated with Vil antigen[1]

Amino acid	Gly1601 in CCP 25 (LHR-D)
Nucleotide	G at bp 4801 (previously reported as 4828) in exon 29

See Sl3 [**KN8**].

Effect of enzymes and chemicals on Vil antigen on intact RBCs

Ficin/Papain	Presumed weakened
Trypsin	Presumed sensitive
α-Chymotrypsin	Presumed sensitive
DTT 200 mM/50 mM	Presumed sensitive/resistant (thus presumed sensitive to WARM™ and ZZAP)

In vitro characteristics of alloanti-Vil

Immunoglobulin class	IgG
Optimal technique	IAT

Clinical significance of alloanti-Vil

No data but unlikely to be significant.

Reference

[1] Moulds, J.M., et al., 2001. Molecular identification of Knops blood group polymorphisms found in long homologous region D of complement receptor 1. Blood 97, 2879–2885.

Sl3 Antigen

Terminology

ISBT symbol (number)	KN8 (022008 or 22.8)
Obsolete name	KMW
History	Subdivision of Sl^a reported in 2002, when differences were noted in the reactivity of various anti-Sl^a (used for population studies). The definitive anti-Sl^a (anti-Sl3) was made by a Caucasian woman (KMW).

Occurrence

All populations	100%

Only one Sl:1,–2,–3 person has been reported[1].

Expression

Cord RBCs	Weak
Altered	Weak on RBCs from patients with diseases causing RBC CR1 deficiency, e.g., autoimmune diseases

Molecular basis associated with Sl3 antigen[1]

Amino acid	Arg1601 and Ser1610 in CCP 25 (LHR-D)
Nucleotide	A at bp 4801 (previously reported as 4828) and A at 4828 (previously reported as 4855) in exon 29
Sl:1,–2,–3	Thr1610 and G at bp 4855; see table below

Effect of enzymes and chemicals on Sl3 antigen on intact RBCs

Ficin/Papain	Presumed weakened
Trypsin	Presumed sensitive
α-Chymotrypsin	Presumed sensitive
DTT 200 mM/50 mM	Presumed sensitive/resistant (thus presumed sensitive to WARM™ and ZZAP)

In vitro characteristics of alloanti-Sl3

Immunoglobulin class	IgG
Optimal technique	IAT

Clinical significance of alloanti-Sl3

No data, but unlikely to be significant.

Relationship of Sl phenotypes

Phenotype	Amino acid 1601	Amino acid 1610	Ethnic association
Sl:1,–2,3	Arg	Ser	Most common in Caucasians
Sl:–1,2,–3	Gly	Ser	Common in Blacks
Sl:1,–2,–3	Arg	Thr	Found only in one Caucasian (KMW)

Reference

[1] Moulds, J.M., et al., 2002. Expansion of the Knops blood group system and subdivision of Sl[a]. Transfusion 42, 251–256.

KCAM Antigen

Terminology

ISBT symbol (number)	KN9 (022009 or 22.9)
History	Named "KAM" in 2005, but because an existing antigen "Kamhuber" was abbreviated "KAM", it was changed to "KCAM" in 2007 when it was placed in the Knops system. "KC" was for Kansas City, and "AM" were the initials of the proband.

Occurrence

Most populations	98%
Blacks	20%

Expression

Cord RBCs	Presumed weak
Altered	Weak on RBCs from patients with diseases causing RBC CR1 deficiency, e.g., autoimmune diseases

Molecular basis associated with KCAM antigen[1,2]

Amino acid	Ile1615 in CCP 25 (LHR-D)
Nucleotide	A at bp 4843 (previously reported as 4870) in exon 29
KCAM–	Val1615 and G at bp 4843

Effect of enzymes and chemicals on KCAM antigen on intact RBCs

Ficin/Papain	Weakened
Trypsin	Sensitive
α-Chymotrypsin	Sensitive
DTT 200 mM/50 mM	Sensitive/resistant (thus sensitive to WARM™ and ZZAP)

In vitro characteristics of alloanti-KCAM

Immunoglobulin class	IgG
Optimal technique	IAT

Clinical significance of alloanti-KCAM

No data, but unlikely to be significant.

References

[1] Moulds, J.M., et al., 2005. KAM: a new allele in the Knops blood group system [abstract]. Transfusion 45 (Suppl.), 27A.

[2] Westhoff, C., et al., 2008. Two examples of Anti-KCAM, an antibody to an antigen in the Knops system [abstract]. Transfusion 48 (Suppl.), 189A.