

Supplemental Data

Correcting for Purifying Selection:

An Improved Human Mitochondrial Molecular Clock

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Antonio Salas, Stephen Oppenheimer, Vincent Macaulay, and Martin B. Richards

Table S1. List of published complete genomes used in this paper.

AF346963	AF382010	AP008303	AP008382	AP008462	AP008541	AP008621
AF346964	AF382011	AP008304	AP008383	AP008464	AP008543	AP008622
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AF346972	AJ842748	AP008312	AP008390	AP008471	AP008550	AP008630
AF346973	AJ842749	AP008313	AP008391	AP008472	AP008551	AP008631
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AF346975	AJ842751	AP008315	AP008393	AP008474	AP008554	AP008633
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AF382004	AP008297	AP008376	AP008456	AP008535	AP008615	AP008694
AF382005	AP008298	AP008377	AP008457	AP008536	AP008616	AP008695
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EF060362	EF064317	EF064334	EF177411	EF177428	EF177445	EF436244
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Table S2. List of primate complete mitochondrial genome sequences

(excluding the genus *Homo*) used in this work.

AF348159.1 *Tarsius bancanus*
 AJ309865.1 *Macaca sylvanus*
 AJ309866.1 *Cebus albifrons*
 AJ309867.1 *Nycticebus coucang*
 AM905039.1 *Daubentonia madagascariensis*
 AM905040.1 *Eulemur mongoz*
 AY612638.1 *Macaca mulatta*
 AY863425.1 *Trachypithecus obscurus*
 AY863426.1 *Cercopithecus aethiops*
 AY863427.1 *Colobus guereza*
 D38113.1 *Pan troglodytes*
 D38114.1 *Gorilla gorilla* complete
 D38115.1 *Pongo pygmaeus*
 D38116.1 *Pan paniscus*
 DQ069713.1 *Cercopithecus aethiops sabaesus*
 DQ355297.1 *Semnopithecus entellus*
 DQ355298.1 *Nasalis larvatus*
 DQ355299.1 *Presbytis melalophos*
 DQ355300.1 *Pygathrix roxellana*
 DQ355301.1 *Procolobus badius*
 DQ355302.1 *Pygathrix nemaeus*
 EF597500.1 *Chlorocebus pygerythrus*
 EF597501.1 *Chlorocebus pygerythrus*
 EF597502.1 *Chlorocebus tantalus*
 EF597503.1 *Chlorocebus sabaesus*
 EU095335.1 *Pan troglodytes*
 EU095336.1 *Gorilla gorilla* partial
 X93335.1 *Pan troglodytes*
 X93347.1 *Gorilla gorilla gorilla*
 X97707.1 *Pongo pygmaeus abelii*
 X99256.1 *Hylobates lar*
 Y18001.1 *Papio hamadryas*

Table S3. Number of occurrences for each mutation.

Location	Amino acid change	Position	Number of occurrences
CR		16519	209
CR		152	157
CR		16311	120
CR		146	109
CR		195	98
CR		16189	90
CR		16129	86
CR		16093	79
CR		16362	67
CR		150	63
12S		709	59
CR		16278	43
CR		204	43
CR		16172	42
CR		16223	37
ND4	S	11914	37
ND2	NS	5460	36
CR		207	36
CR		16319	35
CR		16291	34
CR		16192	33
CR		16390	31
CR		16209	31
THR		15924	31
16S		1719	31
CR		189	31
CR		16086	30
CR		200	30
CR		199	30
CR		151	30
CR		16294	29
CR		16256	29
CR		16111	27
CR		16399	26
CR		16274	26
CR		16234	26
CR		16304	24
ND5	NS	13708	24
ND5	NS	13105	24
ND2	S	5147	24
CR		185	24
12S		1598	23
CR		16261	22
CR		16145	22
CO2	S	8251	22
CR		513	22
CR		64	22

CR		16051	21
CR		16249	20
CR		16126	20
CR		198	20
CR		16356	19
CR		16320	19
16S		3010	19
CR		93	19
CR		16187	18
CR		16176	18
ND5	NS	12358	18
ND3	NS	10398	18
CR		16293	17
CR		16266	17
CR		16092	17
CR		143	17
CR		16325	16
CR		16148	16
CYTB	S	15244	16
-		8281- 9BPDEL	16
CR		228	15
CR		153	15
CR		16309	14
CR		16292	14
ND4L	S	10685	14
CO1	S	6221	14
CR		16526	13
CR		16298	13
ND6	NS	14180	13
ND2	S	4688	13
CR		16368	12
CR		16357	12
CR		16355	12
CR		16224	12
CR		16184	12
CR		16169	12
CYTB	NS	15884	12
CYTB	NS	15314	12
ND6	S	14560	12
ND6	S	14470	12
ND5	NS	13928C	12
HIS		12172	12
ND4	S	12007	12
CO3	S	9254	12
ND2	S	5237	12
12S		961	12
CR		234	12
CR		194	12
CR		16527	11
CR		16288	11
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CR		23	1
CR		16T	1
CR		11	1
CR		9T	1
CR		3	1

Table S4. Comparison of corrected clock age estimates with those using the Mishmar et al. clock.

Interval of age estimates (from the corrected molecular clock)	Average ratio Mishmar et al. age estimate/ corrected-clock age estimate
0–1000	1.501
1000–5000	1.374
5000–10,000	1.357
10,000–20,000	1.255
20,000–50,000	1.187
50,000–100,000	1.128

Table S5. Age estimates, confidence intervals and motifs for the clades presented in figure 5 calculated using the complete mitochondrial genome molecular clock and a maximum likelihood approach.

Clade	Point Estimate	95% CI lower bound	95% CI higher bound	Motif
MtEve	192400	151600	233600	
L0	149700	112200	188000	MtEve+ (1048, 3516A, 5442, 9042, 9347, 10664, 10915, 13276, 16187)
L0k'remaining L0	138100	103100	173900	L0+ (189, 4586, 9818, 16172)
L0k	11200	3300	19500	L0k'remaining L0 + (146, 198, 263, 597, 1438, 5756, 3981, 4025, 4044, 4086, 4225, 4232, 5153, 6815, 7154, 8113A, 8152, 8251, 8270, 8281(9pbD), 8392, 8545, 9755, 11854, 12121, 12172, 12234, 12720, 12810, 14221, 15466, 15766, 15930, 15941, 16093, 16129, 16212, 16243, 16278, 16390)
L0f'remaining L0	108000	77900	139200	L0k'remaining L0t + 73, 195, 2245, 5603, 11641, 15136, 15431
L0a	44800	28900	61500	L0f'remaining L0 + (93, 236,5231, 5460, 8428, 8566, 9755, 11176, 12720, 14308, 16148, 16188G, 16320)
L0a1	26800	15100	39100	L0a + (152, 185, 5096, 16129, 16168)
L0a2	25400	13800	37500	L0a + (5147, 5711, 6257, 8281 (9pbD), 8460, 11172, 16278)
L(3'4'7'6'2'5)'1	166800	130700	203500	MtEve + (182, 4312, 6185, 10589, 11914, 12007, 16230)
L1	140600	107600	174300	L(3'4'7'6'2'5)'1 + (3666, 7389, 13789, 14178, 14560)
L1b	9700	5200	14300	L1 + (185T, 357, 709, 710, 1438, 1738, 2352, 2768, 3308, 3693, 5036, 5046, 5393, 5655, 6548, 6827, 6989, 7055, 7867, 8248, 12519, 13880A, 14203, 14769, 15115, 16126, 16187, 16264, 16270)
L1c	85400	63500	107900	L1 + (151, 186A, 189C, 316, 2885, 5951, 6071, 8027, 9072, 10586, 12810, 13485, 14000A, 14911, 16129, 16294, 16360)
L(3'4'7'6'2'5)'5	149300	116900	182300	L(3'4'7'6'2'5)'1 + (2758, 2885, 7146, 8468, 13105)
L5	120200	114200	126200	L(3'4'7'6'2)'5 + (2423, 7972, 12432, 12950, 16129, 16148, 16166)
L(3'4'7'6)'2	114700	89600	140400	L(3'4'7'6'2)'5 + (247, 825T, 8655, 10688, 10810, 13506, 15301, 16189, 16311)
L2	89300	68100	111100	L(3'4'7'6)'2 + (150, 2416, 8206, 9221, 10115, 11914, 11944, 13590, 16390)
L2a	48300	31100	66300	L2 + (150, 182, 2789, 7175, 7274, 7771, 13803, 14566, 16294)
L2a1	21500	14300	29000	L2a + (146, 12693, 15784, 16309)
L2b'c	61800	43100	81300	L2 + (198, 1442, 2332, 12336, 15110, 15217)
L2b	14300	7000	21900	L2b'c + (204, 1706, 2358, 4158, 4370, 4767, 5027, 5331A, 5814, 6026, 6713, 7624A, 8080, 8387, 10828, 12948, 13924, 16114A, 16129, 16213)

L2c	25200	13400	37700	L2b'c + (325, 680, 709, 3200A, 7624A, 13958C, 15849)
L3'4'7'6	105300	81500	129800	L(3'4'7'6)'2 + (4104, 7521)
L3'4'7	86100	66400	106400	L3'4'7'6 + (152, 182, 3594, 7256, 13650, 16278)
L3	71600	57100	86600	L3'4'7 + (766, 1018)
L3b'c'd	64100	48000	80900	L3 + (13105)
L3b'c	64100	48000	80800	L3b'c'd + (16362)
L3b	16400	9800	23200	L3b'c + (195, 3450, 5773, 6221, 9449, 10086, 10373, 11002, 13914A, 15824, 16278)
L3d	31000	19200	43300	L3b'c'd + (152, 195, 5147, 7424, 8618, 13886, 14284, 16124)
L3h	66700	52000	81800	L3 + 195 + (9575, 7861)
L3+195	71500	57000	86400	L3 + (195)
L3e'i'x	53400	38700	68600	L3 + (150, 10819)
L3e	39000	27200	51200	L3e'i'x + (2352, 14212)
L3i	34800	19900	50500	L3e'i'x + (7645, 14040, 14395)
L3x	36100	23300	49600	L3e'i'x + (3483, 6401, 8311, 8817, 13708, 16086, 16169)
L3f	53200	38600	68300	L3 + 195 + (3396, 4218, 15514, 16209)
M (South Asia)	49400	39000	60200	M3 + 195 + (489, 10400, 14783, 15403)
M (East Asia)	60600	47300	74300	M3 + 195 + (489, 10400, 14783, 15403)
M1	25400	17900	33100	M + (195, 6446, 6680, 12043, 12950C, 14110, 16129, 16189, 16249, 16311)
M1a	21000	13200	29100	M1+ (813, 6671)
M1b	20900	15600	26300	M1 + (13111)
M2	37600	27400	48300	M + (447G, 1780, 8502, 11083, 15670, 16274, 16319)
M2a	20300	11400	29600	M2 + (204, 5252, 7961, 8396, 9758, 12810, 16270, 16352)
M2b	12800	5500	20400	M2 + (152, 195, 1453, 2831T, 3630, 5744, 6647, 9899, 13254, 14766, 16189, 16320, 16362)
M3	35300	21400	50000	M + (482, 16126)
M4'18'38'30'37	40500	30300	51100	M + (12007)
M4	36500	26100	47300	M4'18'38'30 + (16311)
M18	22200	11600	33400	M4'18'38'30 + 246 + (194, 12498, 15942, 16318T)
M38	16800	7900	26300	M4'18'38'30 + 246 + (189, 1808, 6267, 6899, 9966, 15314, 15487)

M30	22300	14600	30200	M4'18'38'30 + (195A, 15431)
M37	34700	22800	47200	M4'18'38'30 + (10556)
M5	39600	27600	52100	M+ (1888, 16129)
M5a	21500	10200	33600	M5 + (709, 3921, 12477, 14323)
M6	21300	12400	30700	M + 461, 3537, 5082, 5301, 5558, 9329, 10640, 13966, 14128, 16231)
M33	44900	32900	57300	M + (2361)
M34	29800	18400	41700	M + (569, 3010, 6794, 11101, 15865, 16249)
M35	39600	26600	53100	M + (199, 12561)
M36	36500	23600	50200	M + (239, 7271, 15110)
M39	32300	20700	44400	M + (66T, 1811, 8679, 15938)
M40	33500	21400	46300	M + (8925, 15721, 15954, 16463)
M41	6400	1200	11800	M + (146, 195, 951, 5773, 13359, 15601)
D	48300	35600	61400	M + (4883, 5178A, 16362)
D4	27000	21000	33200	D + (3010, 8414, 14668)
D1	13500	8800	18300	D4 + (2092, 16325)
D4a	15500	10000	21200	D4 + (3206, 8473, 14979, 16129)
D4a1	6300	3900	8700	D4a + (10410)
D4a2	10500	3600	17700	D4a + (12957)
D4a3	13000	7700	18500	D4a + (5466, 16249)
D4a4	12300	6000	19000	D4a + (16294)
D4b	25800	19700	32000	D4 + (8020)
D4b1	20100	13900	26500	D4b + (10181, 15440, 15951, 16319)
D4b2	18600	12500	25000	D4b + (1382C, 8964, 9824A)
D4c	22500	14600	30600	D4 + (16245)
D4c1	19600	11900	27500	D4c + (2766)
D4c2	2300	0	5600	D4c + (8383, 8419, 9431T)
D4e	22900	15600	30500	D4 + (11215)
D4e1	19300	12300	26600	D4e + (3316, 9536)

D4e2	4900	3000	6900	D4e + (15874)
D4f	3300	-400	7000	D4 + (2706, 4538, 7270, 8764, 11255)
D4g	25300	19000	31800	D4 + (13104)
D4g1	3700	600	6900	D4g + (4343, 8701, 15518, 16278)
D4g2	21100	14700	27800	D4g + (195, 298, 5231)
D4h	18100	10900	25600	D4 + (336, 3644, 5048)
D4i	17000	7600	26800	D4 + (16294)
D4j	14200	7500	21200	D4 + (11696)
D4k	6300	-600	13600	D4 + (195, 12092A, 16362)
D4l	8700	1500	16200	D4 + (1310, 3535, 16145, 16368)
D4m	3900	0	7900	D4 + (1148, 6620, 8762, 9667, 12088, 12651C, 16223, 16244)
D4n	7400	0	15200	D4 + (3421, 16355A)
D4o	17200	10200	24500	D4 + (195, 10646, 16290)
D5	38300	27100	49900	D + (150, 1107, 5301, 10397)
D5ab	34900	24400	45900	D5 + (9180, 16189)
D5a	23800	14900	33100	D5ab + (752, 11944, 12026)
D5a1	7600	2600	12800	D5a + (68, 3496T, 13708, 16390)
D5a2	11500	5700	17700	D5a +(1438)
D5b	21700	13000	30700	D5ab +(456, 681, 1048, 5153, 15724)
D5b1	16000	9100	23200	D5b + (6253)
D5c	5100	200	10200	D5 + (146, 152, 152, 182, 217, 3546, 4200T, 4216, 13105, 14927, 15622, 16223, 16390)
D6	29300	16400	42900	D + (709, 1719, 3714, 12654, 16189)
M7	54800	41600	68400	M + (6455, 9824)
M7a	27500	17300	38200	M7 + (2626, 2772, 4386, 4958, 12771, 16209)
M7a1	18900	11400	26600	M7a + (14364, 16324)
M7a1a	11800	8200	15500	M7a1 + (11017, 11084)
M7a2	21200	11500	31400	M7a + (15422, 16140)
M7b'c	50200	37200	63600	M7 + (199, 4071)

M7b	28700	18800	38900	M7b'c + (150, 4048, 4164, 5351, 5460, 6680, 7684, 7853, 12405, 16129, 16297)
M7b1'2	19900	11200	29100	M7b + (12811)
M7b2	6400	4300	8500	M7b1'2 + (10345, 16189, 16298)
M7b3	13400	5400	21900	M7b + (1664, 6351, 9468, 10497, 12121, 14115, 16086, 16223, 16324)
M7c	24000	15400	32800	M7b'c + (146, 4850, 5442, 11665, 12091, 16295)
M7c1	20600	12600	28900	M7c + (3882)
M7c3	16800	9000	25000	M7c + (3606, 15236)
M8	42700	31000	54900	M + (4715, 7196A, 8584, 15487T, 16298)
M8a	25900	15700	36700	M8 + (6179, 8684, 14470, 16319)
M8a1	2900	-400	6300	M8a + (6719, 8453, 15047, 15148, 15355, 15697, 16311)
M8a2	18300	11200	25800	M8a + (2835, 16184)
C	28300	19400	37400	M8 + (3552A, 9545, 11914, 13263, 14318)
C1'4'6	26100	18100	34500	C + (16327)
C1	17100	12000	22500	C1'4'6 + (16325)
C1a	13900	7900	20100	C1 + (7697, 16051)
C1b	14500	9300	19900	C1 + (493)
C1c	9000	4600	13600	C1 + (1888, 15930)
C4	17700	10600	25000	C1'4'6 + (6026, 11969, 15204)
Z	24300	15400	33600	M8 + (6752, 9090, 15784, 16185, 16260)
Z1	17800	9800	26300	Z + (15261)
Z2	3700	700	6800	Z + (3145, 8188, 14668, 15184)
Z4	14800	7900	22000	Z + (5492, 15475, 16189, 16302)
M9	53400	38200	69200	M + (4491)
M9ab'E	46900	31700	62800	M9 + (16362)
E	27400	16400	39000	M9ab'E + (3027, 3705, 7598, 13626, 16390)
E1	14000	7500	20700	E + (4248, 10834, 13254, 14577)
E1a	10000	6400	13700	E1 + (6620)
E1a1a	7200	4600	9800	E1a + (14766, 16291)

E1b	6300	2400	10300	E1 + (152, 869, 9192)
E2	9900	4600	15400	E + (195, 8440, 9080, 15178, 16051)
E2a	6900	3900	9900	E2 + (8730)
E2b	6600	1800	11500	E2 + (16185)
M9ab	33400	20500	46900	M9abE + (153, 3394)
M9a	15400	8600	22400	M9ab + (1041, 9242, 14308, 16234, 16316)
M9a1	4600	1900	7400	M9a + (153, 11963)
M9a2	4100	-300	8700	M9a + (5951, 9115, 13434, 16300)
M9a3	6100	1700	10600	M9a + (7142, 7861, 14417, 16291)
M10	27200	16300	38700	M + (709, 4140, 8793, 12549, 13152, 14502, 15040, 15071, 16311)
M11	22700	12900	33000	M + (215, 318, 326, 1095, 6531, 7642, 8108, 9950, 11969, 13074)
M12'G	56700	42700	71200	M + (14569)
G	35700	25500	46300	M12'G + (709, 4833, 5108, 16362)
G1	22500	14000	31300	G + (8200, 15323, 15497)
G1a	19000	11200	27100	G1 + (7867)
G2	30400	26100	34800	G + (5601, 13563)
G2a	17700	11400	24200	G2 + (7600, 9377, 9575, 16227, 16278)
G3	29200	18000	41000	G + (16274)
G3a	20900	10600	31800	G3 + (143, 15746)
G3b	14400	5100	24300	G3 + (13477, 14605, 15927)
M13	12400	4700	20400	M + (152, 3644, 5773, 6023, 6253, 6620, 10411, 10790, 13135, 15924, 16145, 16188, 16189, 16381)
N (West Eurasia)	61900	49200	75000	(L3 + 195) + 8701, 9540, 10398, 10873, 15301
N (South Asia)	71200	55800	87100	(L3 + 195) + 8701, 9540, 10398, 10873, 15301
N (East Asia)	58200	44100	72800	(L3 + 195) + 8701, 9540, 10398, 10873, 15301
X	31800	19700	44600	N + (153, 6221, 6371, 13966, 14470, 16189, 16278)
X1	9500	2100	17200	X + (146, 3531, 13785, 13879, 14560, 15672)
X2	20900	11800	30400	X + (195, 225, 1719)

X2a	12800	6100	19900	X2 + (200, 8913, 12397, 14502, 16213)
X2b	14600	7800	21600	X2 + (8393, 13708, 15927)
X2c	7000	100	14300	X2 + (227, 16255)
W	21200	13000	29700	N + (189, 195, 204, 207, 709, 1243, 3505, 5046, 5460, 8251, 8994, 11674, 11947, 12414, 15884C, 16292)
W1	17600	9300	26300	W + (7864)
W2 (W2'3)	18900	11100	27000	W + (194)
N1	54200	41300	67500	N + (1719, 8251, 10238, 12501)
I	26300	16100	37000	N1 + 13780 + 250, 4529T, 10034, 10398, 15043, 15924, 16129, 16391)
N1b	21100	11800	30800	N + (152, 1598, 1703, 2639, 3921A, 4960, 5471, 8251, 8472, 8836, 12822, 16145, 16176G, 16390)
A	29200	19100	39800	N + (663, 1736, 4248, 4824, 8794, 16290, 16319)
Pre-A2 (A2'A6)	25300	16800	34200	A + (16362)
A2	13300	9000	17800	pA2 + (146, 153, 8027, 12007, 16111)
A5	20300	13000	27900	A + (8563, 11536)
A5a	7600	4800	10500	A5 + (4655, 11647, 16187)
A5b	13900	7400	20600	A5 + (961, 1709, 16126, 16235)
A5c	6200	700	11800	A5 + (152, 16129, 16213)
N9	49100	34200	64600	N + (5417)
Y	22300	11800	33300	N9 + (8392, 10398, 14178, 14693, 16126, 16223, 16231)
Y1	13200	4700	22100	Y + (3834, 16266)
Y2	5000	200	9900	Y + (482, 5147, 6941, 7859, 14914, 15244, 16311)
N9a	19700	12800	26900	N9 + (150, 5231, 12358, 12372, 16257A, 16261)
N9a1'3	16700	9300	24300	N9a + (16219)
N9a1	4700	-400	10000	N9a1'3 + (4386, 12007, 16111)
N9a3	8900	2900	15200	N9a1'3 + (4129, 12354, 12612)
N9a2'4'5	16700	9300	24300	N9a + (16172)
N9a2	10100	5200	15200	N9a2'4'5 + (861, 15067)
N9a4	6000	500	11800	N9a2'4'5 + (1664, 16145, 16245)
N9a5	7400	2000	13000	N9a2'4'5 + (3729, 15883, 16189, 16209)

N9b	29100	17200	41600	N9 + (10607, 11016, 13183, 14893, 16189)
N9b1'2'3	20500	13500	27700	N9b + (5147)
N9b1	16800	10400	23400	N9b1'2'3 +(12501)
N9b2	18400	11700	25400	N9b1'2'3 +(16294)
N9b3	8800	600	17500	N9b1'2'3 + (14996)
R (West Eurasia)	59100	47100	71400	N+ (12705, 16223)
R (South Asia)	66600	52600	81000	N+ (12705, 16223)
R (East Asia)	54300	41200	67800	N+ (12705, 16223)
R0	38800	23600	54900	pHV + (64, 2355, 2442, 3847, 13188, 15674, 16126, 16362)
R0a	13300	4700	22300	R + (73, 11719)
HV	27100	19600	34800	pHV + (14766)
HV1	17000	8500	25800	HV + (8014T, 15218, 16067)
HV0	19300	12400	26400	HV + (72, 16298)
HV0b	16600	7700	25900	VpV1 + (195)
HV0a	15600	10200	21100	VpV1 + (15904)
V	13600	9100	18200	PreV + (4580)
H	18600	14700	22600	HV + (2706, 7028)
H1	12200	9100	15400	H + (3010)
H2	11700	6500	17100	H + (1438, 4769)
H3	11800	8400	15400	H + (6776)
H4	12500	7300	17900	H + (3992, 5004, 9123)
H5	11500	6400	16800	H + (456, 16304)
H6	15300	10500	20300	H + (16482, 16362)
H7	15500	10300	21000	H + (4793)
H8	10600	5700	15700	H + (146, 195, 709, 13101C, 16362)
H13	17500	13300	21700	H + (14872)
H14	14500	9200	19900	H + (7645, 10217)

H15	14000	8300	20000	H + (55, 57, 6253)
U	54000	43100	65200	R + (11467, 12308, 12372)
U1	36900	25700	48600	U + (285, 12879, 13104, 14070, 15148, 15954C, 16249)
U1a	22200	13000	31800	U1 + (2218, 4991, 6026, 7581, 14364, 16189)
U5	36000	25300	47200	U + (3197, 9477, 13617, 16270)
U5a	26900	16100	38100	U5 + (14793, 16256)
U5a1	18200	9800	27100	U5a + (15218, 16399)
U5a2	22000	11500	33100	U5a + (16526)
U5b	27400	19400	35600	U5 + (150, 7768, 14182)
U5b1	24000	16400	31900	U5b + (5656)
U5b2	22400	14900	30200	U5b + (1721, 13637)
U5b3	4300	1200	7500	U5b + (373, 7226, 11177, 16169A, 16192, 16235)
U6	35900	26100	46000	U + (3348, 16172)
U6a'bd	33500	25000	42400	U6 + (16129)
U6a	27700	21600	34100	U6a'bd + (7805, 14179, 16278)
U6b'd	24400	12700	36700	U6a'bd + (16311)
U6b	13100	4200	22600	U6b'd + (9438)
U6d	14900	6700	23600	U6b'd + (4336, 12501, 14518)
U6c	11000	4400	17800	U6 + (150, 437, 793, 4965, 5081, 11013, 15244, 16169, 16189)
U2'3'4'7'8'9	53900	43300	64900	U + (1811)
U2	53500	40300	67200	U2'3'4'7'8'9 + (16051)
U2a	27500	13200	42800	U2+ (152, 16206C, 16230, 16311)
U2b	34300	22300	46900	U2 + (146, 2706, 5186T, 12106, 13194, 15049)
U2c	34800	22300	47900	U2 + (5790A, 14935, 15061, 16234)
U2e	16700	9900	23800	U2 + (152, 508, 3720, 5390, 5426, 6045, 6152, 10876, 13020, 13734, 15907, 16129C, 16189, 16362)
U3	40700	29200	52600	U2'3'4'7'8'9 + '150, 14139, 15454, 16343)
U3a	22900	12600	33600	U3 + (4073, 6518, 9266, 10506, 13934, 16390)
U3b	27000	16800	37500	U3 + (4188, 4640A, 9656, 13743)

U4'9	42500	29700	55800	U2'3'4'7'8'9 + (499, 5999)
U4	20900	11000	31200	U4'9 + (195, 4646, 6047, 11332, 14260, 15693, 16356)
U9	25500	13600	38100	U4'9 + (3531, 3834, 6386, 14094)
U7	21800	11500	32600	U2'3'4'7'8'9 + (152, 980, 3741, 5360, 8137, 10142, 13500, 16318T)
U8	50200	39600	61200	U2'3'4'7'8'9 + (9698)
U8a	24900	13600	36900	U8 + (282, 6392, 6455, 7055, 9365, 13145)
U8b'K	46000	35400	57000	U8 + (9055, 14167)
U8b	34900	23400	46800	U8b'k + (6546, 6599, 12771, 16189, 16234)
K	31400	22700	40400	U8b'k + (146, 3480, 10550, 11299, 14798, 16224, 16311)
K1	26700	19300	34300	K + (1189, 10398)
K1a	20500	14600	26700	K1 + (146, 497)
K1b	25000	17700	32500	K1 + (5913)
K1c	19500	10200	29300	K1 + (152)
K2	25700	16200	35600	K + (9716)
K2a	14100	7600	21000	K2a + (152, 709, 4561)
R1	13500	5700	21600	R + (295A, 1391, 3360, 4026, 4917, 5586, 5823, 6557, 6671, 7424, 7547, 8388, 10658, 10825, 13948, 14632, 15721, 16311)
R2'JT	54700	42600	67100	R + (4216, 16126)
JT	50300	38400	62500	R2'JT + (11251, 15452A)
J	32600	22400	43200	JT + (295, 489, 10398, 12612, 13708, 16069)
J1	24100	15800	32700	J + (462, 3010)
Pre-J1a	15500	8900	22300	J1 + (8269, 16145, 16222, 16261)
J1a	11800	6100	17600	P'J1a + (5460, 13879)
J1b	11300	6700	16000	J + (185, 228, 14798)
J1b1	7200	3000	11500	J1b + (482, 3394)
J2	23500	14000	33400	J + (150, 152, 7476, 15257)
J2b	10500	4100	17200	J2 + (5633, 10172, 16193, 16278)
T	26800	18100	35800	JT + (709, 1888, 4917, 8697, 10463, 13368, 14905, 15607, 15928, 16294)
T1	14700	8000	21700	T + (12633A, 16163, 16186, 16189)

T1a	7800	3300	12500	T1 + (152, 195, 9899)
Pre-T2	21800	14200	29600	T + (11812, 14233)
T2	18100	11800	24600	PreT2 + (16296)
T2b	8400	5300	11600	T2 + (930, 5147, 16304)
R5	37500	24400	51200	R + (8594, 10754, 14544, 16524)
R5a	19100	11200	27200	R5 + (152, 11293, 13635, 14040, 15385, 16356)
R6	51100	35900	66800	R + (195, 12285, 16274, 16362)
R7	35600	22100	49700	R + (1442, 6248, 9051, 9110, 10289, 13105, 13830, 16260, 16261, 16319, 16362)
R8	42100	26700	58300	R + (2755, 3384, 7759, 9449, 13215)
R8a	20200	9500	31600	R8 + (709, 5510, 5911, 9716, 13782, 15326)
R30	64000	49900	78600	R + (8584)
R31	64500	50100	79300	R + (15884)
B	50700	38100	63800	R + (8281 (9bpD), 16189)
B4	44200	32800	56000	B+ (16217)
B4a	25800	18100	33900	B4 + (5465, 9123, 16261)
B4a1	24200	18000	30700	B4a+ (10238)
B4a1a	10400	5500	15400	B4a1 + (146, 6719, 12239, 15746)
B4a1b	6200	1000	11500	B4a1 + (9932, 10915, 13143, 16288, 16311)
B4a1c	20000	13300	27100	B4a1 +(709)
B4a2	18300	10000	27000	B4a + (6620, 9812)
B4bd	39000	28300	50100	B4 + (827, 15535)
B4b	27700	18500	37200	B4bd + (499, 4820, 13590)
B4b1	27500	19800	35400	B4b + (16316)
B4b1a	24300	14500	34600	B4b1 + (16218)
Pre-B4b1b	21200	13400	29300	B4b1 + (207, 6023, 6413)
B4b1b	3900	1600	6200	Pre'B4b1b + (199, 202, 2831, 4117, 8206, 15236, 16284)
B2	14600	9300	20000	B4b + (3547, 4977, 6473, 9950, 11177)
B4d	28700	17600	40400	B4bd + (11914, 13942)

B4c	31600	21200	42300	B4 + (1119, 15346)
B4f	16200	8300	24500	B4 + (200, 1442, 4612, 5127, 6332, 7389, 11969, 13105, 16168, 16172, 16249, 16325, 16390)
B5	42200	30700	54100	B + (709, 8584, 9950, 10398, 16140)
B5a	26600	15500	38300	B5 + (210, 3537, 15235, 16266A)
B5a2	14500	6500	22900	B5a + (93, 9962, 11149, 11151, 14149)
B5b	25900	17800	34300	B5 + (204, 1598, 8829, 12361, 15223, 15508, 15662, 15851, 15927, 16243)
B5b1	22500	14300	30900	B5b + (103, 8784)
B5b2	17400	10600	24400	B5b + (4895, 15850, 16111, 16234, 16463)
R9	47200	35100	59800	R + (3970, 13928C, 16304)
Pre-R9b	38800	27100	51100	R9 + (1541)
R9b	21200	15700	26900	Pre'R9b + (12714, 16309, 16390)
F	43400	32200	55000	R9 + (6392, 10310)
F1	33500	23900	43400	F + (6962, 10609, 12406, 12882)
F1ac	28200	19000	37700	F1 + (9053, 13759, 16219)
F1a	22200	14200	30500	F1ac + (4086, 16172)
F1c	17300	8900	26000	F1ac + (152, 6599, 10454)
F1b	15900	8600	23500	F1 + (152, 10976, 12633, 14476, 16129, 16189, 16232A, 16249, 16311)
F1d	6800	300	13500	F1 + (146, 1734, 5628, 7738, 15402, 16189)
F2	17700	8400	27500	F + (1005, 1824, 7828, 10535, 10586, 12238, 13708)
F4	35800	24700	47400	F + (5263, 12630, 15670)
R11'B6	48400	33900	63600	R + (12950, 16189)
R11	21000	10500	32200	R11'B6 + (185, 189, 709, 8277, 10031, 10398, 11061, 13681, 16311)