Names for LU (ISBT 005) Blood Group Alleles

Intro

General description:	The Lutheran blood group system consists of 28 antigens carried on a single pass type 1 membrane glycoprotein (aka CD239, basal cell adhesion molecule, B-CAM, Lutheran glycoprotein) with five disulfide-bonded, extracellular, immunoglobulin superfamily (IgSF) domains, which has adhesion properties and may mediate intracellular signalling. There are two glycoprotein isoforms, products of alternative splicing of *BCAM*; the longer isoform, consists of 628 amino acids (NM_005581.4 transcript 1), whilst the shorter isoform, consists of 588 amino acids (NM_001013257.2 transcript 2).
Gene name:	*BCAM (LU)*
Number of exons:	15
Initiation codon:	Within exon 1
Stop codon:	Within exon 15
Entrez Gene ID:	4059
LRG:	LRG_798
LRG sequence:	NG_007480.1 (genomic) NM_005581.4 (transcript 1, B-CAM, 628 amino acids)
Reference allele:	*LU*02* (shaded) Acceptable: *LU*B*, or Lu^b if inferred by haemagglutination
Reference allele *LU*02* encodes:	*LU2, LU4, LU5, LU6, LU7, LU8, LU12, LU13, LU16, LU17, LU18, LU20, LU21, LU22, LU23, LU24, LU25, LU26, LU27, LU28, LU29, LU30*
Antithetical antigens:	[LU1 LU2]; [LU6 LU9]; [LU8 LU14]; [LU18 LU19]

Phenotype	Allele name	Nucleotide change	Exon Intron	Predicted amino acid change	(Reference No.) PMID	Accession number	rs number
LU:1 or Lu(a+)	*LU*01* or *LU*A*	c.230G>A	3	p.Arg77His	(1), PMID: 9166867 (2), PMID: 9192786	n.a.	rs28399653
LU:-16	*LU*01.-16*	c.230G>A c.679C>T	3 6	p.Arg77His p.Arg227Cys	(3), PMID: 14641871	n.a.	rs28399653 rs150474390
LU:1,19	*LU*01.19*	c.230G>A c.1615A>G	3 12	p.Arg77His p.Thr539Ala	(5), Abstract	n.a.	rs28399653 rs1135062
LU:2 or Lu(b+)	*LU*02* or *LU*B*				(1), PMID: 9166867 (2), PMID: 9192786	NG_007480.1	
LU:-4	*LU*02.-04.1*	c.524G>A	5	p.Arg175Gln	(3), PMID: 14641871	n.a.	rs141223803
LU:-4	*LU*02.-04.2*	c.524G>T	5	p.Arg175Leu	(4), Abstract	n.a.	rs141223803
LU:-5	*LU*02.-05*	c.326G>A	3	p.Arg109His	(3), PMID: 14641871	n.a.	rs114801603
LU:-7	*LU*02.-07*	c.1274A>C	10	p.Glu425Ala	(6), PMID: 15355502	n.a.	rs1229944491
LU:-6,9	*LU*02.09*	c.824C>T	7	p.Ser275Phe	(3), PMID: 14641871	n.a.	rs139610351
LU:-8,14	*LU*02.14*	c.611T>A	6	p.Met204Lys	(3), PMID: 14641871	n.a.	rs28399656
LU:-12	*LU*02.-12.1*	c.100-105 delCGCTTG	2	p.Arg34_Leu35del	(3), PMID: 14641871	n.a.	rs573141230
LU:-12	*LU*02.-12.2*	c.419G>A	3	p.Arg140Gln	(3), PMID: 14641871	n.a.	rs760604448
LU:-13	*LU*02.-13*	c.1340C>T c.1671C>T c.1742A>T	11 13 13	p.Ser447Leu p.Ser557Ser (silent) p.Gln581Leu	(3), PMID: 14641871	n.a.	rs117737673 rs28399658 rs28399659
LU:-17	*LU*02.-17*	c.340G>A	3	p.Glu114Lys	(3), PMID: 14641871	n.a.	n.a.
LU:-18,19 or Au(a−b+)	*LU*02.19*	c.1615A>G	12	p.Thr539Ala	(1), PMID: 9166867	n.a.	rs1135062
LU:-18,19,-8,14	*LU*02.19.14*	c.611T>A c.1615A>G	6 12	p.Met204Lys p.Thr539Ala	(5), Abstract	n.a.	rs28399656 rs1135062
LU:-20	*LU*02.-20*	c.905C>T	7	p.Thr302Met	(3), PMID: 14641871	n.a.	rs768582759
LU:-21	*LU*02.-21*	c.282C>G	3	p.Asp94Glu	(7), PMID: 15355502	n.a.	n.a.

Phenotype	Allele name	Nucleotide change	Exon Intron	Predicted amino acid change	(Reference No.) PMID	Accession number	rs number
LU:-22, LURC–	*LU*02.–22*	c.223C>T	3	p.Arg75Cys	(8), Abstract	n.a.	rs570194003
LU:-23, LUIT–	*LU*02.-23*	c.469G>A c.1289C>T	4 10	p.Gly157Arg p.Thr430Ile	(9), Abstract	LK391768	n.a. rs763826249
LU:-24, LUGA–	*LU*02.-24*	c.212G>A c.711C>T c.714C>T	3 6 6	p.Arg71His p.Cys237Cys (silent) p.Ala238Ala (silent)	(10), Abstract	KU695257	rs763340461 rs3810141 rs3810140
LU:-25, LUAC–	*LU*02.-25*	c.662C>T	6	p.Thr221Ile	(11), Abstract	KX664213	rs992788732
LU:-26, LUBI–	*LU*02.-26*	c.1495C>T	12	p.Arg499Trp	(11), Abstract	KX664212	rs148391498
LU:-27, LUYA–	*LU*02.-27*	c.324G>A c.1184G>A	3 9	p.Gly108Gly (silent) p.Arg395His	(12), Abstract	n.a.	rs3745159 rs200421757
LU:-28, LUNU–	*LU*02.-28*	c.121G>A	2	p.Val41Met	(13), Abstract	MK965667	rs957795435
LU:-29, LURA–	*LU*02.-29*	c.1351A>C	11	p.Lys451Gln	(14), Abstract	MK965666	rs28399630
LU:-30, LUOM–	*LU*02.-30*	c.674G>A	6	p.Arg225Gln	(19), Abstract, (20), Abstract	OQ877130	rs765186154
Weak phenotypes							
Lu(b+^{w})	*LU*02W.01*	c.559C>T c.711C>T c.714C>T	5 6 6	p.Arg187Cys p.Cys237Cys (silent) p.Ala238Ala (silent)	(15), PMID: 27043150	KT322137	rs780286955 rs3810141 rs3810140
Lu(b+^{w}) comment: similarity to *LU*02.14*	*LU*02W.02*	c.611T>A c.638C>T	6 6	p.Met204Lys p.Ser213Leu	(15), PMID: 27043150	KT322138	rs28399656 rs773562897
Lu(b+^{w}) comment: similarity to *LU*02.-13*	*LU*02W.03*	c.1306C>T c.1340C>T c.1671C>T c.1742A>T	10 11 13 13	p.Arg436Cys p.Ser447Leu p.Ser557Ser (silent) p.Gln581Leu	(15), PMID: 27043150	KU214879	rs150798131 rs117737673 rs28399658 rs28399659

Phenotype	Allele name	Nucleotide change	Exon Intron	Predicted amino acid change	(Reference No.) PMID	Accession number	rs number
Null phenotypes							
Lu_{null}	*LU*02N.01*	c.691C>T	6	p.Arg231Ter	(16), PMID: 17319831	n.a.	rs121918132
Lu_{null}	*LU*02N.02*	c.204+323_504+183 del (del ex 3&4, 1063 bp)	3 4	p.Thr69_Glu168del	(16), PMID: 17319831	n.a.	n.a.
Lu_{null}	*LU*02N.03*	c.711C>A	6	p.Cys237Ter	(16), PMID: 17319831	n.a.	rs3810141
Lu_{null}	*LU*02N.04*	c.361C>T	3	p.Arg121Ter	(16), PMID: 17319831	n.a.	rs121918133
Lu_{null}	*LU*02N.05*	c.123_124dupGG	2	p.Glu42GlyfsTer3	(17), Abstract	n.a.	rs779533801
Lu_{null}	*LU*02N.06*	del ex 3 to 15, 26933 bp	3 to 15	p.68Leu-X629	(18), Abstract	n.a.	n.a.
Lu_{null}	*LU*02N.07*	c.1049del2ins3	8	p.Leu350GlnfsTer425	(15), PMID: 27043150	KT322139	n.a.

References

1. PMID: 9166867 Parsons SF, Mallinson G, Daniels GL, et al. Use of domain-deletion mutants to locate Lutheran blood group antigens to each of the five immunoglobulin superfamily domains of the Lutheran glycoprotein: elucidation of the molecular basis of the Lu(a)/Lu(b) and the Au(a)/Au(b) polymorphisms. Blood (1997) 89(11), 4219-25.

2. PMID: 9192786 El Nemer W, Rahuel C, Colin Y, et al. Organization of the human LU gene and molecular basis of the Lu(a)/Lu(b) blood group polymorphism. Blood (1997) 89(12), 4608-16.

3. PMID: 14641871 Crew VK, Green C, Daniels G. Molecular bases of the antigens of the Lutheran blood group system. Transfusion (2003) 43(12), 1729-37.

4. Abstract Karamatic Crew V, Warke N, Ahrens N, et al. The second example of LU:-4: a serological and molecular study. *Transfusion Med.* 2006; 16(S1): 40.

5. Abstract Trost N, Meyer S, Vollmert C, et al. MALDI-TOF MS Based BCAM Genotyping of 37,234 Swiss Proves two new Lutheran Blood Group Alleles, Both Positive for Aub Specific 1,615 G. Vox Sang. (2016) 111 (Suppl. 1), 62.

6. PMID: 23421542 Hue-Roye K, Reid ME. The molecular basis of the LU:7 and LU:-7 phenotypes. Immunohematology. (2012) 28(4), 130-1.

7. PMID: 15355502 Crew VK, Poole J, Banks J, et al. LU21: a new high-frequency antigen in the Lutheran blood group system. Vox Sang. (2004) 87(2), 109-13.

8. Abstract Karamatic Crew V, Thornton N, Burton N, et al. Two heterozygous mutations in an individual result in the loss of a novel high incidence Lutheran antigen LURC. Transfus Med (2009) 19(Suppl.1), 10

9. Abstract Hustinx H, Lejon-Crottet S, Henny C, et al. LUIT: A Novel High Incidence Antigen in the Lutheran Blood Group System. Vox Sang. (2014) 107 (Suppl. 1), 172.

10. Abstract Brennan S, Shakarian G, Vege S, et al. A New Antibody in the Lutheran Blood Group System against a Novel High-Prevalence Antigen Named LUGA. Transfusion (2015), 55 (3S), 36A

11. Abstract Karamatic Crew V, Laundy R, Bahashwan A, et al. Two Novel High Incidence Antigens in the Lutheran Blood Group System (LUAC and LUBI). Vox Sang. (2016) 111 (Suppl. 1), 63.

12. Abstract Vrignaud C, Ramelet S, Amiranoff D, et al. Characterization of a Novel High-Prevalence Antigen in the Lutheran Blood Group System. Transfusion (2018) 58 Supplement S2, 42A-43A.

13. Abstract Karamatic Crew V, Mayer B, Baglow L, et al. A Novel High Frequency Antigen in the Lutheran Blood Group System (LUNU). Vox Sang. (2019) 114 Issue S1, 52.

14. Abstract Yosephi L, Karamatic Crew V, Shinar E, et al. A Lutheran Related Antibody Detected in a Patient with a Homozygous Missense BCAM Mutation Indicating a Novel Antigen of the System. Vox Sang. (2019) 114, Issue S1, 52.

15. PMID: 27043150 Garcia-Sanchez F, Pardi C, Kupatawintu P, et al. Identification of new KLF1 and LU alleles during the resolution of Lutheran typing discrepancies. Transfusion (2016) 56(6), 1413-8.

16. PMID: 17319831 Karamatic Crew V, Mallinson G, Green C, et al. Different inactivating mutations in the LU genes of three individuals with the Lutheran-null phenotype. Transfusion (2007) 47(3), 492-8.

17. Abstract Crew VK, Bullock T, Poole J, *et al* .; A novel *LU* mutation giving rise to a new example of the recessive type Lutheran-null phenotype. *Transfusion Med.* 2009; 19 (S1): 24.

18. Abstract Ogasawara K, Tsuneyama H, Uchikawa M, et al. An example of Lutheran-null phenotype in a Japanese individual with 27-kb deletion from intron 2 of the LU genes. Transfusion (2008) 48(Suppl), 218A.

19. Abstract AlSubhi S, Karamatic Crew V, Jones B, McNeill A, Walser P, Al-Muhaidri R, Al-Habsi K, Thornton N. LUOM, a novel high incidence antigen in the Lutheran blood group system. Transfusion Medicine, 2022, 32 (Suppl. 2): 13 (abstract no. MK06), DOI: 10.1111/tme.12907

20. Abstract Alsubhi S, Mankelow T, Karamatic Crew V, Jones B, McNeill B, Al-Muhaidri R, Al-Habsi K, Thornton N. The expression of BCAM c.674G>A in K562 and HEK293T cell lines helps to define a novel Lutheran antigen LUOM. Vox Sang, 2023, 118 (Suppl. 1): 25 (abstract no. PA01-L05), DOI: 10.1111/vox.134322.

Track of changes

			from	to
1	**Version**		**v5.0 25-FEB-2020**	**v5.1 31-JUL-2023**
2	Author	created:	Christoph Gassner, December 2019	Christoph Gassner, July 2023
3	Review	reviewed:	Nicole Thornton, Vanja Crew, February 2020	Nicole Thornton, Vanja Crew, July 2023
4	Intro	Text changed		In Lutheran blood group system number of antigens changed to 28 because of reinstantiation of prematurely deleted Lu11. Antigen Lu11 is under review pending further decisions.
5	Allele Table	Allele added		added *LU*02.-30* allele, encoding the lack of new antigen LUOM
6	References	added		added Abstract (19), (20)
7	**End Version**		**v5.0 25-FEB-2020**	**v5.1 31-JUL-2023**

Track of changes

			from	to
1	**Version**		**v4.1 170106**	**v5.0 25-FEB-2020**
2	Author	created:	Christoph Gassner, v4.1 170106	Christoph Gassner, December 2019
3	Review	reviewed:	n.a.	Nicole Thornton, Vanja Crew, February 2020
4	General		Last word version published on ISBT website	First Excel map version. Spread-sheets "Intro", "Allele Table", "References", and "Versioning" created.
5	Intro	Text changed	The Lutheran blood group system consists of 22 antigens carried on a single pass type 1 membrane glycoprotein (aka CD239, BCAM) with five disulfide-bonded, extracellular, immunoglobulin superfamily (IgSF) domains, which has adhesion properties and may mediate intracellular signalling. It consists of 597 amino acids.	The Lutheran blood group system consists of 29 antigens carried on a single pass type 1 membrane glycoprotein (aka CD239, basal cell adhesion molecule, B-CAM, Lutheran glycoprotein) with five disulfide-bonded, extracellular, immunoglobulin superfamily (IgSF) domains, which has adhesion properties and may mediate intracellular signalling. There are two glycoprotein isoforms, products of alternative splicing of BCAM; the longer isoform consists of 628 amino acids (NM_005581.4 transcript 1), whilst the shorter isoform consists of 588 amino acids (NM_001013257.2 transcript 2).
6	Intro	LRG ID line added:	n.a.	LRG_798
8	Intro	Reference allele line moved from Allele Table to Intro:	n.a.	Reference allele *LU*02* encodes LU2, LU4, LU5, LU6, LU7, LU8, LU12, LU13, LU16, LU17, LU18, LU20, LU21, LU22, LU23, LU24, LU25, LU26, LU27, LU28, LU29
9	Intro	Antithetical Antigens line created in Intro:	n.a.	Antithetical antigens: [LU1 LU2]; [LU6 LU9]; [LU8 LU14]; [LU18 LU19]
10	Allele Table	changed		Table columns "(Reference No.) PMID", "Accession number" and "rs-number" added, content added.
11	Allele Table	Text change: Line moved to Intro:	Reference allele *LU*02* encodes LU2, LU4, LU5, LU6, LU7, LU8, LU12, LU13, LU16, LU17, LU18, LU20, LU21, LU22, LU23, (LU24)	see above

Track of changes

			from	to
1	**Version**		**v4.1 170106**	**v5.0 25-FEB-2020**
12	Allele Table	Text change:	LU:–22, LURC, and all throughout LU:-26, LUBI	LU:–22, LURC-, and all throughout LU:-26, LUBI-
13	Allele Table	Antigen/allele added:	n.a.	LU:-27, LUYA−, ISBT Toronto 2018.
14	References	added	n.a.	**Abstract.** Vrignaud C, Ramelet S, Amiranoff D, et al. Characterization of a Novel High-Prevalence Antigen in the Lutheran Blood Group System. Transfusion (2018) 58 Supplement S2, 183A.
15	Allele Table	Antigen/allele added:	n.a.	LU:-28, LUNU−, ISBT Basel 2019
16	References	added	n.a.	**Abstract.** Karamatic Crew V, Mayer B, Baglow L, et al. A Novel High Frequency Antigen in the Lutheran Blood Group System (LUNU). Vox Sang. (2019) 114 Issue S1, 52.
17	Allele Table	Antigen/allele added:	n.a.	LU:-29, LURA−, ISBT Basel 2019
18	References	added	n.a.	**Abstract.** Yosephi L, Karamatic Crew V, Shinar E, et al. A Lutheran Related Antibody Detected in a Patient with a Homozygous Missense BCAM Mutation Indicating a Novel Antigen of the System. Vox Sang. (2019) 114, Issue S1, 52.
19	Allele Table	Section added:	n.a.	Section for Lutheran weak phenotypes added. *LU*02W.01* to *LU*02W.03* added.
20	References	added	n.a.	**PMID: 27043150.** Garcia-Sanchez F, Pardi C, Kupatawintu P, et al. Identification of new KLF1 and LU alleles during the resolution of Lutheran typing discrepancies. Transfusion (2016) 56(6), 1413-8.
21	Allele Table	Line position change:	n.a.	*LU*01.-16* moved to thegroup of *LU*01* alleles.
22	Allele Table	Antigen/allele added:	n.a.	*LU*02N.06* added

Track of changes

			from	to
1	**Version**		**v4.1 170106**	**v5.0 25-FEB-2020**
23	References	added	n.a.	**Abstract.** Ogasawara K, Tsuneyama H, Uchikawa M, et al. An example of Lutheran-null phenotype in a Japanese individual with 27-kb deletion from intron 2 of the LU genes. Transfusion (2008) 48(Suppl), 218A.
24	Allele Table	Antigen/allele added:	n.a.	*LU*02N.07* added
25	References	added	n.a.	**PMID: 27043150.** Garcia-Sanchez F, Pardi C, Kupatawintu P, et al. Identification of new KLF1 and LU alleles during the resolution of Lutheran typing discrepancies. Transfusion (2016) 56(6), 1413-8.
26	Allele Table	Entry change:	Description of mutation for *LU*02N.02* changed from 322intron2+exon3+intron3+exon4del	Description of mutation for *LU*02N.02* changed to c.204+323_504+183del (ex 3, 4 del 1063 bp)
27	References	All references new:	n.a.	All references (1) to (18) added for the first time.
28	**End of changes**		**v4.1 170106**	**v5.0 25-FEB-2020**