

1 SUPPLEMENTARY FIGURE AND TABLE

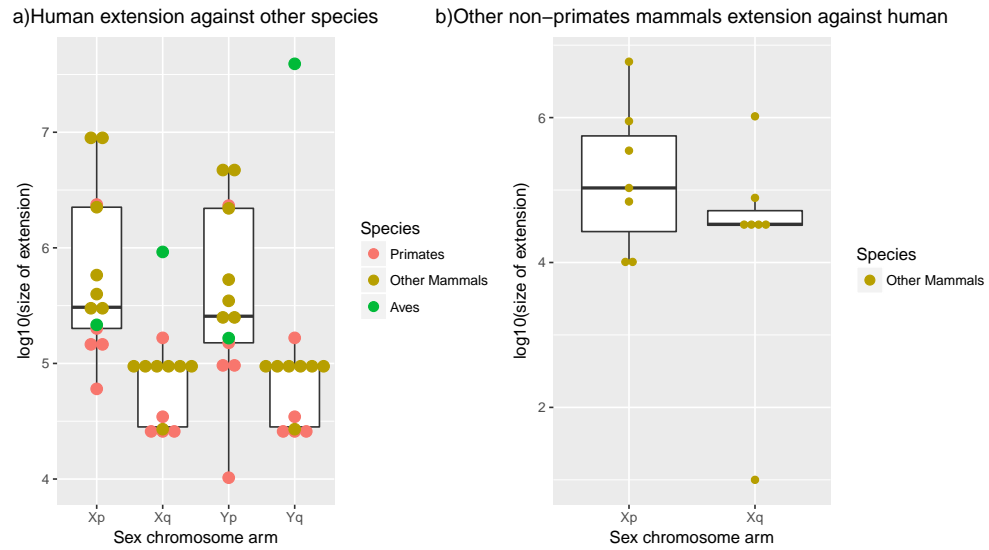


Figure S1. Human sex chromosome extension sequence.

a is for human extension against other species and *b* is for other non-primates mammals extension against human. Each dot is an estimated size of human extension sequence against a species on each arm. Y axis is the normalized size of extension. Reference gap and deletion (Murine Xp 9M deletion(?)) is included in estimation.

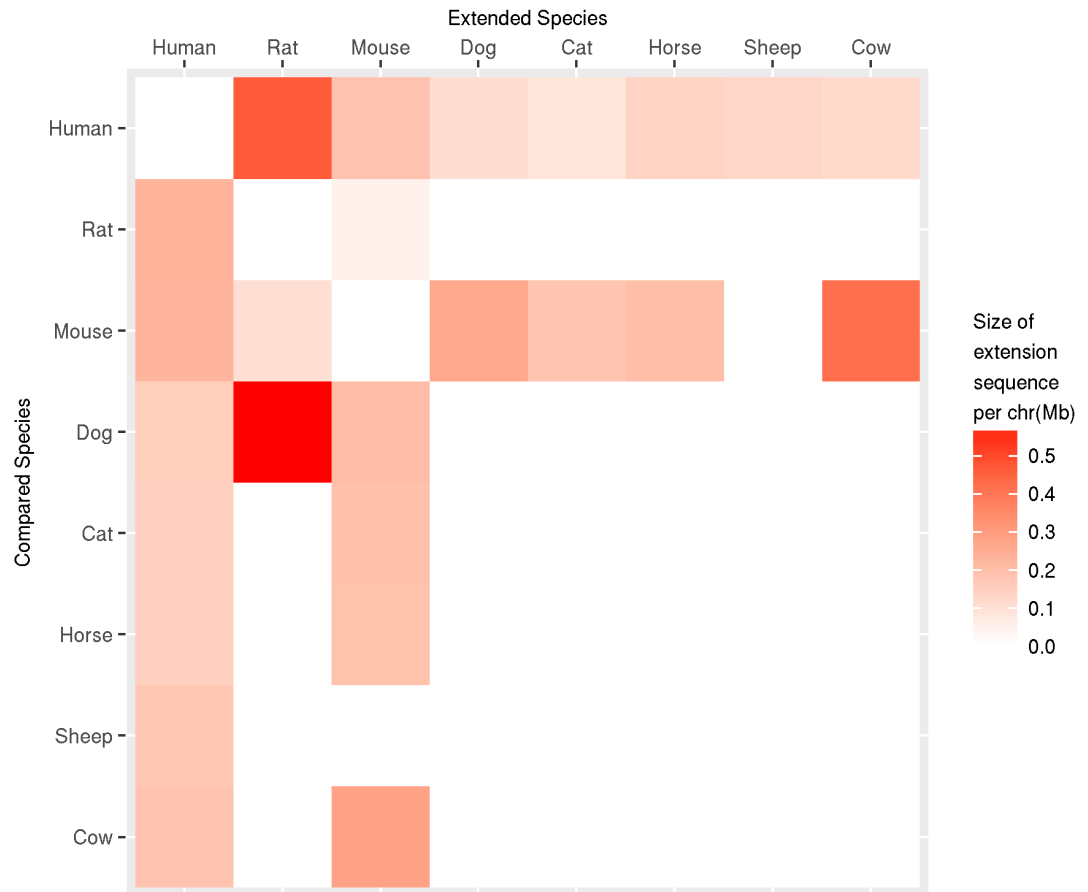


Figure S2. A heatmap of species extension sequence.
No data is indicated by white box.

Table S1. Summary of subtelomeric interstitial telomere sequence(ITS) and its relation with homology boundary.

*ITS with no homology boundary is not showed. * This re-orientation of chr2 follows the GRCh38 update.*

Reference GRCh37				Homology boundary overlap sizes to ITS				
				Both	distal		proximal	
Chromosome	Start	End	Arm	full	1bp+	-50bp,0	1bp+	-50bp,0
chr1	234506	234691	p	18	0	0	0	0
chr2	243166561	243166746	p*	19	0	0	0	0
chr4	23135	23326	p	20	0	0	0	0
chr6	147636	147986	p	2	0	8	0	0
chr7	16384	16986	p	4	8	6	0	0
chr8	11917	12102	p	19	0	0	0	0
chr8	155252	155736	p	1	11	4	0	3
chr8	169441	169626	p	18	0	0	0	0
chr8	170440	170577	p	0	6	2	0	0
chr9	141023514	141023656	q	1	0	0	0	0
chr10	110219	110551	p	2	0	0	0	0
chr10	135502709	135502799	q	2	0	0	0	0
chr10	135502846	135503008	q	2	11	6	0	0
chr11	175280	176542	p	4	7	6	0	0
chr16	90188062	90188814	q	4	8	6	0	0
chr18	63621	64200	p	2	0	3	0	0
chr18	94523	94691	p	1	0	0	0	0
chr18	98752	98793	p	0	1	0	0	19
chr18	100078	100263	p	19	0	0	0	0
chr18	105193	105469	p	2	11	6	0	0
chr18	105514	105670	p	2	0	0	0	0
chr19	245537	246002	p	1	9	5	0	4
chr19	258043	258228	p	20	0	0	0	0
chr19	59097932	59098077	q	0	12	7	0	0
chr20	62918053	62918986	q	2	4	3	0	0
chr22	51224559	51224818	q	1	12	6	0	0
Total number of duplications				166	100	68	0	26
Total number of ITS sites (>1)				23	12	13	0	3
					14		3	

Table S2. Summary of ITS permutation.

Types			Observation	Permutation				P-value
				Average	Permutation compare to Observation			
				Less than	Equal	More than		
Number of ITS sites	Both	Full Duplication	23	25.7	0	5	995	0.005
		1 or more	12	1.9	1000	0	0	<0.001
	Distal	-50 to 0	13	0.4	1000	0	0	<0.001
		-50 to 1 or more	14	2.2	1000	0	0	<0.001
	Proximal	1 or more	0	1.9	0	731	269	
		-50 to 0	3	0.4	620	213	167	
		-50 to 1 or more	3	2.1	637	209	154	
	Number of Dup Pairs	Both	Full Duplication	166	230.6	21	2	977
1 or more			100	5.4	1000	0	0	<0.001
Distal		-50 to 0	68	0.8	1000	0	0	<0.001
		1 or more	0	4.9	0	162	836	
Proximal		-50 to 0	26	0.7	1000	0	0	<0.001

Table S3. Summary of duplication pairs with unequal size of ITS.

The remaining duplication pairs with equal size of ITS (92%) are not reported.

Region of duplication pair 1	Region of duplication pair 2	Pair 1 ITS region	Pair 2 ITS region/size of deletion	size of ITS1	size of ITS2
chr11:169119-189425	chr7:10238-29843	chr11:175280-176542	chr7:16384-16986	1263	602
chr11:149569-179961	chr9:141123686-141153431	chr11:175280-176542	chr9:141023514-141023656	1263	142
chr11:128429-179961	chr16:90184650-90235480	chr11:175280-176542	chr16:90188062-90188814	1263	752
chr16:90184461-90194963	chr7:10238-20586	chr16:90188062-90188814	chr7:16384-16986	753	602
chr18:98796-105154	chr1:249220515-249225340	chr18:100078-100263	1192 deletion include ITS	186	0
chr18:25330-98754	chr9:141019504-141090402	chr18:63621-64200	chr9:141023514-141023656	580	142
chr18:14414-84190	chr10:60000-130311	chr18:63621-64200	chr10:110219-110551	580	332
chr19:246802-259397	chr6:148314-151820	chr19:258043-258228	chr6:147636-147986	186	350
chr20:62914355-62944856	chr6:121769-151529	chr20:62918053-62918986	chr6:147636-147986	934	350
chr2:243152476-243170633	chr1:249221180-249240008	chr2:243166561-243166746	1168 deletion include ITS	186	0
chr4:16224-31885	chr1:249214359-249229111	chr4:23135-23326	1193 deletion include ITS	192	0
chr4:16233-37400	chr5:14549-30972	chr4:23135-23326	4205 deletion include ITS	192	0
chr8:10004-15989	chr1:249221180-249225981	chr8:11917-12102	1169 deletion include ITS	186	0

Table S4. Summary of ITS fragments aligned to primates.

P(proximal) is 500 bp proximal sequence joined with ITS. *D*(distal) is ITS joined with a 500bp distal sequence. The 'full' ITS with both proximal and distal sequence is indicated by alignments of both *P* and *D*. *G*(gap) is 500bp proximal sequence joined with 500bp distal sequence(the gap is ITS). * This re-orientation of chr2 follows the GRCh38 update.

ITS position	Chimpanzee			Bonobo			Gorilla			Orangutan			Baboon			Sum		
	P	D	G	P	D	G	P	D	G	P	D	G	P	D	G	P	D	G
chr1:234506-234691	2	3	0	5	3	0	4	5	0	10	10	0	9	21	0	30	42	0
Chr2:243166561-243166746*	3	3	0	5	3	0	4	5	0	10	10	0	9	21	0	31	42	0
chr4:23135-23326	3	3	0	5	3	0	4	5	0	10	10	0	15	19	0	37	40	0
chr6:147636-147986	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0
chr7:16384-16986	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
chr8:11917-12102	3	3	0	5	3	0	4	5	0	10	10	0	9	21	0	31	42	0
chr8:155252-155736	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	2	1	0
chr8:169441-169626	0	3	0	1	3	0	0	5	0	0	10	0	0	21	0	1	42	0
chr8:170440-170577	1	3	0	1	3	0	0	4	0	0	5	0	0	0	0	2	15	0
chr9:141023514-141023656	1	1	0	0	0	0	0	1	0	0	1	0	1	1	0	2	4	0
chr10:110219-110551	1	0	0	1	1	0	0	0	0	3	2	0	2	1	0	7	4	0
chr10:135502709-135502799	0	0	0	0	1	0	0	1	0	0	4	0	0	0	0	0	6	0
chr10:135502846-135503008	0	3	0	2	3	0	0	5	0	0	5	0	0	0	0	2	16	0
chr11:175280-176542	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
chr16:90188062-90188814	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
chr18:63621-64200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
chr18:94523-94691	1	1	0	0	0	0	0	1	0	0	1	0	1	1	0	2	4	0
chr18:98752-98793	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
chr18:100078-100263	3	3	0	5	3	0	4	5	0	10	10	0	15	21	0	37	42	0
chr18:105193-105469	0	1	0	0	1	0	0	4	0	0	4	0	0	0	0	0	10	0
chr18:105514-105670	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	0
chr19:245537-246002	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0	3	2	0
chr19:258043-258228	3	3	0	5	3	0	4	5	0	10	10	0	15	21	0	37	42	0
chr19:59097932-59098077	0	3	0	0	3	0	1	4	0	0	5	0	0	0	0	1	15	0
chr20:62918053-62918986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
chr22:51224559-51224818	0	0	0	1	2	0	0	4	0	0	4	0	0	0	0	1	10	0
Sum	21	34	0	36	36	0	27	64	0	65	102	0	77	148	0	226	384	0

Table S5. Human extension sequence with 13 species for 41 chromosome ends.

** means the average chromosome extension rate for human against non-primate mammal. Cat and elephant is not showed here.*

Species	Chimp	Gorilla	Orangutan	Gibbon	Rhesus	Marmoset	Dog	Horse	Cow	Sheep	Rat	Mouse	Chicken	Rate*(bp/kyr)
1p	917	973	55001	30732	30732	824837	835364	830944	831011	831011	836464	858617	842068	9.967
2p	1391	3609	12365	3425	3425	3425	3574	3443	23205	23205	166465	164192	1069019	0.762
3p	4229	3868	0	0	0	0	0	0	1	0	45	1303	110886	0.002
4p	9026	1527	11844	20598	36553	35534	482855	482965	482961	483208	483104	483105	252755	5.75
5p	57711	4508	59443	6792	14936	77530	71660	76867	310025	181388	181427	181424	463078	1.989
6p	48073	79744	102091	90447	153495	174182	121288	120728	214466	120716	190024	121260	285770	1.762
7p	273937	238	9550	3083	21743	36749	21799	60370	141124	140311	159203	158646	183082	1.352
8p	3908	7073	169045	167221	168941	167446	171859	172967	329657	320808	629420	601099	1486737	4.416
9p	54049	1075	61293	39963	39963	113622	41342	41336	41342	41345	40881	40580	42441	0.489
10p	10926	18231	15885	33201	30033	74969	79159	78565	98550	98550	78739	78697	165419	1.016
11p	42548	8202	218539	210022	131919	133438	132147	132881	132117	132067	132874	132897	144121	1.577
12p	88390	85758	111773	86848	139339	86	87444	87443	87500	88540	89308	88548	174769	1.049
16p	20227	15622	24261	26878	36964	36844	15837	15850	15877	16066	18819	166592	37467	0.494
17p	0	0	24753	0	10	3	3122	1	358	357	5282	1	5978	0.018
18p	102546	16176	102546	102546	102546	102546	102543	102525	102525	102525	102542	102542	106494	1.22
19p	116144	0	30443	204408	207545	219487	217638	686040	217624	217624	221160	221180	247113	3.534
20p	13810	0	0	1511	1508	3199	7907	7902	7890	7902	190646	62696	359063	0.565
1q	16835	17280	3073	8770	17493	26273	420563	586638	70707	27486	1617696	1619007	394878	8.615
2q	103981	133097	186073	383591	181715	378904	373763	392948	349549	349547	382946	444940	430942	4.55
3q	207	1618	189846	165563	153403	157971	190353	190318	255488	190304	190355	190356	279695	2.395
4q	37235	21440	87459	48927	84087	159414	151776	150890	150866	150866	159747	159619	217664	1.832
5q	66637	4576	189375	233428	189532	219062	217006	217338	214161	214161	229610	223252	626701	2.61
6q	130806	9217	137814	146644	138204	160084	161185	161453	277502	161281	161308	161313	162773	2.15
7q	2581	2397	23406	742	2397	24265	9234	2397	13833	13833	190724	190762	390040	0.834
8q	1723	7399	11691	6609	9271	174748	75633	23482	391765	391765	145678	130686	29898	2.299
9q	31401	7333	54129	63018	77582	129991	134322	134265	133775	236339	134276	134275	123936	1.8
10q	44840	13578	34811	130696	117648	145407	150549	145334	280766	172254	245646	245652	904699	2.46
11q	3154	18216	1282	1821	7179	1283	57578	40216	226504	226470	111790	102977	489187	1.518
12q	38082	63227	23695	24080	24085	52834	57280	57247	24276	24318	336994	331528	60788	1.65
13q	127815	3372	0	9279	552	1879	33990	33969	16777	15486	41979	16948	17721	0.315
14q	870	870	1011	10290	870	69892	954975	56319	1207788	1218690	957365	957365	1293239	10.62
15q	513	1629	48152	146815	30959	253816	254866	255206	255912	255913	255522	255522	549074	3.041
16q	6755	51842	0	144708	160084	150370	159022	150713	150659	150666	184995	184723	131961	1.945
17q	132931	134071	133999	120585	16019	19200	16382	17076	41254	17281	50277	41274	343690	0.364
18q	1654	1601	2905	1325	3486	2897	9110	6614	8522	8512	6642	5770	120543	0.089
19q	29940	9674	38606	28697	21310	22083	23553	23553	25234	28255	33181	33222	43879	0.331
20q	17719	6766	49158	50313	49696	51291	57884	57890	57854	57854	58079	57929	60307	0.689
21q	25243	4249	3192	2737	16756	33187	28306	27465	34859	34860	94160	34983	94717	0.505
22q	19653	22983	20008	20014	22056	59440	23863	23620	55999	55999	22185	22386	515520	0.404
2Aq	32251	0	0	211615	0	192797	220942	211614	193660	193660	220161	223241	1269730	2.506
2Bp	23849	0	0	71407	0	69048	69050	69046	69050	68966	75421	75421	110714	0.847
Total	1744507	783039	2248517	3059349	2444036	4560033	6246723	5936438	7542993	7070389	9433140	9306530	14638556	
MRC(A/year)	4-13M	8-10M	11-16M	15.9M-17.6M	25M	65M-110M							310M	
Rate(bp/year)	134.1~436.1	78.30~97.87	140.5~204.4	173.8~192.4	97.76	182.4	56.78~96.10	53.96~91.32	68.57~116.0	64.27~108.7	85.75~145.1	84.60~143.1	47.22	
Chr pair	48	48	48	52	42	46	78	64	60	54	42	40	78	

Table S6. Summary of non-extinction chromosome ends in both human and non-primates mammals.

Species 1 summary					Species 2 summary					+/-
Species	arm	Missing size	Alignment Start	Alignment end	Species	arm	Missing size	Alignment Start	Alignment end	
Human	10p	135365	135365	37113432	Cat	B4p	127287	127287	33333670	+
Human	19p	277624	277624	19777907	Cat	A2p	16431	16431	14262958	+
Human	2q	358353	133138373	242841020	Cat	C1q	30139	124053039	221411063	+
Human	6q	221906	30227075	170893161	Cat	B2q	62590	31916422	154199199	+
Human	7q	173302	7040216	158965361	Cat	A2q	5031	101164933	169038598	+
Human	8q	83498	48168969	146280524	Cat	F2q	9332	16915	82754204	+
Human	9q	194322	5884866	141019109	Cat	D4q	8602	34042573	96011804	+
Human	10q	162445	59925381	135372302	Cat	D2q	0	22343236	89822065	+
Human	17q	16208	3907600	81179002	Cat	E1q	55223	137039	62946879	+
Human	18q	68522	18526869	78008726	Cat	D3q	22591	45171811	95719138	+
Human	22q	82320	32783308	51222246	Cat	B4q	16481	129498234	144243076	+
Human	10q	290766	89189936	135243981	Cow	26q	0	9616919	51826547	+
Human	19q	35234	30088950	59093749	Cow	18q	1628	39229296	65809426	+
Human	2p	13574	13574	42984706	Dog	17p	51922	51922	34302390	+
Human	6p	181288	181288	30181690	Dog	35p	590196	590196	26407419	+
Human	10p	139159	139159	37097792	Dog	2q	115	50769298	85426593	-
Human	2q	383763	225198378	242815610	Dog	25q	403	37611622	51628530	+
Human	6q	221185	170102486	170893882	Dog	12q	9252	71953888	72488829	+
Human	9q	194322	124206542	141019109	Dog	9p	31132	31132	13260498	-
Human	10q	160549	49271712	135374198	Dog	28q	27264	75215	41154848	+
Human	13q	93990	53216327	115075888	Dog	22q	79209	9673649	61360725	+
Human	16q	219022	58849149	90135731	Dog	5p	1318	1318	25356307	-
Human	19q	33553	28654258	59095430	Dog	1p	24300	24300	23306206	-
Human	20q	117884	29841230	62907636	Dog	24q	26392	20767966	47672387	+
Human	21q	38306	15478747	48091589	Dog	31q	32853	11137799	39863068	+
Human	1p	840944	840944	60426846	Horse	2q	279717	72153278	120577970	-
Human	2p	13443	13443	110485399	Horse	15q	217704	6812	91353744	-
Human	6p	180728	180728	73919925	Horse	20p	612462	612462	64164826	+
Human	19p	746040	746040	8442856	Horse	7p	666	666	5599328	+
Human	9q	194265	34891056	141019166	Horse	25q	474	218064	39536490	+
Human	13q	93969	19922656	115075909	Horse	17q	24012	419545	80733895	+
Human	17q	17076	16840168	81178134	Horse	11p	425463	425463	61289656	-
Human	18q	66614	5392074	78010634	Horse	8q	718	30505306	94056955	+
Human	20q	117890	29841186	62907630	Horse	22q	19	22312019	49946778	+
Human	21q	37465	15478747	48092430	Horse	26q	10726	13389947	41855451	+
Human	22q	83620	32783318	51220946	Horse	28q	3	30642874	46177336	+
Human	17q	41274	29378552	81153936	Mouse	11q	273838	79305714	121808705	+
Human	18q	65770	66339760	78011478	Mouse	18p	158537	158537	10664291	-
Human	20q	117929	1746870	62907591	Mouse	2q	255194	129457714	181858030	+
Human	18p	112542	112542	595854	Rat	18q	781005	86921417	87420924	-
Human	12q	346994	132378990	133504901	Rat	12q	106642	51907910	52610128	+
Human	16p	76066	76066	31540446	Sheep	24p	33978	33978	27539904	+
Human	6q	221281	74126790	170893786	Sheep	8q	8982	633	90686186	+
Human	7q	23833	7058129	159114830	Sheep	4q	8946	15016423	119246687	+
Human	10q	182254	89189936	135352493	Sheep	22q	129223	8873750	50703309	+
Human	11q	286470	134346458	134720046	Sheep	15q	109817	80708239	80813775	+
Human	13q	75486	41467241	115094392	Sheep	10q	7909	11478842	86439304	+
Human	14q	1278690	24968513	106070850	Sheep	18q	137064	33600671	68467538	+
Human	19q	38255	30088950	59090728	Sheep	14q	8427	39510236	62714198	+
Human	22q	115999	32783276	51188567	Sheep	3q	55449	176085127	224227781	+