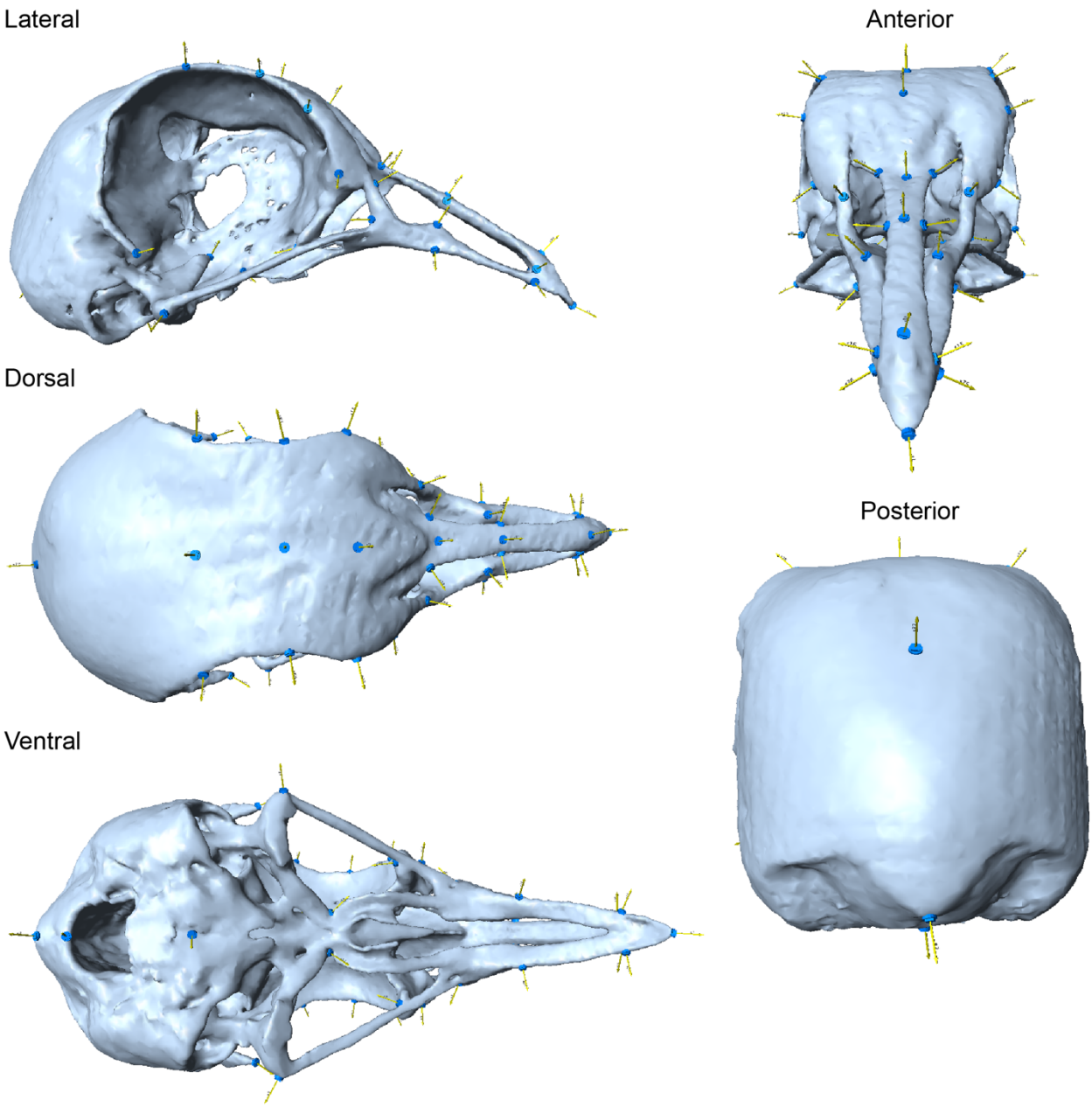
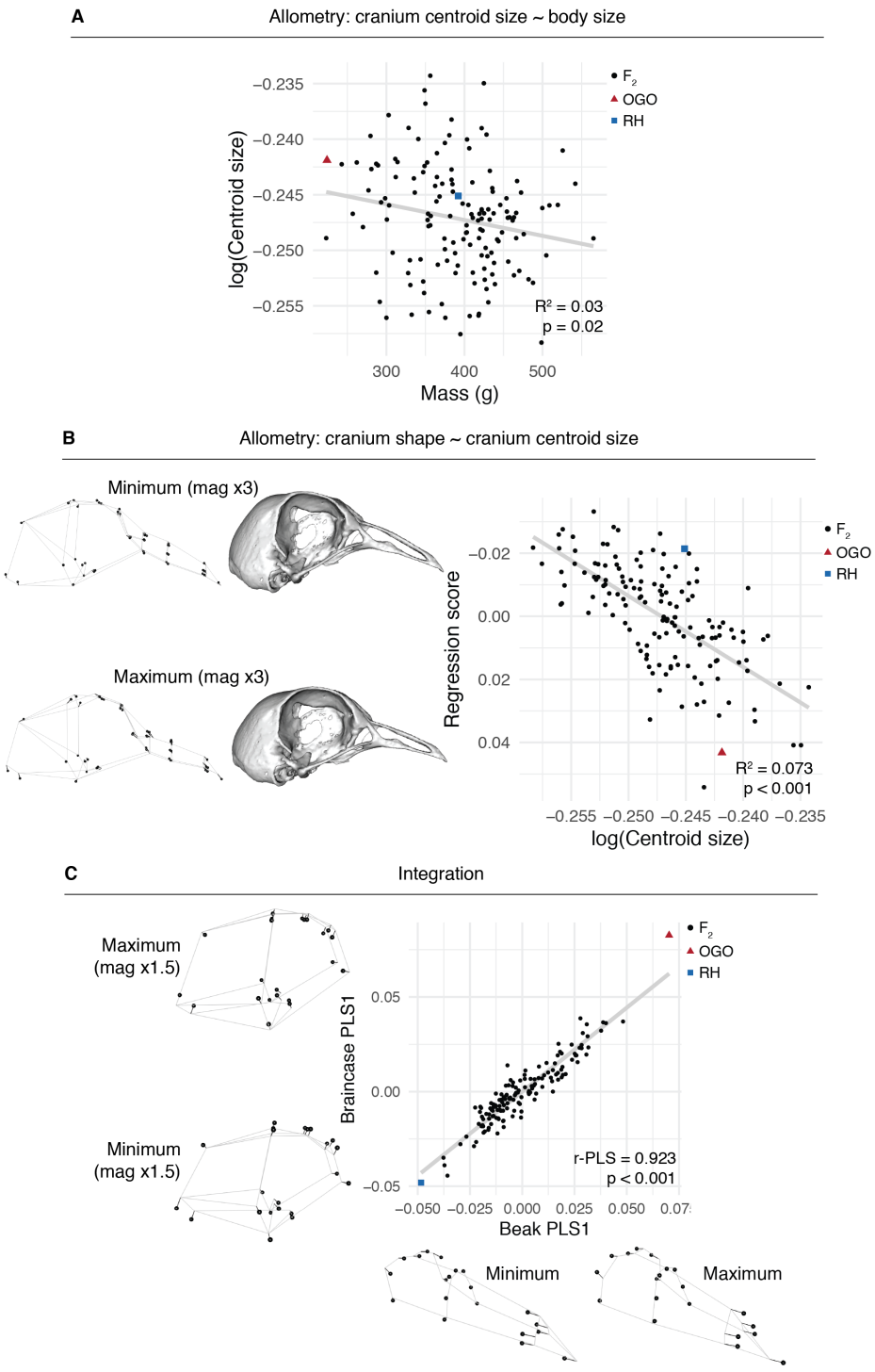
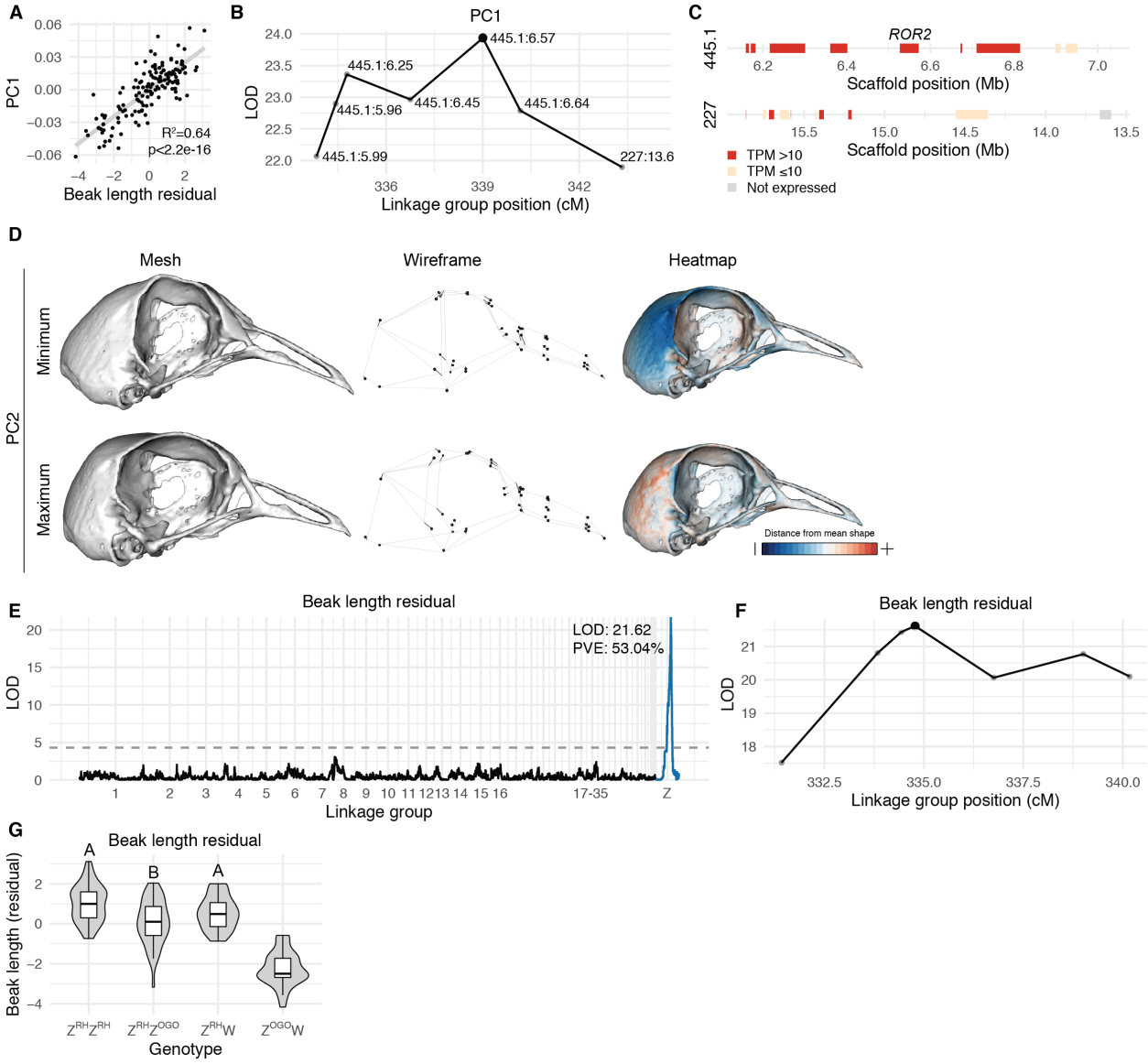


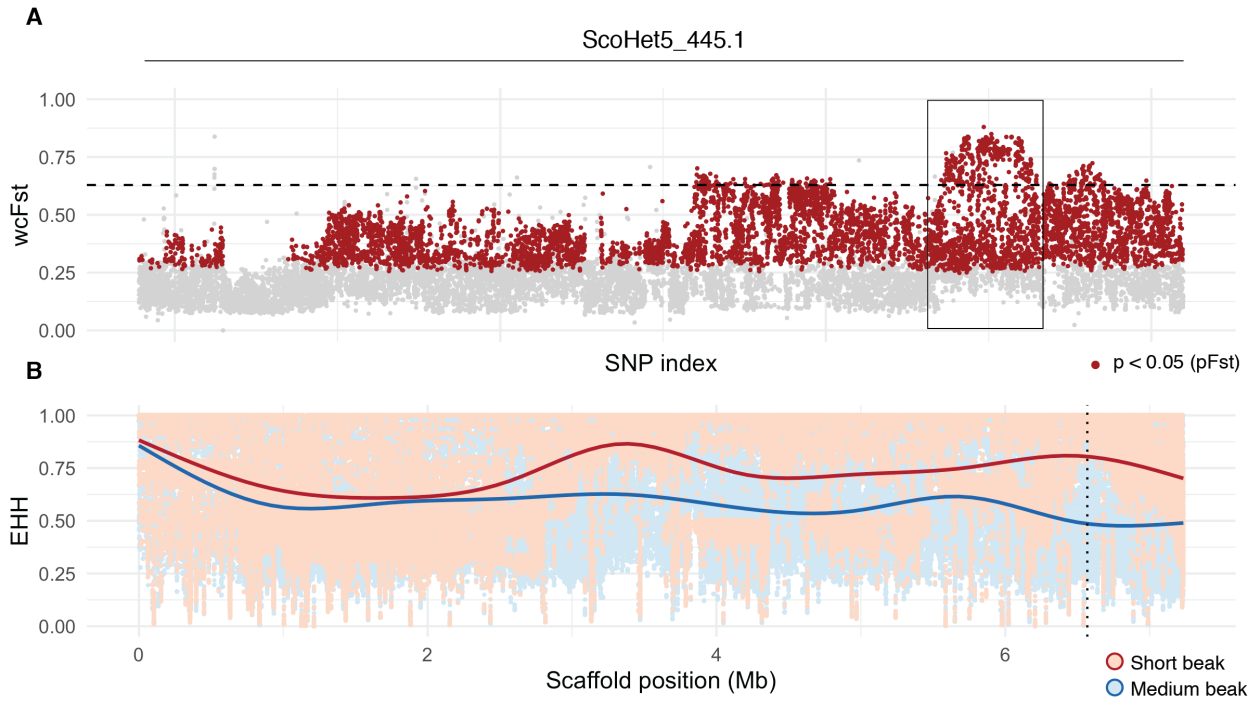
Figure S1. Pigeon craniofacial landmark atlas, related to Figures 1-2. Landmarks are indicated by blue discs.



Supplemental Figure 2. Allometry and integration in the RH x OGO cross, related to Figures 1-2. (A) Cranium centroid size ~ body size (mass) linear regression. (B) Cranium shape ~ centroid size linear regression. (B) Beak vs. braincase PLS1 shapes. Minimum and maximum shapes are depicted as wireframes and/or warped meshes along corresponding axis.



Supplemental Figure 3. Geometric morphometric and QTL analysis of craniofacial skeleton shape in RH x OGO cross, related to Figures 1-2. (A) Scatter plot of beak length residual vs. PC1 score for all RH x OGO F_2 individuals. (B) LOD support interval for PC1 QTL peak on Z. Markers in interval are denoted with dots and labeled with genomic scaffold name (ScoHet5_445.1 or ScoHet5_227) and position (in Mb); black dot indicates QTL peak marker (ScoHet5_445.1:6.57-Mb), which was used to estimate QTL effects. (C) Genes in PC1 QTL interval, color-coded by mRNA expression level in facial primordia derived from HH29 RH embryos. *ROR2* is located directly under QTL peak. (D) Minimum and maximum PC2 shapes depicted as warped mesh (left), wireframe showing landmark displacement (center), or heatmap indicating regional shape changes (right). For mesh and wireframe models, shape change is magnified 1.5x to aid visualization. (E) Genome-wide QTL scan for beak length using residuals from beak length ~ body mass linear regression. (F) LOD support interval is nearly identical to PC1 QTL interval (displayed in Figure 2D). Genes in interval on ScoHet5_445.1 are displayed at bottom and color-coded by expression level. (G) Plot of QTL effects, using peak marker highlighted by black dot in (F).



Supplemental Figure 4. Allele frequency differentiation (F_{ST}) and extended haplotype homozygosity (EHH) on scaffold ScoHet5_445.1 in short and medium/long beak pigeons, related to Figure 3. (A) F_{ST} on ScoHet5_445.1. Boxed region indicates ~293-kb peak region displayed in Figure 3D-E. (B) EHH on ScoHet5_445.1. Smoothed lines represent local regression fitting; dotted vertical line indicates position of ScoHet5_445.1:6568443.

Supplemental Table 1. Description of skull and jaw landmarks, related to Figures 1-2.

Landmark	Location	Side	Group	Type
1	Nasal	Midline	Beak	Midline
2	Premaxillary bone; distal tip	Midline	Beak	Midline
3	Supraoccipital bone	Midline	Skull	Midline
4	Jugal bone; lateral point	Left	Skull	Bilateral
5	Jugal bone; lateral point	Right	Skull	Bilateral
6	Junction of maxilla and nasal	Left	Beak	Bilateral
7	Junction of maxilla and nasal	Right	Beak	Bilateral
8	Lacrimal bone; inferior and lateral tip	Left	Skull	Bilateral
9	Lacrimal bone; inferior and lateral tip	Right	Skull	Bilateral
10	Lateral junction between lacrimal and frontal	Left	Skull	Bilateral
11	Lateral junction between lacrimal and frontal	Right	Skull	Bilateral
12	Lateralmost point of anterior orbital rim	Left	Skull	Bilateral
13	Lateralmost point of anterior orbital rim	Right	Skull	Bilateral
14	Quadrate bone; proximal tip	Left	Skull	Bilateral
15	Quadrate bone; proximal tip	Right	Skull	Bilateral
16	Junction of premaxillary and nasal distal	Left	Beak	Bilateral
17	Junction of premaxillary and nasal distal	Right	Beak	Bilateral
18	Dorsal process on premaxillary	Left	Beak	Bilateral
19	Dorsal process on premaxillary	Right	Beak	Bilateral
20	Distal tip of supraorbital process	Left	Skull	Bilateral
21	Distal tip of supraorbital process	Right	Skull	Bilateral
22	Edge of nasal bone where shape changes	Left	Beak	Bilateral
23	Edge of nasal bone where shape changes	Right	Beak	Bilateral
24	Eustachian opening and foramen	Midline	Skull	Midline
25	Dorsal surface of nasal bone	Right	Beak	Bilateral
26	Dorsal surface of nasal bone	Left	Beak	Bilateral
27	Lateralmost point of posterior orbital rim	Left	Skull	Bilateral
28	Lateralmost point of posterior orbital rim	Right	Skull	Bilateral
29	Basioccipital bone; most ventral/lateral point	Midline	Skull	Midline
30	Midline of frontal bone	Midline	Skull	Midline
31	Base of skull	Midline	Skull	Midline
32	Midline of nasal bone; distal to s0	Midline	Beak	Midline
33	Midline of premaxillary bone; dorsal tip	Midline	Beak	Midline
34	Midline of frontal bone	Midline	Skull	Midline
35	Caudal/dorsal tip of lateral process of mandible	Left	Mandible	Bilateral
36	Caudal/dorsal tip of lateral process of mandible	Right	Mandible	Bilateral
37	Caudal/ventral tip of lateral process of mandible	Left	Mandible	Bilateral
38	Caudal/ventral tip of lateral process of mandible	Right	Mandible	Bilateral
39	Medialmost tip of medial process of mandible	Left	Mandible	Bilateral
40	Medialmost tip of medial process of mandible	Right	Mandible	Bilateral
41	Ventralmost point of junction of dentary bones of mandible	Midline	Mandible	Midline
42	Distal tip of mandible	Midline	Mandible	Midline
43	Dorsalmost point of dentary bone of mandible	Left	Mandible	Bilateral
44	Dorsalmost point of dentary bone of mandible	Right	Mandible	Bilateral
45	Rostral boundary of crest on dentary bone of mandible	Left	Mandible	Bilateral
46	Rostral boundary of crest on dentary bone of mandible	Right	Mandible	Bilateral
47	Ventral edge of mandible; below s24	Right	Mandible	Bilateral
48	Ventral edge of mandible; below s25	Left	Mandible	Bilateral

49	Junction of palatine and pterygoid	Left	Skull	Bilateral
50	Junction of palatine and pterygoid	Right	Skull	Bilateral
51	Coronoid process of mandible	Left	Mandible	Bilateral
52	Coronoid process of mandible	Right	Mandible	Bilateral
53	Lateral edge of basioccipital	Left	Skull	Bilateral
54	Lateral edge of basioccipital	Right	Skull	Bilateral
55	Ventral point on mandible	Left	Mandible	Bilateral
56	Ventral point on mandible	Right	Mandible	Bilateral
57	Dorsal orbital rim	Left	Skull	Bilateral
58	Dorsal orbital rim	Right	Skull	Bilateral
59	Midline of frontal bone	Midline	Skull	Midline
60	Ventral point on mandible	Left	Mandible	Bilateral
61	Ventral point on mandible	Right	Mandible	Bilateral
62	Dorsal point on mandible	Left	Mandible	Bilateral
63	Dorsal point on mandible	Right	Mandible	Bilateral
64	Ventral point on maxilla	Left	Beak	Bilateral
65	Ventral point on maxilla	Right	Beak	Bilateral
66	Ventral point on premaxillary	Left	Beak	Bilateral
67	Ventral point on premaxillary	Right	Beak	Bilateral
68	Back of skull	Midline	Skull	Midline
69	Dorsal point on mandible	Left	Mandible	Bilateral
70	Dorsal point on mandible	Right	Mandible	Bilateral
71	Lateral edge of nasal bone	Right	Beak	Bilateral
72	Lateral edge of nasal bone	Left	Beak	Bilateral
73	Supraoccipital bone	Midline	Skull	Midline

Supplemental Table 2. Genes in the PC1 QTL interval, related to Figure 2.

gene_name	transcript_id	scaf	start	end	+/-	hh29_UB mean_TPM	log2FC	padj
HINT1	A306_00009604RA	ScoHet5_445.1	6159145	6166612	-	157.67	0.05	1.00
LYRM7	A306_00009605RB	ScoHet5_445.1	6171150	6182072	+	16.76	0.11	1.00
CDC42SE2	A306_00009606RA	ScoHet5_445.1	6216144	6300706	+	34.64	0.11	0.89
SPTLC1	A306_00009607RA	ScoHet5_445.1	6360869	6401521	+	28.17	-0.09	0.97
ROR2	A306_00009608RA	ScoHet5_445.1	6527151	6572089	+	77.00	-0.03	1.00
NFIL3	A306_00009609RA	ScoHet5_445.1	6672005	6675999	+	18.23	-0.10	1.00
AUH	A306_00009610RA	ScoHet5_445.1	6710427	6814414	+	11.79	0.08	1.00
TPPP2	A306_00009612RB	ScoHet5_445.1	6900579	6910482	+	0.31	NA	NA
SYK	A306_00009613RA	ScoHet5_445.1	6923332	6951239	-	0.76	0.04	1.00
DIRAS2	A306_00009614RA	ScoHet5_445.1	7030905	7031731	+	0.80	-0.37	1.00
GADD45G	A306_00008003RA	ScoHet5_227	15860157	15861535	+	11.85	-0.04	1.00
SEMA4D	A306_00008002RB	ScoHet5_227	15736305	15755614	-	8.08	-0.25	0.81
SECISBP2	A306_00008001RA	ScoHet5_227	15688753	15717766	+	47.91	-0.09	0.92
CKS2	A306_00008000RA	ScoHet5_227	15685310	15687317	+	73.55	0.02	1.00
SHC3	A306_00007999RA	ScoHet5_227	15592914	15649490	-	1.85	-0.55	0.74
S1PR3	A306_00007998RA	ScoHet5_227	15580626	15582285	+	177.86	-0.01	1.00
NXNL2	A306_00007997RA	ScoHet5_227	15421761	15429938	+	1.14	0.14	1.00
SPIN1	A306_00007996RA	ScoHet5_227	15377456	15406359	+	139.72	-0.04	1.00
HIATL1	A306_00007995RA	ScoHet5_227	15205161	15225885	-	12.98	-0.21	0.78
CNTNAP4	A306_00007994RA	ScoHet5_227	14358256	14557435	-	0.82	0.20	1.00
LRRC2	A306_00007993RA	ScoHet5_227	13594215	13664317	+	0.02	-0.40	NA