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A genetic contribution from the Far East into Ashkenazi Jews via the ancient Silk Road

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Contemporary Jews retain a genetic imprint from their Near Eastern ancestry, but obtained substantial genetic components from their neighboring populations during their history. Whether they received any genetic contribution from the Far East remains unknown, but frequent communication with the Chinese has been observed since the Silk Road period. To address this issue, mitochondrial DNA (mtDNA) variation from 55,595 Eurasians are analyzed. The existence of some eastern Eurasian haplotypes in eastern Ashkenazi Jews supports an East Asian genetic contribution, likely from Chinese. Further evidence indicates that this connection can be attributed to a gene flow event that occurred less than 1.4 kilo-years ago (kya), which falls within the time frame of the Silk Road scenario and fits well with historical records and archaeological discoveries. This observed genetic contribution from Chinese to Ashkenazi Jews demonstrates that the historical exchange between Ashkenazim and the Far East was not confined to the cultural sphere but also extended to an exchange of genes.

Consistent with their displaced ethno-history since the ancient Northern Kingdom of Israel was invaded and occupied by the Neo-Assyrian Empire¹, contemporary Jews, including Ashkenazi Jews, Sephardic Jews, North African Jews and Middle Eastern Jews², retain a genetic imprint of their Near Eastern ancestry, but have received a substantial contribution, to a variable extent, from their neighboring populations such as Europeans, Near Easterners, and North Africans^{2–8}. However, it has hitherto remained unclear whether Jews received any genetic contribution from populations outside western Eurasia. Intriguingly, frequent communication has been observed between Jews and Chinese since the early centuries of the Common Era, plausibly initiated by the Silk Road. For instance, Hebrew letters and prayers in the 8th century from ancient Jewish merchants were found in the northwestern region of China⁹. Some unearthed pottery figurines from the Tang Dynasty (618–907AD) have Semitic characteristics⁹, and synagogues were recorded in the epigraphy from the Ming (1368–1644AD) and Qing Dynasties (1644–1912AD)^{9,10}. Nonetheless, such connections, as revealed by the archaeological discoveries and historical records, have been confined to economic and cultural exchanges; so far, no direct evidence of a genetic contribution from Chinese into Jews has been reported.

To address the issue of whether Jews received any genetic contribution from the Far East, and thus shed more light on their ethno-origins, mitochondrial DNA (mtDNA) variation (mainly from the control region of the molecule, plus some coding-region variants) of 1,930 Jews and 21,191 East Asians, retrieved from previous studies as well as our unpublished data, were considered and analyzed, with especial attention to pinpointing eastern Eurasian haplogroups in Jews (Supplementary Table S1). Then, mtDNA control region variants of an additional 32,474 Eurasian individuals were analyzed to gain further insights into the phylogeographic distribution of M33c (Supplementary Table S1), so that the total number of Eurasian mtDNAs considered here was 55,595. Our results do reveal a direct genetic connection, as manifested by the sharing of some Eastern Eurasian haplogroups e.g. N9a, A, and M33c, between Jews and Chinese. Further analyses, including phylogeny reconstruction with the aid of new mtDNA genomes, confirm that this connection was established at least by a founder lineage M33c2. The differentiation time of this lineage is estimated to ~1.4 kilo-years ago (kya), which fits well with the historical records and, most importantly, indicates that the exchange between Jews and the Far East was not confined to culture but also extended to the demic.



Table 1 | The shared eastern Eurasian haplotypes between Ashkenazi Jews and Chinese

Sample ID	Haplogroup	HVS-I (16000+)	HVS-II	Population	Region/Country	Reference
AS2C5	A	182C 183C 189 193.1C 223 290 319 362	73 150 152 204 235 263	Ashkenazi	Hungary	32
472	N9a	129 223 257A 261	73 146 150 263	Ashkenazi	Russia	7
75916	N9a	129 223 257A 261	73 146 150 263 309.1C 309.2C 315.1C	Ashkenazi	Belarus	Family Tree DNA
110612	N9a	129 223 257A 261	73 146 150 263 309.1C 309.2C 315.1C	Ashkenazi	Belarus	Family Tree DNA
Bel 1 ^a	M33c	111 223 235 362 (519)	73 263 315.1C (489)	Ashkenazi	Belarus	This study
EU148486 ^a	M33c	111 223 235 362 (519)	73 263 315.1C (489)	Ashkenazi	Belarus	Family Tree DNA
4130 ^b	M33c	111 223 235 362 (519)	73 263 315.1C (489)	Ashkenazi	Belarus	Family Tree DNA
135479 ^b	M33c	111 223 235 362 (519)	73 263 315.1C (489)	Ashkenazi	Belarus	Family Tree DNA
266609 ^b	M33c	111 223 235 362 (519)	73 263 315.1C (489)	Ashkenazi	Western Ukraine	Family Tree DNA
N50366 ^b	M33c	111 223 235 362 (519)	73 263 315.1C (489)	Ashkenazi	Western Ukraine	Family Tree DNA
N105293 ^b	M33c	111 223 235 362 (519)	73 263 315.1C (489)	Ashkenazi	Western Ukraine	Family Tree DNA
50126 ^b	M33c	111 223 235 362 (519)	73 263 315.1C (489)	Ashkenazi	Russia	Family Tree DNA
289247	M33c	111 223 235 362 (519)	73 263 315.1C (489)	Ashkenazi	Russia	Family Tree DNA
403	M33c	111 223 235 362 (519)	73 263	Ashkenazi	Western Ukraine	Family Tree DNA
404	M33c	111 223 235 362 (519)	73 263	Ashkenazi	Belarus	7
405	M33c	111 223 235 362 (519)	73 263	Ashkenazi	Poland	7
406	M33c	111 223 235 362 (519)	73 263	Ashkenazi	Poland	7
Forum 1 ^{a,c}	M33c	111 223 235 362 (519)	73 263	Ashkenazi	Romania	7
			73 263 315.1C (489)	Jew	Belarus/Russia/Lithuania	A Genetic Genealogy Community
JQ702003 ^a	M33c	111 223 235 362 (519)	73 263 315.1C (489)	N.A.	N.A.	14
HN-SZ420 ^a	M33c	111 192 223 362 (519)	73 263 315.1C (489)	Han	Hunan, China	33, This study
HN-SZ167 ^a	M33c	111 223 235 356 362 (519)	73 263 309.1C 315.1C (489)	Han	Hunan, China	33, This study
HN-SZ104 ^a	M33c	111 223 235 362 (519)	73 263 308-310d 315.1C (489)	Han	Hunan, China	33, This study
HN-SZ527 ^a	M33c	111 223 235 362 (519)	73 263 309.1C 315.1C (489)	Han	Hunan, China	33, This study
JSH08058	M33c	111 129 223 235 284 300 362 (519)	73 150 263 315.1C	Han	Jiangsu, China	This study
K9534 ^a	M33c	111 129 140 223 235 300 362 (519)	73 150 263 309.1C 315.1C (489)	Han	Jilin, China	This study
K9511 ^a	M33c	111 192 223 235 362 (519)	73 263 315.1C 471 (489)	Han	Jilin, China	This study
H11694 ^a	M33c	104 111 223 362 (519)	73 263	Han	Shaanxi, China	This study
H11281 ^a	M33c	111 223 235 362 (519)	73 263 309.1C 315.1C	Han	Shaanxi, China	This study
DJY76 ^a	M33c	111 223 235 243 362 (519)	73 263 309.1C 315.1C	Han	Sichuan, China	This study
Zhuang21 ^a	M33c	093 104 111 223 235 362 (519)	73 263 309.1C 315.1C (489)	Zhuang	Guangxi, China	This study
Zhuang74	M33c	093 104 111 223 235 362 (519)	73 263 309.1C 315.1C (489)	Zhuang	Guangxi, China	This study
Zhuang9	M33c	093 104 111 223 235 362 (519)	73 263 315.1C (489)	Zhuang	Guangxi, China	This study
HN-SZ416	M33c	093 104 111 223 362 (519)	73 263 309.1C 315.1C (489)	Han	Hunan, China	33
Dongguan-65	M33c	093 104 111 223 235 311 362	73 263 210 309.1C 310 315.1C	Han	Guangdong, China	34
539	M33c	093 104 111 223 235 362		Han	Guangxi, China	35
129	M33c	093 104 111 223 235 362		Han	Guangxi, China	35
136	M33c	093 104 111 223 235 362		Han	Guangxi, China	35
499	M33c	093 104 111 223 235 362		Han	Guangxi, China	35
370	M33c	104 111 223 235 362		Han	Guangxi, China	35
149	M33c	111 223 235 362		Han	Guangxi, China	35
Viet0121	M33c	111 223 362 (519)	73 203 263 309.1C 309.2C 315.1C (489)	Vietnamese	Vietnam	36
GD7815 ^a	M33c	093 104 111 223 362	73 146 263 309.1C 315.1C	Han	Guangdong, China	13
Yao171 ^a	M33c	111 129 223 235 362 (519)	73 263 309.1C 309.2C 315.1C	Yao	Hunan, China	13
MK13	M33c	111 129 223 235 300 362		Kam-Tai	Guizhou, China	37
Kinh117	M33c	111 223 362 (519)		Kinh	Vietnam	38
(03B)045	M33c	093 104 111 223 235 362 (519)	73 263 309.1C 315.1C	Han	Guangdong, China	39
YZ-Tib05-23	M33c	092 104 111 223 362		Tibetan	Yunnan, China	40
YZ-Tib05-8	M33c	092 104 111 223 362		Tibetan	Yunnan, China	40



Table 1 | Continued

Sample ID	Haplogroup	HVS-I (16000+)	HVS-II	Population	Region/Country	Reference
MHN43	M33c	111 223 235 362		Miao	Hunan, China	41
YBP28	M33c	093 104 111 223 235 362		Yao	Guangdong, China	41
YLO22	M33c	093 104 111 223 235 305C 362		Yao	Guangxi, China	41
YLO03	M33c	111 223 235 362		Yao	Guangxi, China	41
YLO23	M33c	111 223 235 362		Yao	Guangxi, China	41
GD7821	M33c	093 104 111 223 235 362	73 263 309.1C 315.1C	Han	Guangdong, China	42
HG00457 ^a	M33c	111 223 362 (519)		Han	Hunan/Fujian, China	15
TL397	M33c	093 101 111 223 235 362 (519)		Thai	Thailand	43

^aThe whole-mtDNA genome information is displayed on the phylogenetic tree (Figure 2).

^bThe individual has coding region information confirming its haplogroup assignment from the Family Tree DNA (www.familytreedna.com).

^cThis sequence is from A Genetic Genealogy Community (http://eng.molgen.org/viewtopic.php?t=41&t=141).

N.A. = not available.

All the samples in this study have confirmed G2361A mutation when assigning their haplogroup. The mutations (e.g. 489 and 16519) outside HVS-I and HVS-II are listed in the parentheses. The haplogroups A and N9a mtDNAs in the Far East are not shown here.

Results and Discussion

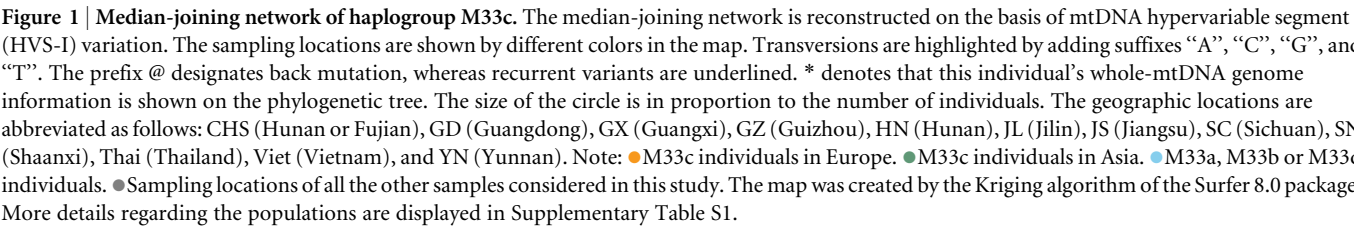
Our analysis of the mtDNA variation in a total of 23,121 individuals from East Asian populations and Jews reveals that mtDNAs of four Ashkenazi Jewish individuals can be allocated into eastern Eurasian haplogroups A and N9a, suggesting that Ashkenazi Jews received a genetic contribution from East Asia (Table 1). Intriguingly, our results also disclose that 14 eastern Ashkenazi Jews belong to haplogroup M33c (Table 1), for which sister clusters, M33a, M33b and M33d, are prevalent in the Indian Subcontinent and thus most plausibly trace their origins there^{11,12}.

To achieve further insight into the phylogeographic distribution of M33c, mtDNA variants (mainly from the control region) of an additional 32,474 Eurasian individuals were analyzed, so that the total number of Eurasian mtDNAs considered here was 55,595. As shown in Table 1, besides the 14 Ashkenazi Jewish M33c lineages, an additional 38 M33c mtDNAs (with the specific control-region motif showing transitions at positions 16111, 16223, 16235, and 16362) were pinpointed, among which 34 are from China, 2 from Vietnam, and 1 from Thailand, with the remaining individual most likely from Europe but with ambiguous ancestry. Thus, despite the restricted distribution of M33a, M33b and M33d in South Asia, it is most likely that M33c originated, or at least differentiated, in eastern Asia. This notion receives clear support from the median network, in which virtually all of the diversity of this haplogroup is observed in China (Figure 1).

To shed light on the phylogeny within haplogroup M33c, 11 mtDNAs, covering the widest range of internal variation within the haplogroup, were chosen for whole-mtDNA genome sequencing. In good agreement with the previous result¹³, the resulting phylogenetic tree (Figure 2), incorporating five previously reported mtDNA genomes^{13–15} as well as one whose information was released online (A Genetic Genealogy Community; <http://eng.molgen.org>), confirms that M33c is defined by mutations at positions 3316, 4079, 5894, 8227, 8848, 16111, and 16235. Of note is that five clades within M33c appear respectively characterized by diagnostic coding-region variant(s), and these are named M33c1 to M33c5 here. With the exception of M33c2, all the samples in these clades are from China. The likely origin of M33 in South Asia and the restriction to China of M33c, dating to 10 kya according to the estimation based on whole-mtDNA genome, implies some dispersal from South to East Asia in the immediate postglacial.

Intriguingly, sub-haplogroup M33c2 (defined by three additional coding-region variants at positions 4182, 4577, and 7364) consists of three different haplotypes (one seen in three Ashkenazi Jews, another in a single Chinese individual and the third in the likely European with unknown ethnicity). Although there is no control-region variant in the defining motif of M33c2, multiple lines of evidence suggest that the pinpointed 14 Ashkenazi Jewish M33c mtDNAs most likely all belong to this clade: (1) all of the 14 mtDNAs share an identical control-region motif (Table 1); (2) the three completely sequenced Ashkenazi Jewish mtDNAs with this motif (EU148486, Bel 1 and Forum 1) belong to M33c2 (Figure 2); (3) M33c shows a virtually exclusive distribution in Ashkenazi Jews in western Eurasia, even though 55,595 mtDNAs have been checked (Table 1 and Supplementary Table S1). Thus, it is plausible that the unknown European individual (JQ702003) was in fact from a Jewish population or had Ashkenazi Jewish ancestry.

Age estimates for M33c2 are similar whether based either on the whole genome or on the control region alone (Table 2), and the age of ~1.4 kya fits well with the medieval operation of the Silk Road. We note that this is an upper bound for the gene flow event during which the lineage was assimilated into the Ashkenazim; it is the age of the subclade overall, which most likely arose within China, and indeed there is no variation at all within the Jewish lineages, suggesting a very recent event. If we assume that the unidentified European lineage belongs within the Ashkenazi diversity, we can date the



The ancient Silk Road was an important transportation hub connecting China and the Mediterranean region from the Han Dynasty (206BC–220AD) onwards, and there are likely to have been Jewish merchants at the eastern end of the Silk Road from the early centuries AD. Moreover, Jewish merchants in Europe, referred to as Radhanites, were involved in trade between west and east as early as the ninth century¹⁶. It has been suggested, on the basis of contrasts between patterns of mtDNA and Y-chromosome variation¹⁷, that such merchants may have formed the nucleus for a number of extant Jewish communities. European country¹⁸ during the late Middle Ages, is demographically not possible. Recent work also suggests a sizable Jewish presence in eastern Germany (the Danube region, rather than the Rhineland) prior to the expansion in Poland between 1500 and 1650AD²². The M33c2 mtDNAs are confined to eastern European Ashkenazim in the present database (the single unknown example is of likely East European ancestry¹⁴), suggesting that these groups had contacts to the east to the extent that they mediated female gene flow. Extensive genetic admixture has been observed in populations residing around the ancient Silk Road region^{23,24}. Our currently

Ashkenazi origins are controversial¹⁸. According to recent archaeological evidence, the Jewish community of Cologne, mentioned by Emperor Constantine in 321AD, existed in the city continuously until they had to leave in 1423–1424AD¹⁹. This suggests that Ashkenazi Jewry may date to Roman times, possibly originating in

Extensive genetic admixture has been observed in populations residing around the ancient Silk Road region^{23,24}. Our currently observed genetic imprint echoes the previously observed ancient communications between Jews and Chinese and, most significantly, implies that such historical exchanges were not confined to the cultural realm but involved gene flow. This unexpected ancient genetic connection between Ashkenazi Jews and the Far East, as witnessed a

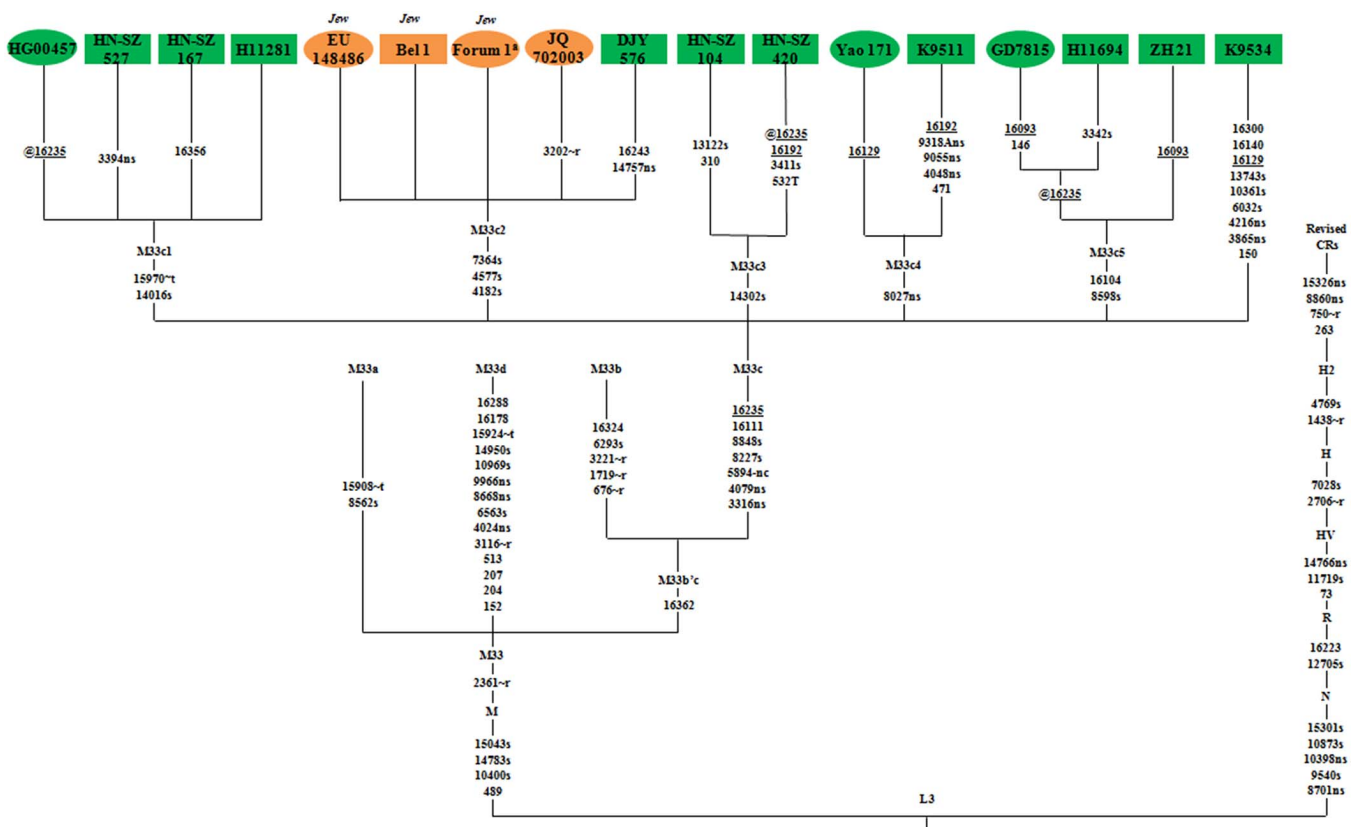


Figure 2 | Phylogenetic tree of haplogroup M33c. The nucleotide positions in the sequences are scored relative to the rCRS²⁷. Transversions are annotated by adding suffixes “A” and “T”. The recurrent variants are underlined and prefix @ designates a back mutational event; “s” means synonymous and “ns” means nonsynonymous mutation; “nc” refers to mutations at the intergenic noncoding regions in segments 577–16023; and “r” and “t” denote mutations in rRNA genes and tRNA genes, respectively. Length polymorphisms (e.g., 309.1C, 309.2C and 315.1C) are disregarded from the analysis. The newly sequenced samples in this study are marked in rectangles, while mtDNAs from the published literature are displayed in ellipses. Note: * This individual is from A Genetic Genealogy Community (<http://eng.molgen.org/viewtopic.php?f=41&t=141>).

least by mtDNA haplogroup M33c2, provides the first evidence for a significant genetic contribution from Chinese to eastern European Ashkenazi Jews that was most likely mediated by the Silk Road between around 640 and 1400 years ago. Although the involvement of male Jewish traders has been suggested before¹⁷, our results, focusing on the female line of descent, specifically point to the involvement also of women. Well-resolved evidence from the male-specific part of the Y chromosome and from the autosomes would help to further illustrate the rather complex, pan-Eurasian ethno-history of Jews.

Methods

mtDNA Data collection and mining. mtDNA variation (mainly from control region) of 23,121 East Asians and Jews, retrieved from previous studies as well as our unpublished data, were considered and analyzed, with especial attention to pinpointing the eastern Eurasian haplogroups in Jews. Then, additional 32,474 individuals were analyzed to gain further insights into the phylogeographic

distribution of M33c, leading the total number of Eurasian mtDNAs considered here to 55,595. The study project was approved by the Ethics Committee at Kunming Institute of Zoology, Chinese Academy of Sciences. Each participant was informed about the study and provided informed consent. All mtDNAs collected and considered in the present study were first allocated to haplogroups, based mainly on their control-region motifs, which were then further confirmed by typing specific coding-region variation according to the PhyloTree (mtDNA tree Build 16²⁵; <http://www.phylotree.org/>).

DNA amplification and sequencing. For haplogroups of interest, special attention was paid to the intrinsic phylogeny reconstructed on entire mitogenome information. In this way, entire mitogenomes for 11 selected representatives from haplogroup M33c were amplified, sequenced, and dealt with as described elsewhere^{13,26}. The sequencing outputs were edited and aligned by Lasergene (DNASTar Inc., Madison, Wisconsin, USA) and compared with the revised Cambridge Reference Sequence (rCRS)²⁷.

Data analysis. The median-joining network of M33c was constructed manually²⁸ and then confirmed using Network 4.612 (<http://www.fluxus-engineering.com/sharenet>).

Table 2 | Ages of the major clades of haplogroup M33c estimated from control-region and whole-mtDNA genome data with 95% confidence intervals

Haplogroup	Control region			Whole-mtDNA genome			
	Rho			Rho			Maximum Likelihood
	<i>n</i>	$\rho \pm \sigma$	Age (kya)	<i>n</i>	$\rho \pm \sigma$	Age (kya)	Age (kya)
M33c	52	1.13 ± 0.47	21.38 [4.1;38.7]	17	3.88 ± 0.76	10.29 [6.2;14.4]	8.95 [5.2;12.8]
M33c2	16	0.06 ± 0.06	1.18 [0;3.5]	5	0.60 ± 0.35	1.55 [0;3.3]	1.55 [0;3.3]
M33c2*	—	—	—	4	0.25 ± 0.25	0.64 [0;1.9]	0.64 [0;1.9]

M33c2*: the Chinese individual is not considered for the estimation.



htm). The most parsimonious phylogenetic tree (Figure 2) was reconstructed by hand as carried out previously^{13,26}. The coalescence ages were estimated by the $p \pm \sigma$ method^{29,30} and maximum likelihood (ML) analysis. Recently corrected calibrated mutation rates³¹ were adopted in the p statistic and the ML analysis.

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Author contributions

Q.-P.K. designed the research; Y.-C.L., W.Z. and Y.-G.Y. collected the samples; J.-Y.T., H.-W.W. and Y.-C.L. collected the data; J.-Y.T. and H.-W.W. performed the experiments; J.-Y.T., H.-W.W., Y.-C.L. and Q.-P.K. analyzed data; J.-Y.T., Y.-C.L., J.v.S., M.B.R. and Q.-P.K. wrote the paper.

Additional information

Accession codes All of the sequences obtained in this study have been deposited into GenBank, with accession codes KP313552–KP313562 (for whole mtDNA genomes) and KP313549–KP313551 (for control region sequences).

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Supplementary Information

A genetic contribution from the Far East into Ashkenazi Jews via the ancient Silk Road

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Supplementary Table S1 Sample information of populations analyzed in present study (A total of 853 populations, 55,595 individuals)

Population, Region/Country	Sample Size	References
<i>Jew</i>		
Ethiopian Jewish, Ethiopia	41	1
Yemenite Jewish, Yemen	45	1
Ashkenazi, Austria/Hungary	29	2
Ashkenazi, Byelorussia	10	2
Ashkenazi, Czech Republic	15	2
Ashkenazi, Estonia	1	2
Ashkenazi, France	49	2
Ashkenazi, Germany	32	2
Ashkenazi, Latvia	8	2
Ashkenazi, Lithuania	30	2
Ashkenazi, Moldavia	1	2
Ashkenazi, Netherlands	21	2
Ashkenazi, Poland	170	2
Ashkenazi, Romania	97	2
Ashkenazi, Russia	63	2
Ashkenazi, Switzerland	3	2
Ashkenazi, Ukraine	54	2
Azerbaijan Mountain Jews, Azerbaijan	58	3
Belmonte Jews, Belmonte	30	3
Spanish Exilers, Bulgaria	71	3
Cochin Jews, India	45	3
Ethiopia Jews, Ethiopia	29	3
Mountain Jews, Georgia	74	3
Bnei Israel, India	34	3
Near East Jews, Iran	82	3
Near East Jews, Iraq	135	3
North Africa Jews, Libya	83	3
North Africa Jews, Morocco	149	3
North Africa Jews, Tunisia	37	3
Spanish Exilers, Turkey	123	3
Yemen Jews, Yemen	119	3
Spanish Exilers, Former Yugoslavia	1	3
Spanish Exilers, Greece	3	3
Spanish Exilers, Italy	9	3
Spanish Exilers, Netherlands	1	3
Spanish Exilers, Rodus	1	3
Spanish Exilers, Spain	3	3
Spanish Exilers, Surinam	1	3
Ashkenazi Jews, Hungary	173	4

<i>East Asia</i>		
Manchurian, China	40	5
Korean-Chinese, South Korea	51	5
Korean, South Korea	185	5
Chinese Han, Beijing, China	40	5
Hong Kong people, Hong Kong, China	377	6
Ancient workers, China	19	7
Japanese, Japan	4	8
Chinese, China	5	8
Tibetan, China	168	9
Tibetan, China	220	9
Tibetan, China	71	9
Tibetan, China	62	9
Tibetan, China	61	10
Tibetan, China	55	10
Tibetan, China	59	10
Tibetan, China	58	10
Tibetan, China	46	10
Monba, China	51	10
Tibetan, China	53	10
Lhoba, China	20	10
Tibetan, China	56	10
Tibetan, China	59	10
Tibetan, China	44	10
Tibetan, China	40	11
Bai, China	40	12
Hani, China	33	12
Lahu, China	15	12
Naxi, China	45	12
Pumi, China	35	12
Tibetan, China	35	12
Yi, China	56	12
Lahu, China	35	13
Lahu, China	32	14
Tibetan, China	24	14
Va, China	36	13
Va, China	22	14
Hui, China	45	15
Kazak, China	53	15
Mongoloid, China	49	15
Uygur, China	47	15
Uzbek, China	58	15
Bonan, China	95	16
Dongxiang, China	96	17

Salar, China	99	18
Salar, China	10	19
Yugur, China	100	20
Dongxiang, China	10	19
Xiaohe cemetery, China	20	21
Xiaohe cemetery , China	17	22
Daheyan, Xinjiang, China	58	23
Niya Site, Xinjiang, China	14	24
Yuansha Ruins, Xinjiang, China	15	24
Zagunluke Cemetery, Xinjiang, China	13	24
Ancient samples from Xinjiang, China	11	25
Taiyuan, Shanxi, China	2	22
Daur, China	45	26
Ewenki, China	47	26
Kor, China	48	26
Mongoloid, China	48	26
Oro, China	44	26
Kor-S, China	55	27
H-Anhui, China	42	28
H-Fujian, China	51	28
H-Gansu, China	45	28
H-Guangxi, China	26	28
H-Hunan, China	16	28
H-Jiangsu, China	67	28
H-Jiangxi, China	23	28
H-Liaoning, China	51	28
H-Neimeng, China	45	28
H-Qinhai, China	44	28
H-Shanghai, China	56	28
H-Shannxi, China	53	28
H-Sichuan, China	70	28
H-Yunnan, China	58	28
H-Zhejiang, China	61	28
H-GD, China	30	29
H-LN, China	51	29
H-QD, China	50	29
H-WH, China	42	29
H-XJ, China	47	29
H-YN, China	43	29
H-SD, China	76	30
Han, Yan Bian, Jilin, China	51	27
Ab-Taiwanese, China	180	31
TW-Han, China	155	32
H-GD, China	69	33

C-SH, China	120	34
H-CS, China	82	35
H-Xi'an, China	85	35
Aini, China	47	12
BAI, China	19	12
Jino, China	18	12
QH-Tib, China	56	12
Tujia, China	66	12
Tujia, China	31	12
YN-Dai, China	21	14
YN-Dai, China	38	11
MHN, China	103	36
MYN, China	39	36
YBN, China	19	36
YBP, China	35	36
YDB, China	10	36
YGS, China	24	36
YHT, China	19	36
YKM, China	40	36
YLO, China	42	36
YLT, China	26	36
YMB, China	6	36
YMI, China	32	36
YPA, China	32	36
YTU, China	41	36
YWU, China	31	36
YXB, China	11	36
YYM, China	27	36
Q_Tib, China	76	9
G_Tib, China	83	9
XZ-Lhoba, China	50	Our unpublished data
XZ-Monba, China	31	Our unpublished data
wanyan, China	46	Our unpublished data
Japanese, Japan	50	37
Japanese, Japan	162	38
Japanese, Japan	211	39
Gifu, Japan	137	40
Japanese, Japan	150	34
Japanese, Japan	100	41
Japanese, Japan	124	42
Japanese, Japan	62	43
Ainu, Japan	50	43
Pyukyuan, Japan	50	43
Achang-YN, China	60	Our unpublished data

Bai-YN, China	21	Our unpublished data
Bai-YN, China	19	Our unpublished data
Blang-YN, China	90	Our unpublished data
Dai-YN, China	46	Our unpublished data
Dai-YN, China	24	Our unpublished data
Dai-YN, China	30	Our unpublished data
Dai-YN, China	27	Our unpublished data
Deang-YN, China	52	Our unpublished data
Drung -YN, China	35	Our unpublished data
Hani-YN, China	9	Our unpublished data
Hani-YN, China	39	Our unpublished data
Hani-YN, China	18	Our unpublished data
Jingpo-YN, China	60	Our unpublished data
Jino-YN, China	51	Our unpublished data
Lahu-YN, China	26	Our unpublished data
Lahu-YN, China	36	Our unpublished data
Lisu-YN, China	31	Our unpublished data
Lisu-YN, China	20	Our unpublished data
Lisu-YN, China	18	Our unpublished data
Naxi-YN, China	62	Our unpublished data
Naxi-YN, China	6	Our unpublished data
Nu-YN, China	40	Our unpublished data
Pumi-YN, China	19	Our unpublished data
Pumi-YN, China	25	Our unpublished data
Tibetan-YN, China	11	Our unpublished data
Tibetan-YN, China	54	Our unpublished data
Wa-YN, China	14	Our unpublished data
Yao-YN, China	8	Our unpublished data
Yi-YN, China	28	Our unpublished data
Yi-YN, China	67	Our unpublished data
Blang-YN, China	48	Our unpublished data
DL-YN, China	48	Our unpublished data
Dongxiang-GS, China	63	Our unpublished data
GL-GZ, China	102	Our unpublished data
GX-Dong, China	100	Our unpublished data
GX-Maonan, China	48	Our unpublished data
GX-Mulam, China	48	Our unpublished data
GX-Yao, China	29	Our unpublished data
GZ-Bouyei, China	85	Our unpublished data
GZ-Miao, China	35	Our unpublished data
GZ-She, China	49	Our unpublished data
GZ-Shui, China	64	Our unpublished data
GZ-Yao, China	40	Our unpublished data
Han-GS, China	43	Our unpublished data

Han-JS, China	1	Our unpublished data
Han-NX, China	111	Our unpublished data
Han-SX, China	2	Our unpublished data
Hainan-Li, China	59	Our unpublished data
HN-Miao, China	49	Our unpublished data
HN-Tujia, China	46	Our unpublished data
HN-Yao, China	52	Our unpublished data
Hui-QH, China	33	Our unpublished data
Hui-GS, China	21	Our unpublished data
IM-Buryat, China	59	Our unpublished data
IM-Man, China	122	Our unpublished data
IM-Xibe, China	49	Our unpublished data
Li-HI, China	216	Our unpublished data
LN-Man, China	31	Our unpublished data
Han-BJ, China	45	Our unpublished data
Han-QH, China	142	Our unpublished data
QH-Tu, China	64	Our unpublished data
QJ-YN, China	40	Our unpublished data
Sala-QH, China	16	Our unpublished data
XM, China	40	Our unpublished data
YN-Bai, China	66	Our unpublished data
YN-Blang, China	37	Our unpublished data
YN-Dai, China	85	Our unpublished data
YN-Hani, China	44	Our unpublished data
YN-Jino, China	31	Our unpublished data
YN-Kucong, China	34	Our unpublished data
YN-Lisu, China	43	Our unpublished data
YN-Mosuo, China	64	Our unpublished data
YN-Naxi, China	56	Our unpublished data
YN-Pumi, China	59	Our unpublished data
YN-Yi, China	90	Our unpublished data
Zhuang-GX, China	79	Our unpublished data
Han-GD, China	105	44
HHT-NM, China	107	45
LQ-NM, China	48	45
TH-YN, China	46	45
AC, China	6	46
BG, China	32	46
BU, China	31	46
CL, China	30	46
CU, China	30	46
CX, China	25	46
CY, China	12	46
DA, China	56	46

DG, China	40	46
DN, China	10	46
GA, China	42	46
HL, China	34	46
HS, China	30	46
JM, China	27	46
LC, China	30	46
LG, China	31	46
LL, China	4	46
LQ, China	25	46
MK, China	33	46
ML, China	39	46
MN, China	32	46
MO, China	29	46
MQ, China	17	46
PO, China	34	46
PY, China	30	46
RG, China	31	46
TN, China	30	46
WG, China	14	46
WS, China	33	46
YR, China	15	46
HAN- Chaoshan, GD, China	102	47
HAN- Meizhou, GD, China	170	47
Northern-Han, China	60	48
Japanese_Honshu, Japan	82	48
Indonesian, Indonesian	54	48
Koryak-KMAN, Koryak	110	48
Japanese_Kyushu, Japan	104	48
Malaysian-MAL, Malaysian	52	48
Nivkhi, Nivkhi	57	48
Okinawa, Japan	45	48
Philippine, Philippine	29	48
Philippine, Philippine	30	48
Kam, China	72	49
Laka, China	67	49
Mien, China	29	49
Mulam, China	27	49
Pinghua_Han, China	39	49
Pinghua_Han, China	48	49
Pinghua_Han, China	111	49
Zhuang_GB, China	54	49
Zhuang_GB, China	4	49
Zhuang_GB, China	9	49

Zhuang_GB, China	10	49
Bunun, China	18	50
Atayal, China	18	50
Amis, China	21	50
Paiwan, China	21	50
Undefined, Taiwan China	64	51
Han-JS, China	99	Our unpublished data
HSK-XJ, China	44	Our unpublished data
Kirgiz-XJ, China	60	Our unpublished data
Mg-XJ, China	96	Our unpublished data
Tajik-XJ, China	56	Our unpublished data
Uyu-XJ, China	274	Our unpublished data
Uzbek-XJ, China	46	Our unpublished data
Han-HLJ, China	180	Our unpublished data
Han-SX, China	220	Our unpublished data
Han-JL, China	199	Our unpublished data
Han-LN, China	191	Our unpublished data
Han-HN, China	1502	52
Han-YN, China	396	Our unpublished data
Han-SN, China	398	Our unpublished data
Han-AH, China	375	Our unpublished data
Han cancer of the esophagus, China	190	53
Han cancer of the esophagus, China	106	Our unpublished data
Han-SC, China	556	Our unpublished data
Han-SC, China	214	Our unpublished data
Han-SC, China	312	Our unpublished data
Koreans 103, South Korea	103	54
ZA_Chamdo_Ji, China	29	55
ZA_Lhasa_Ji, China	44	55
ZA_Nyingchi_Ji, China	52	55
ZA_Shigatse_Ji, China	29	55
ZA_Shannan_Ji, China	55	55
ZA_Nakchu_Ji, China	5	55
Tib_Ji, China	73	55
Tibetan, China	156	56
Korean, South Korea	694	57
HA, Shandong, China	253	Our unpublished data
HA, Neimeng, China	141	Our unpublished data
Dongbei, China	249	Our unpublished data
QI, Sichuan, China	60	Our unpublished data
Southeast Asia		
Vietnamese, Vietnam	42	5
Thais, Thailand	40	5
Vietnamese, Vietnam	187	58

Burman, Karen, Myanmar	327	59
Thai LHON, Thailand	42	Tharaphan et al. GenBank DQ149024-DQ149065
Indonesian, Sumatra, Pekanbaru, Indonesia	55	60
Indonesian, Sumatra, Medan, Indonesia	44	60
Malaysian, Semang, Malaysia	263	60
Malaysian, Melayu, Malaysia	4	60
Vietnamese, Vietnam	2	8
Samoan, Samoa	9	8
Philippines, Philippines	3	8
Borneo, Borneo	13	8
Java, Java	2	8
Burmans, Myanmar	32	Our unpublished data
Burmans, Myanmar	54	Our unpublished data
Burmans, Myanmar	51	Our unpublished data
Burmans, Myanmar	122	Our unpublished data
Burmans, Myanmar	69	Our unpublished data
Burmans, Myanmar	72	Our unpublished data
Chin, Myanmar	58	Our unpublished data
Chin, Myanmar	13	Our unpublished data
Chin, Myanmar	187	Our unpublished data
Naga, Myanmar	30	Our unpublished data
Naga, Myanmar	39	Our unpublished data
Naga, Myanmar	32	Our unpublished data
Rakhine, Myanmar	24	Our unpublished data
Rakhine, Myanmar	63	Our unpublished data
Akha, Thailand	91	61
Lahu, Thailand	39	61
Lisu, Thailand	25	61
Lisu, Thailand	42	61
Lisu, Thailand	53	61
Mussur, Thailand	21	61
Cham, Vietnam	168	62
Kinh, Vietnam	139	62
Thai, Thailand	190	63
Thai, Thailand	32	11
Cambodia, Cambodia	31	64
Thai, Thailand	30	65
Thai, Thailand	44	65
Lao Song, Thailand	25	65
ChB, Thailand	20	66
Khm, Thailand	22	66

Th_K, Thailand	32	66
Phuthai, Thailand	25	65
Chong, Thailand	25	65
Bangka, Sumatra, Indonesia	34	67
Batek, Malaysia	45	67
Jahai, Malaysia	39	67
Medan, Sumatra, Indonesia	42	67
Melayu, Malaysia	6	67
Mendriq, Malaysia	31	67
Padang, Malaysia	24	67
Palembang, Sumatra, Indonesia	50	67
Pekanbaru, Sumatra, Indonesia	52	67
Semai, Malaysia	6	67
Semelai, Malaysia	61	67
Temiar, Malaysia	46	67
Temuan, Malaysia	33	67
Philippine, Philippines	61	50
Java, Indonesia	46	50
Banjarmasin, Indonesia	89	50
Kota Kinabalu, Malaysia	61	50
Manado, Indonesia	89	50
Palu, Indonesia	38	50
Ujung Padang, Indonesia	46	50
Toraja, Indonesia	64	50
Bali, Indonesia	82	50
Mataram, Indonesia	44	50
Flores, Indonesia	2	50
Waingapu, Indonesia	50	50
Alor, Malaysia	45	50
Ambon, Indonesia	43	50
Luzon, Philippines	168	51
Visayas, Philippines	103	51
Mindanao, Philippines	70	51
Mal, Malaysia	124	68
HA, Singapore	205	69
Sakai, Thailand	20	65
Mussur, Thailand	21	65
White Karen, Thailand	40	61
Red Karen, Thailand	39	61
BK, Thailand	13	66
NUL, Thailand	17	66
Benu, Malaysia	10	70
Gopeng, Malaysia	22	70
Kuala Kurau, Malaysia	17	70

Lembah Bujang, Malaysia	26	70
Lenggeng, Malaysia	12	70
Machang, Malaysia	24	70
Kota Bharu, Malaysia	5	70
Muar, Malaysia	17	70
Parit Buntar, Malaysia	16	70
Parit Buntar, Malaysia	1	70
Pontian, Malaysia	20	70
Rantau Panjang, Malaysia	32	70
Semerah, Malaysia	13	70
Sri Menanti, Malaysia	22	70
Yan, Malaysia	11	70
Laos, Laos	214	71
South Asia		
Tipperah, India	20	72
Indians, Jammu and Kashmir, India	7	Bhat et al. GenBank AN. AY642034-AY642040
Indian, India	12	Darvishi et al. GenBank DQ143184- DQ143195
Indian, north India	4	Darvishi et al. GenBank DQ176757- DQ176760
Chakma, India	92	Our unpublished data
Ralt, India	104	Our unpublished data
Kuki, India	45	Our unpublished data
Adi, India	45	73
Apatani, India	26	73
Apatani, India	21	73
Naga, India	43	73
Nishi, India	44	73
Garos, India	76	74
Lyngnga, India	74	74
Nongtrai, India	27	74
Maram, India	60	74
Bhoi, India	29	74
Khynriam, India	82	74
War_Khas, India	29	74
Pnar, India	51	74
War_Jaint, India	17	74
Pakistani, Pakistan	100	75
Baluch, Pakistan	39	75
Brahui, Pakistan	38	75
Gujarati, India	34	75
Hazara, Pakistan	23	75
Hunza Burusho, Pakistan	44	75

Kalash, Pakistan	44	75
Makrani, Pakistan	33	75
Mazandarian, Pakistan	44	75
Pathan, Pakistan	44	75
Sindhi, Pakistan	23	75
Moor, Sri Lanka	43	76
Sinhalese, Sri Lanka	59	76
Indo-European, India	94	77
Dravidian, India	17	77
Kadar, India	7	78
Mixed MD, MDU, TH, India	96	Our unpublished data
Mixed DG, AMK, ARA, CNP, ERI, KAM, India	400	Our unpublished data
Mixed KAN, KAS, NAT, TNP, ODC, India	263	Our unpublished data
Mixed NGL, VRU, VEM, VKD, TN, MX, India	190	Our unpublished data
Baduga, India	2	79
Irula, India	16	72, 73
Kota, India	25	73
Kurumba, India	8	73
Kurumba Betta, India	19	73
Kurumba Mullu, Mulla Krumba, India	15	73
Oorali, India	3	79
Sakkili, India	6	79
Soligas, India	12	73
Malayalam, India	3	80
Cochin, India	52	76
Cochin Jews, India	37	76
Kattunaiken, India	16	73
Kuruchian, India	46	73
Kuruman Mullu, Mullu Kurunan, India	37	73
Paniya, India	11	73
Mixed TVM, India	64	Our unpublished data
Havik, India	38	78
Mukri, India	42	78
Kannada, India	5	80
Koragas, India	31	73
Kuruva, India	25	81
Kurumba Jenu, India	6	73
Yerava, India	53	73
Bhovi, India	30	82
Gowda, India	37	82
Brahmin, India	29	82

Lingayat, India	17	82
Christians, India	21	82
Muslim, India	24	82
Siddi, India	7	83
Telugu, Andhra Pradesh, Ind, TE, India	15	80, 84, 85
Lambadi, India	75	84
Andh, AndhSA, AndhX, India	95	73, 84
Brahmin, India	34	84
Kapu, KTK, KP, India	67	84, 85
Madiga, India	24	84
Yadava, India	40	84
Wadabahija, India	8	84
Mala, India	23	84
Kshatriya, India	9	84
Relli, India	20	84
Jalari, India	7	84
Vysya, India	9	84
Chenchu, India	96	88
Koya, India	81	88
Erukula, India	5	79
Yanadi, India	10	79
Thogataveera, India	84	Our unpublished data
Reddy, India	68	Our unpublished data
Pardhi, India	38	73
Thoti, India	39	73
Akhutota, India	22	87
PantaWatkins, India	29	87
Pokanati, India	36	87
Vanne, India	26	87
Irula, India	19	89
Chenchu, India	75	90
Kolam, India	128	90
Gond, India	75	90
Naikpod, N, NP, Z, India	83	86
Pardhan, D, I, J, S, W, India	170	86
Chitpavan Brahmin, India	17	91
Desasth Brahmin, India	15	91
Brahmin, India	9	92
Konkanastha Brahmin, India	50	76
Dhangar, India	16	91
Maratha, India	30	91-93
Maharashtra, Marathi, India	29	80, 84
Nav-Baudh, India	17	92, 93
Parsi, India	37	76

Bohra, India	5	93
Irani, India	5	93
Korku, India	9	93
Madia Gond, India	13	93
Kolam, India	8	93
Kathodi, India	1	79
Koli, India	6	79
Sikh, India	23	73
Gujarat, India	61	75, 76
Brahmin, India	29	94
Khatri, India	11	94
Jat Singh, India	27	76, 94
Scheduled caste, India	19	76, 94
Lobana, India	49	84
Brahmin, India	18	76
Kshatriya, India	22	76
PunjabP, PBAN, PHC, PNIR, PP, PPUR, PPUS, PRAJ, PRAM, PSUR, PSUS, PUSH, India	42	77, 85
Bhoksa, India	22	84
Tharu, India	31	76, 84
MundaMun, India	4	79
KoriKor, India	1	79
Rohidas, India	1	79
Yadava, India	6	79
Bhargava, India	165	Our unpublished data
Chaturvedi, India	82	Our unpublished data
Brahmin Mixed, India	146	Our unpublished data
Uttar Pradesh Brahmin, India	23	76
Rajput, India	14	79
Lodhe, India	1	79
HI, U, Uttar Pradesh, USIN, UKIR, UANI, UBHA, UBOB, UCHA, UD, UHC, UJEA, India	93	77, 80, 84
Delhi, India	10	85
Kanet, India	29	76
Rajput, Rajsthan, India	33	76, 84
Kashmir, India	13	84
Baluch, Pakistan	14	75
Brahui, Pakistan	12	75
Hazara, Pakistan	12	75
Hunza Burusho, Pakistan	23	75
KarachiKAR, Pakistan, UR, Pakistan	74	75, 80, 84
Parsi, Pakistan	23	75

Pathan, Pakistan	23	75
SindhiSI, Pakistan	14	75
Pushtoons, Pakistan	16	73
Makrani, Pakistan	8	73
BI, BD, BHC, BSUY, BVIJ, Bihar, India	43	77, 80, 84
BhumijBhuJ, BM, India	60	94, 95
Ho, India	20	95
Kharia, India	39	87, 95
KanwarKan, India	6	79
SatnamISat, India	3	79
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Munda, India	169	Our unpublished data
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Bengal Sudra, India	8	76
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Munda, India	6	72
Santhal, India	14	72
Dhimal, India	75	Our unpublished data
Kol, India	73	Our unpublished data
Lachung, India	35	Our unpublished data
Mech, India	45	Our unpublished data
Munda, India	40	Our unpublished data
Oran, India	98	Our unpublished data

Phariya, India	175	Our unpublished data
Rabha, India	49	Our unpublished data
Santhal, India	83	Our unpublished data
Toto, India	11	Our unpublished data
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Bodo, India	65	Our unpublished data
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Shia Muslim, India	120	100
Sunni Muslim, India	131	100
Dawoodi Bohra, India	62	100
Dawoodi Bohra, India	50	100
Mappla, India	61	100
Iranian Shia, India	48	100
Tharu-C I, Nepal	57	101
Tharu-C II, Nepal	76	101
Tharu-E, Nepal	40	101
Nepal-Kathamandu, Nepal	200	Our unpublished data
Nepal-East Nepal, Nepal	46	Our unpublished data
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Besermians, Udmurtia	41	Grosheva et al. GenBank AN. KF380839-KF380879
Mongolian, Mongolia	47	5
Volga-Turkic, Russia	2	Zaporozhchenko et al. GenBank AN. DQ656492-DQ656493
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Autochthonous Basque lineages, Spain	51	Cardoso et al. GenBank AN. JX669021-JX669071
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