

Supplementary materials

Table S1: Full details of the genetic code organization (amino acid numbers 1–1274) in the S-protein gene of Table 2. The genome codes (1274 codes) were divided into seven classes (classes 1–6 had 200 codes each; class 7 had 74 codes).

Class 1: Amino acids 1–200

Amino acid No. 1-100	Codons	Codon No. • Amino acid	Plane No. in Figure 1	Amino acid No. 101-200	Codons	Codon No. • Amino acid	Plane No. in Figure 1
1	ATG	45M	3rd	101	ATA	29I	2nd
2	TTT	63F	4th	102	AGA	25R	2nd
3	GTT	62V	4th	103	GGC	10G	1st
4	TTT	63F	4th	104	TGG	43W	3rd
5	CTT	60L	4th	105	ATT	61I	4th
6	GTT	62V	4th	106	TTT	63F	4th
7	TTA	31L	2nd	107	GGT	58G	4th
8	TTG	47L	3rd	108	ACT	49T	4th
9	CCA	16P	2nd	109	ACT	49T	4th
10	CTA	28L	2nd	110	TTA	31L	2nd
11	GTC	14V	1st	111	GAT	54D	4th
12	TCT	51S	4th	112	TCG	35S	3rd
13	AGT	57S	4th	113	AAG	37K	3rd
14	CAG	36Q	3rd	114	ACC	1T	1st
15	TGT	59C	4th	115	CAG	36Q	3rd
16	GTT	62V	4th	116	TCC	3S	1st
17	AAT	53N	4th	117	CTA	28L	2nd
18	CTT	60L	4th	118	CTT	60L	4th
19	ACA	17T	2nd	119	ATT	61I	4th
20	ACC	1T	1st	120	GTT	62V	4th
21	AGA	25R	2nd	121	AAT	53N	4th
22	ACT	49T	4th	122	AAC	5N	1st
23	CAA	20Q	2nd	123	GCT	50A	4th
24	TTA	31L	2nd	124	ACT	49T	4th
25	CCC	0P	1st	125	AAT	53N	4th
26	CCT	48P	4th	126	GTT	62V	4th
27	GCA	18A	2nd	127	GTT	62V	4th
28	TAC	7Y	1st	128	ATT	61I	4th
29	ACT	49T	4th	129	AAA	21K	2nd
30	AAT	53N	4th	130	GTC	14V	1st
31	TCT	51S	4th	131	TGT	59C	4th

32	TTC	15F	1st	132	GAA	22E	2nd
33	ACA	17T	2nd	133	TTT	63F	4th
34	CGT	56R	4th	134	CAA	20Q	2nd
35	GGT	58G	4th	135	TTT	63F	4th
36	GTT	62V	4th	136	TGT	59C	4th
37	TAT	55Y	4th	137	AAT	53N	4th
38	TAC	7Y	1st	138	GAT	54D	4th
39	CCT	48P	4th	139	CCA	16P	2nd
40	GAC	6D	1st	140	TTT	63F	4th
41	AAA	21K	2nd	141	TTG	47L	3rd
42	GTT	62V	4th	142	GGT	58G	4th
43	TTC	15F	1st	143	GTT	62V	4th
44	AGA	25R	2nd	144	TAT	55Y	4th
45	TCC	3S	1st	145	TAC	7Y	1st
46	TCA	19S	2nd	146	CAC	4H	1st
47	GTT	62V	4th	147	AAA	21K	2nd
48	TTA	31L	2nd	148	AAC	5N	1st
49	CAT	52H	4th	149	AAC	5N	1st
50	TCA	19S	2nd	150	AAA	21K	2nd
51	ACT	49T	4th	151	AGT	57S	4th
52	CAG	36Q	3rd	152	TGG	43W	3rd
53	GAC	6D	1st	153	ATG	45M	3rd
54	TTG	47L	3rd	154	GAA	22E	2nd
55	TTC	15F	1st	155	AGT	57S	4th
56	TTA	31L	2nd	156	GAG	38E	3rd
57	CCT	48P	4th	157	TTC	15F	1st
58	TTC	15F	1st	158	AGA	25R	2nd
59	TTT	63F	4th	159	GTT	62V	4th
60	TCC	3S	1st	160	TAT	55Y	4th
61	AAT	53N	4th	161	TCT	51S	4th
62	GTT	62V	4th	162	AGT	57S	4th
63	ACT	49T	4th	163	GCG	34A	3rd
64	TGG	43W	3rd	164	AAT	53N	4th
65	TTC	15F	1st	165	AAT	53N	4th
66	CAT	52H	4th	166	TGC	11C	1st
67	GCT	50A	4th	167	ACT	49T	4th
68	ATA	29 I	2nd	168	TTT	63F	4th
69	CAT	52H	4th	169	GAA	22E	2nd
70	GTC	14V	1st	170	TAT	55Y	4th
71	TCT	51S	4th	171	GTC	14V	1st
72	GGG	42G	3rd	172	TCT	51S	4th
73	ACC	1T	1st	173	CAG	36Q	3rd

74	AAT	53N	4th	174	CCT	48P	4th
75	GGT	58G	4th	175	TTT	63F	4th
76	ACT	49T	4th	176	CTT	60L	4th
77	AAG	37K	3rd	177	ATG	45M	3rd
78	AGG	41R	3rd	178	GAC	6D	1st
79	TTT	63F	4th	179	CTT	60L	4th
80	GAT	54D	4th	180	GAA	22E	2nd
81	AAC	5N	1st	181	GGA	26G	2nd
82	CCT	48P	4th	182	AAA	21K	2nd
83	GTC	14V	1st	183	CAG	36Q	3rd
84	CTA	28L	2nd	184	GGT	58G	4th
85	CCA	16P	2nd	185	AAT	53N	4th
86	TTT	63F	4th	186	TTC	15F	1st
87	AAT	53N	4th	187	AAA	21K	2nd
88	GAT	54D	4th	188	AAT	53N	4th
89	GGT	58G	4th	189	CTT	60L	4th
90	GTT	62V	4th	190	AGG	41R	3rd
91	TAT	55Y	4th	191	GAA	22E	2nd
92	TTT	63F	4th	192	TTT	63F	4th
93	GCT	50A	4th	193	GTG	46V	3rd
94	TCC	3S	1st	194	TTT	63F	4th
95	ACT	49T	4th	195	AAG	37K	3rd
96	GAG	38E	3rd	196	AAT	53N	4th
97	AAG	37K	3rd	197	ATT	61I	4th
98	TCT	51S	4th	198	GAT	54D	4th
99	AAC	5N	1st	199	GGT	58G	4th
100	ATA	29I	2nd	200	TAT	55Y	4th

Class 2: Amino acids 201–400

Amino acid No. 201-300	Codons	Codon No. • Amino acid	Plane No. in Figure 1	Amino acid No. 301-400	Codons	Codon No. • Amino acid	Plane No. in Figure 1
201	TTT	63F	4th	301	TGT	59C	4th
202	AAA	21K	2nd	302	ACG	33T	3rd
203	ATA	29I	2nd	303	TTG	47L	3rd
204	TAT	55Y	4th	304	AAA	21K	2nd
205	TCT	51S	4th	305	TCC	3S	1st
206	AAG	37K	3rd	306	TTC	15F	1st
207	CAC	4H	1st	307	ACT	49T	4th
208	ACG	33T	3rd	308	GTA	30V	2nd

209	CCT	48P	4th	309	GAA	22E	2nd
210	ATT	61I	4th	310	AAA	21K	2nd
211	AAT	53N	4th	311	GGA	26G	2nd
212	TTA	31L	2nd	312	ATC	13I	1st
213	GTG	46V	4th	313	TAT	55Y	4th
214	CGT	56R	4th	314	CAA	20Q	2nd
215	GAT	54D	4th	315	ACT	49T	4th
216	CTC	12L	1st	316	TCT	51S	4th
217	CCT	48P	4th	317	AAC	5N	1st
218	CAG	36Q	3rd	318	TTT	63F	4th
219	GGT	58G	4th	319	AGA	25R	2nd
220	TTT	63F	4th	320	GTC	14V	1st
221	TCG	35S	3rd	321	CAA	20Q	2nd
222	GCT	50A	4th	322	CCA	16P	2nd
223	TTA	31L	2nd	323	ACA	17T	2nd
224	GAA	22E	2nd	324	GAA	22E	2nd
225	CCA	16P	2nd	325	TCT	51S	4th
226	TTG	47L	3rd	326	ATT	61I	4th
227	GTA	30V	2nd	327	GTT	62V	4th
228	GAT	54D	4th	328	AGA	25R	2nd
229	TTG	47L	3rd	329	TTT	63F	4th
230	CCA	16P	2nd	330	CCT	48P	4th
231	ATA	29I	2nd	331	AAT	53N	4th
232	GGT	58G	4th	332	ATT	61I	4th
233	ATT	61I	4th	333	ACA	17T	2nd
234	AAC	5N	1st	334	AAC	5N	1st
235	ATC	13I	1st	335	TTG	47L	4th
236	ACT	49T	4th	336	TGC	11C	1st
237	AGG	41R	3rd	337	CCT	48P	4th
238	TTT	63F	4th	338	TTT	63F	4th
239	CAA	20Q	2nd	339	GGT	58G	4th
240	ACT	49T	4th	340	GAA	22E	2nd
241	TTA	31L	2nd	341	GTT	62V	4th
242	CTT	60L	4th	342	TTT	63F	4th
243	GCT	50A	4th	343	AAC	5N	1st
244	TTA	31L	2nd	344	GCC	2A	1st
245	CAT	52H	4th	345	ACC	1T	1st
246	AGA	25R	2nd	346	AGA	25R	2nd
247	AGT	57S	4th	347	TTT	63F	4th
248	TAT	55Y	4th	348	GCA	18A	2nd
249	TTG	47L	3rd	349	TCT	51S	4th
250	ACT	49T	4th	350	GTT	62V	4th

251	CCT	48P	4th	351	TAT	55Y	4th
252	GGT	58G	4th	352	GCT	50A	4th
253	GAT	54D	4th	353	TGG	43W	3rd
254	TCT	51S	4th	354	AAC	5N	1st
255	TCT	51S	4th	355	AGG	41R	3rd
256	TCA	19S	2nd	356	AAG	37K	3rd
257	GGT	58G	4th	357	AGA	25R	2nd
258	TGG	43W	3rd	358	ATC	13I	1st
259	ACA	17T	2nd	359	AGC	9S	1st
260	GCT	50A	4th	360	AAC	5N	1st
261	GGT	58G	4th	361	TGT	59C	4th
262	GCT	50A	4th	362	GTT	62V	4th
263	GCA	18A	2nd	363	GCT	50A	4th
264	GCT	50A	4th	364	GAT	54D	4th
265	TAT	55Y	4th	365	TAT	55Y	4th
266	TAT	55Y	4th	366	TCT	51S	4th
267	GTG	46V	3rd	367	GTC	14V	1st
268	GGT	58G	4th	368	CTA	28L	2nd
269	TAT	55Y	4th	369	TAT	55Y	4th
270	CTT	60L	4th	370	AAT	53N	4th
271	CAA	20Q	2nd	371	TCC	3S	1st
272	CTT	48P	4th	372	GCA	18A	2nd
273	AGG	41R	3rd	373	TCA	19S	2nd
274	ACT	49T	4th	374	TTT	63F	4th
275	TTT	63F	4th	375	TCC	3S	1st
276	CTA	28L	2nd	376	ACT	49T	4th
277	TTA	31L	2nd	377	TTT	63F	4th
278	AAA	21K	2nd	378	AAG	37K	3rd
279	TAT	55Y	4th	379	TGT	59C	4th
280	AAT	53N	4th	380	TAT	55Y	4th
281	GAA	22E	2nd	381	GGA	26G	2nd
282	AAT	53N	4th	382	GTG	46V	3rd
283	GGA	26G	2nd	383	TCT	51S	4th
284	ACC	1T	1st	384	CCT	48P	4th
285	ATT	61I	4th	385	ACT	49T	4th
286	ACA	17T	2nd	386	AAA	21K	2nd
287	GAT	54D	4th	387	TTA	31L	2nd
288	GCT	50A	4th	388	AAT	53N	4th
289	GTA	30V	2nd	389	GAT	54D	4th
290	GAC	6D	1st	390	CTC	12L	1st
291	TGT	59C	4th	391	TGC	11C	1st
292	GCA	18A	2nd	392	TTT	63F	4th

293	CTT	60L	4th	393	ACT	49T	4th
294	GAC	6D	1st	394	AAT	53N	4th
295	CCT	48P	4th	395	GTC	14V	1st
296	CTC	12L	1st	396	TAT	55Y	4th
297	TCA	19S	2nd	397	GCA	18A	2nd
298	GAA	22E	2nd	398	GAT	54D	4th
299	ACA	17T	2nd	399	TCA	19S	2nd
300	AAG	37K	3rd	400	TTT	63F	4th

Class 3: Amino acids 401–600

Amino acid No. 401-500	Codons	Codon No. • Amino acid	Plane No. in Figure 1	Amino acid No. 501-600	Codons	Codon No. • Amino acid	Plane No. in Figure 1
401	GTA	30V	3rd	501	AAT	53N	4th
402	ATT	61I	4th	502	GGT	58G	4th
403	AGA	25R	2nd	503	GTT	62V	4th
404	GGT	58G	4th	504	GGT	58G	4th
405	GAT	54D	4th	505	TAC	7Y	1st
406	GAA	22E	2nd	506	CAA	20Q	2nd
407	GTC	14V	1st	507	CCA	16P	2nd
408	AGA	25R	2nd	508	TAC	7Y	1st
409	CAA	20Q	2nd	509	AGA	25R	2nd
410	ATC	13I	1st	510	GTA	30V	2nd
411	GCT	50A	4th	511	GTA	30V	2nd
412	CCA	16P	2nd	512	GTA	30V	2nd
413	GGG	42G	3rd	513	CTT	60L	4th
414	CAA	20Q	2nd	514	TCT	51S	4th
415	ACT	49T	4th	515	TTT	63F	4th
416	GGA	26G	2nd	516	GAA	22E	2nd
417	AAG	37K	3rd	517	CTT	60L	4th
418	ATT	61I	4th	518	CTA	28L	2nd
419	GCT	50A	4th	519	CAT	52H	4th
420	GAT	54D	4th	520	GCA	18A	2nd
421	TAT	55Y	4th	521	CCA	16P	2nd
422	AAT	53N	4th	522	GCA	18A	2nd
423	TAT	55Y	4th	523	ACT	49T	4th
424	AAA	21K	2nd	524	GTT	62V	4th
425	TTA	31L	2nd	525	TGT	59C	4th
426	CCA	16P	2nd	526	GGA	26G	2nd
427	GAT	54D	4th	527	CCT	48P	4th

428	GAT	54D	4th	528	AAA	21K	2nd
429	TTT	63F	4th	529	AAG	37K	3rd
430	ACA	17T	2nd	530	TCT	51S	4th
431	GGC	10G	1st	531	ACT	49T	4th
432	TGC	11C	1st	532	AAT	53N	4th
433	GTT	62V	4th	533	TTG	47L	3rd
434	ATA	29I	2nd	534	GTT	62V	4th
435	GCT	50A	4th	535	AAA	21K	2nd
436	TGG	43W	3rd	536	AAC	5N	1st
437	AAT	53N	4th	537	AAA	21K	2nd
438	TCT	51S	4th	538	TGT	59C	4th
439	AAC	5N	1st	539	GTC	14V	1st
440	AAT	53N	4th	540	AAT	53N	4th
441	CTT	60L	4th	541	TTC	15F	1st
442	GAT	54D	4th	542	AAC	5N	1st
443	TCT	51S	4th	543	TTC	15F	1st
444	AAG	37K	3rd	544	AAT	53N	4th
445	GTT	62V	4th	545	GGT	58G	4th
446	GGT	58G	4th	546	TTA	31L	2nd
447	GGT	58G	4th	547	ACA	17T	2nd
448	AAT	53N	4th	548	GGC	10G	1st
449	TAT	55Y	4th	549	ACA	17T	2nd
450	AAT	53N	4th	550	GGT	58G	4th
451	TAC	7Y	1st	551	GTT	62V	4th
452	CTG	44L	3rd	552	CTT	60L	4th
453	TAT	55Y	4th	553	ACT	49T	4th
454	AGA	25R	2nd	554	GAG	38E	3rd
455	TTG	47L	3rd	555	TCT	51S	4th
456	TTT	63F	4th	556	AAC	5N	1st
457	AGG	41R	3rd	557	AAA	21K	2nd
458	AAG	37K	3rd	558	AAG	37K	3rd
459	TCT	51S	4th	559	TTT	63F	4th
460	AAT	53N	4th	560	CTG	44L	3rd
461	CTC	12L	1st	561	CCT	48P	4th
462	AAA	21K	2nd	562	TTC	15F	1st
463	CCT	48P	4th	563	CAA	20Q	2nd
464	TTT	63F	4th	564	CAA	20Q	2nd
465	GAG	38E	3rd	565	TTT	63F	4th
466	AGA	25R	2nd	566	GGC	10G	1st
467	GAT	54D	4th	567	AGA	25R	2nd
468	ATT	61I	4th	568	GAC	6D	1st
469	TCA	19S	2nd	569	ATT	61I	4th

470	ACT	49T	4th	570	GCT	50A	4th
471	GAA	22E	2nd	571	GAC	6D	1st
472	ATC	13I	1st	572	ACT	49T	4th
473	TAT	55Y	4th	573	ACT	49T	4th
474	CAG	36Q	3rd	574	GAT	54D	4th
475	GCC	2A	1st	575	GCT	50A	4th
476	GGT	58G	4th	576	GTC	14V	1st
477	AGC	9S	1st	577	CGT	56R	4th
478	ACA	17T	2nd	578	GAT	54D	4th
479	CCT	48P	4th	579	CCA	16P	2nd
480	TGT	59C	4th	580	CAG	36Q	3rd
481	AAT	53N	4th	581	ACA	17T	2nd
482	GGT	58G	4th	582	CTT	60L	4th
483	GTT	62V	4th	583	GAG	38E	3rd
484	GAA	22E	2nd	584	ATT	61I	4th
485	GGT	58G	4th	585	CTT	60L	4th
486	TTT	63F	4th	586	GAC	6D	1st
487	AAT	53N	4th	587	ATT	61I	4th
488	TGT	59C	4th	588	ACA	17T	2nd
489	TAC	7Y	1st	589	CCA	16P	2nd
490	TTT	63F	4th	590	TGT	59C	4th
491	CCT	48P	4th	591	TCT	51S	4th
492	TTA	31L	2nd	592	TTT	63F	4th
493	CAA	20Q	2nd	593	GGT	58G	4th
494	TCA	19S	2nd	594	GGT	58G	4th
495	TAT	55Y	4th	595	GTC	14V	1st
496	GGT	58G	4th	596	AGT	57S	4th
497	TTC	15F	1st	597	GTT	62V	4th
498	CAA	20Q	2nd	598	ATA	29I	2nd
499	CCC	0P	1st	599	ACA	17T	2nd
500	ACT	49T	4th	600	CCA	16P	2nd

Class 4: Amino acids 601–800

Amino acid No. 601-700	Codons	Codon No. • Amino acid	Plane No. in Figure 1	Amino acid No. 701-800	Codons	Codon No. • Amino acid	Plane No. in Figure 1
601	GGA	26G	2nd	701	GCA	18A	2nd
602	ACA	17T	2nd	702	GAA	22E	2nd
603	AAT	53N	4th	703	AAT	53N	4th
604	ACT	49T	4th	704	TCA	19S	2nd

605	TCT	51S	4th	705	GTT	62V	4th
606	AAC	5N	1st	706	GCT	50A	4th
607	CAG	36Q	3rd	707	TAC	7Y	1st
608	GTT	62V	4th	708	TCT	51S	4th
609	GCT	50A	4th	709	AAT	53N	4th
610	GTT	62V	4th	710	AAC	5N	1st
611	CTT	60L	4th	711	TCT	51S	4th
612	TAT	55Y	4th	712	ATT	61I	4th
613	CAG	36Q	3rd	713	GCC	2A	1st
614	GAT	54D	4th	714	ATA	29I	2nd
615	GTT	62V	4th	715	CCC	0P	1st
616	AAC	5N	1st	716	ACA	17T	2nd
617	TGC	11C	1st	717	AAT	53N	4th
618	ACA	17T	2nd	718	TTT	63F	4th
619	GAA	22E	2nd	719	ACT	49T	4th
620	GTC	14V	1st	720	ATT	61I	4th
621	CCT	48P	4th	721	AGT	57S	4th
622	GTT	62V	4th	722	GTT	62V	4th
623	GCT	50A	4th	723	ACC	1T	1st
624	ATT	61I	4th	724	ACA	17T	2nd
625	CAT	52H	4th	725	GAA	22E	2nd
626	GCA	18A	2nd	726	ATT	61I	4th
627	GAT	54D	4th	727	CTA	28L	2nd
628	CAA	20Q	2nd	728	CCA	16P	2nd
629	CTT	60L	4th	729	GTG	46V	3rd
630	ACT	49T	4th	730	TCT	51S	4th
631	CCT	48P	4th	731	ATG	45M	3rd
632	ACT	49T	4th	732	ACC	1T	1st
633	TGG	43W	3rd	733	AAG	37K	3rd
634	CGT	56R	4th	734	ACA	17T	2nd
635	GTT	62V	4th	735	TCA	19S	2nd
636	TAT	55Y	4th	736	GTA	30V	2nd
637	TCT	51S	4th	737	GAT	54D	4th
638	ACA	17T	2nd	738	TGT	59C	4th
639	GGT	58G	4th	739	ACA	17T	2nd
640	TCT	51S	4th	740	ATG	45M	3rd
641	AAT	53N	4th	741	TAC	7Y	1st
642	GTT	62V	4th	742	ATT	61I	4th
643	TTT	63F	4th	743	TGT	59C	4th
644	CAA	20Q	2nd	744	GGT	58G	4th
645	ACA	17T	2nd	745	GAT	54D	4th
646	CGT	56R	4th	746	TCA	19S	2nd

647	GCA	18A	2nd	747	ACT	49T	4th
648	GGC	10G	1st	748	GAA	22E	2nd
649	TGT	59C	4th	749	TGC	11C	1st
650	TTA	31L	2nd	750	AGC	9S	1st
651	ATA	29I	2nd	751	AAT	53N	4th
652	GGG	42G	3rd	752	CTT	60L	4th
653	GCT	50A	4th	753	TTG	47L	3rd
654	GAA	22E	2nd	754	TTG	47L	3rd
655	CAT	52H	4th	755	CAA	20Q	2nd
656	GTC	14V	1st	756	TAT	55Y	4th
657	AAC	5N	1st	757	GGC	10G	1st
658	AAC	5N	1st	758	AGT	57S	4th
659	TCA	19S	2nd	759	TTT	63F	4th
660	TAT	55Y	4th	760	TGT	59C	4th
661	GAG	38E	3rd	761	ACA	17T	2nd
662	TGT	59C	4th	762	CAA	20Q	2nd
663	GAC	6D	1st	763	TTA	31L	2nd
664	ATA	29I	2nd	764	AAC	5N	1st
665	CCC	0P	1st	765	CGT	56R	4th
666	ATT	61I	4th	766	GCT	50A	4th
667	GGT	58G	4th	767	TTA	31L	2nd
668	GCA	18A	2nd	768	ACT	49T	4th
669	GGT	58G	4th	769	GGA	26G	2nd
670	ATA	29I	2nd	770	ATA	29I	2nd
671	TGC	11C	1st	771	GCT	50A	4th
672	GCT	50A	4th	772	GTT	62V	4th
673	AGT	57S	4th	773	GAA	22E	2nd
674	TAT	55Y	4th	774	CAA	20Q	2nd
675	CAG	36Q	3rd	775	GAC	6D	1st
676	ACT	49T	4th	776	AAA	21K	2nd
677	CAG	36Q	3rd	777	AAC	5N	1st
678	ACT	49T	4th	778	ACC	1T	1st
679	AAT	53N	4th	779	CAA	20Q	2nd
680	TCT	51S	4th	780	GAA	22E	2nd
681	CCT	48P	4th	781	GTT	62V	4th
682	CGG	40R	3rd	782	TTT	63F	4th
683	CGG	40R	3rd	783	GCA	18A	2nd
684	GCA	18A	2nd	784	CAA	20Q	2nd
685	CGT	56R	4th	785	GTC	14V	1st
686	AGT	57S	4th	786	AAA	21K	2nd
687	GTA	30V	2nd	787	CAA	20Q	2nd
688	GCT	50A	4th	788	ATT	61I	4th

689	AGT	57S	4th	789	TAC	7Y	1st
690	CAA	20Q	2nd	790	AAA	21K	2nd
691	TCC	3S	1st	791	ACA	17T	2nd
692	ATC	13I	1st	792	CCA	16P	2nd
693	ATT	61I	4th	793	CCA	16P	2nd
694	GCC	2A	1st	794	ATT	61I	4th
695	TAC	7Y	1st	795	AAA	21K	2nd
696	ACT	49T	4th	796	GAT	54D	4th
697	ATG	45M	3rd	797	TTT	63F	4th
698	TCA	19S	2nd	798	GGT	58G	4th
699	CTT	60L	4th	799	GGT	58G	4th
700	GGT	58G	4th	800	TTT	63F	4th

Class 5: Amino acids 801–1000

Amino acid No. 801-900	Codons	Codon No. • Amino acid	Plane No. in Figure 1	Amino acid No. 901-1000	Codons	Codon No. • Amino acid	Plane No. in Figure 1
801	AAT	53N	4th	901	CAA	20Q	2nd
802	TTT	63F	4th	902	ATG	45M	3rd
803	TCA	19S	2nd	903	GCT	50A	4th
804	CAA	20Q	2nd	904	TAT	55Y	4th
805	ATA	29I	2nd	905	AGG	41R	3rd
806	TTA	31L	2nd	906	TTT	63F	4th
807	CCA	16P	2nd	907	AAT	53N	4th
808	GAT	54D	4th	908	GGT	58G	4th
809	CCA	16P	2nd	909	ATT	61I	4th
810	TCA	19S	2nd	910	GGA	26G	2nd
811	AAA	21K	2nd	911	GTT	62V	4th
812	CCA	16P	2nd	912	ACA	17T	2nd
813	AGC	9S	1st	913	CAG	36Q	3rd
814	AAG	37K	3rd	914	AAT	53N	4th
815	AGG	41R	3rd	915	GTT	62V	4th
816	TCA	19S	2nd	916	CTC	12L	1st
817	TTT	63F	4th	917	TAT	55Y	4th
818	ATT	61I	4th	918	GAG	38E	3rd
819	GAA	22E	2nd	919	AAC	5N	1st
820	GAT	54D	4th	920	CAA	20Q	2nd
821	CTA	28L	2nd	921	AAA	21K	2nd
822	CTT	60L	4th	922	TTG	47L	3rd
823	TTC	15F	1st	923	ATT	61I	4th

824	AAC	5N	1st	924	GCC	2A	1st
825	AAA	21K	2nd	925	AAC	5N	1st
826	GTG	46V	3rd	926	CAA	20Q	2nd
827	ACA	17T	2nd	927	TTT	63F	4th
828	CTT	60L	4th	928	AAT	53N	4th
829	GCA	18A	2nd	929	AGT	57S	4th
830	GAT	54D	4th	930	GCT	50A	4th
831	GCT	50A	4th	931	ATT	61I	4th
832	GGC	10G	1st	932	GGC	10G	1st
833	TTC	15F	1st	933	AAA	21K	2nd
834	ATC	13I	1st	934	ATT	61I	4th
835	AAA	21K	2nd	935	CAA	20Q	2nd
836	CAA	20Q	2nd	936	GAC	6D	1st
837	TAT	55Y	4th	937	TCA	19S	2nd
838	GGT	58G	4th	938	CTT	60L	4th
839	GAT	54D	4th	939	TCT	51S	4th
840	TGC	11C	1st	940	TCC	3S	1st
841	CTT	60L	4th	941	ACA	17T	2nd
842	GGT	58G	4th	942	GCA	18A	2nd
843	GAT	54D	4th	943	AGT	57S	4th
844	ATT	61I	4th	944	GCA	18A	2nd
845	GCT	50A	4th	945	CTT	60L	4th
846	GCT	50A	4th	946	GGA	26G	2nd
847	AGA	25R	2nd	947	AAA	21K	2nd
848	GAC	6D	1st	948	CTT	60L	4th
849	CTC	12L	1st	949	CAA	20Q	2nd
850	ATT	61I	4th	950	GAT	54D	4th
851	TGT	59C	4th	951	GTG	46V	3rd
852	GCA	18A	2nd	952	GTC	14V	1st
853	CAA	20Q	2nd	953	AAC	5N	1st
854	AAG	37K	3rd	954	CAA	20Q	2nd
855	TTT	63F	4th	955	AAT	53N	4th
856	AAC	5N	1st	956	GCA	18A	2nd
857	GGC	10G	1st	957	CAA	20Q	2nd
858	CTT	60L	4th	958	GCT	50A	4th
859	ACT	49T	4th	959	TTA	31L	2nd
860	GTT	62V	4th	960	AAC	5N	1st
861	TTG	47L	3rd	961	ACG	33T	3rd
862	CCA	16P	2nd	962	CTT	60L	4th
863	CCT	48P	4th	963	GTT	62V	4th
864	TTG	47L	3rd	964	AAA	21K	2nd
865	CTC	12L	1st	965	CAA	20Q	2nd

866	ACA	17T	2nd	966	CTT	60L	4th
867	GAT	54D	4th	967	AGC	9S	1st
868	GAA	22E	2nd	968	TCC	3S	1st
869	ATG	45M	3rd	969	AAT	53N	4th
870	ATT	61I	4th	970	TTT	63F	4th
871	GCT	50A	4th	971	GGT	58G	4th
872	CAA	20Q	2nd	972	GCA	18A	2nd
873	TAC	7Y	1st	973	ATT	61I	4th
874	ACT	49T	4th	974	TCA	19S	2nd
875	TCT	51S	4th	975	AGT	57S	4th
876	GCA	18A	2nd	976	GTT	62V	4th
877	CTG	44L	3rd	977	TTA	31L	2nd
878	TTA	31L	2nd	978	AAT	53N	4th
879	GCG	34A	3rd	979	GAT	54D	4th
880	GGT	58G	4th	980	ATC	13I	1st
881	ACA	17T	2nd	981	CTT	60L	4th
882	ATC	13I	1st	982	TCA	19S	2nd
883	ACT	49T	4th	983	CGT	56R	4th
884	TCT	51S	4th	984	CTT	60L	4th
885	GGT	58G	4th	985	GAC	6D	1st
886	TGG	43W	3rd	986	AAA	21K	2nd
887	ACC	1T	1st	987	GTT	62V	4th
888	TTT	63F	4th	988	GAG	38E	3rd
889	GGT	58G	4th	989	GCT	50A	4th
890	GCA	18A	2nd	990	GAA	22E	2nd
891	GGT	58G	4th	991	GTG	46V	3rd
892	GCT	50A	4th	992	CAA	20Q	2nd
893	GCA	18A	2nd	993	ATT	61I	4th
894	TTA	31L	2nd	994	GAT	54D	4th
895	CAA	20Q	2nd	995	AGG	41R	3rd
896	ATA	29I	2nd	996	TTG	47L	3rd
897	CCA	16P	2nd	997	ATC	13I	1st
898	TTT	63F	4th	998	ACA	17T	2nd
899	GCT	50A	4th	999	GGC	10G	1st
900	ATG	45M	3rd	1000	AGA	25R	2nd

Class 6: Amino acids 1001–1200

Amino acid No. 1001-1100	Codons	Codon No. • Amino acid	Plane No. in Figure 1	Amino acid No. 1101-1200	Codons	Codon No. • Amino acid	Plane No. in Figure 1
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1001	CTT	60L	4th	1101	CAC	4H	1st
1002	CAA	20Q	2nd	1102	TGG	43W	3rd
1003	AGT	57S	4th	1103	TTT	63F	4th
1004	TTG	47L	3rd	1104	GTA	30V	2nd
1005	CAG	36Q	3rd	1105	ACA	17T	2nd
1006	ACA	17T	2nd	1106	CAA	20Q	2nd
1007	TAT	55Y	4th	1107	AGG	41R	3rd
1008	GTG	46V	3rd	1108	AAT	53N	4th
1009	ACT	49T	4th	1109	TTT	63F	4th
1010	CAA	20Q	2nd	1110	TAT	55Y	4th
1011	CAA	20Q	2nd	1111	GAA	22E	2nd
1012	TTA	31L	2nd	1112	CCA	16P	2nd
1013	ATT	61I	4th	1113	CAA	20Q	2nd
1014	AGA	25R	2nd	1114	ATC	13I	1st
1015	GCT	50A	4th	1115	ATT	61I	4th
1016	GCA	18A	2nd	1116	ACT	49T	4th
1017	GAA	22E	2nd	1117	ACA	17T	2nd
1018	ATC	13I	1st	1118	GAC	6D	1st
1019	AGA	25R	2nd	1119	AAC	5N	1st
1020	GCT	50A	4th	1120	ACA	17T	2nd
1021	TCT	51S	4th	1121	TTT	63F	4th
1022	GCT	50A	4th	1122	GTG	46V	3rd
1023	AAT	53N	4th	1123	TCT	51S	4th
1024	CTT	60L	4th	1124	GGT	58G	4th
1025	GCT	50A	4th	1125	AAC	5N	1st
1026	GCT	50A	4th	1126	TGT	59C	4th
1027	ACT	49T	4th	1127	GAT	54D	4th
1028	AAA	21K	2nd	1128	GTT	62V	4th
1029	ATG	45M	3rd	1129	GTA	30V	2nd
1030	TCA	19S	2nd	1130	ATA	29I	2nd
1031	GAG	38E	3rd	1131	GGA	26G	2nd
1032	TGT	59C	4th	1132	ATT	61I	4th
1033	GTA	30V	2nd	1133	GTC	14V	1st
1034	CTT	60L	4th	1134	AAC	5N	1st
1035	GGA	26G	2nd	1135	AAC	5N	1st
1036	CAA	20Q	2nd	1136	ACA	17T	2nd
1037	TCA	19S	2nd	1137	GTT	62V	4th
1038	AAA	21K	2nd	1138	TAT	55Y	4th
1039	AGA	25R	2nd	1139	GAT	54D	4th
1040	GTT	62V	4th	1140	CCT	48P	4th
1041	GAT	54D	4th	1141	TTG	47L	3rd
1042	TTT	63F	4th	1142	CAA	20Q	2nd

1043	TGT	59C	4th	1143	CCT	48P	4th
1044	GGA	26G	2nd	1144	GAA	22E	2nd
1045	AAG	37K	3rd	1145	TTA	31L	2nd
1046	GGC	10G	1st	1146	GAC	6D	1st
1047	TAT	55Y	4th	1147	TCA	19S	2nd
1048	CAT	52H	4th	1148	TTC	15F	1st
1049	CTT	60L	4th	1149	AAG	37K	3rd
1050	ATG	45M	3rd	1150	GAG	38E	3rd
1051	TCC	3S	1st	1151	GAG	38E	3rd
1052	TTC	15F	1st	1152	TTA	31L	2nd
1053	CCT	48P	4th	1153	GAT	54D	4th
1054	CAG	36Q	3rd	1154	AAA	21K	2nd
1055	TCA	19S	2nd	1155	TAT	55Y	4th
1056	GCA	18A	2nd	1156	TTT	63F	4th
1057	CCT	48P	4th	1157	AAG	37K	3rd
1058	CAT	52H	4th	1158	AAT	53N	4th
1059	GGT	58G	4th	1159	CAT	52H	4th
1060	GTA	30V	2nd	1160	ACA	17T	2nd
1061	GTC	14V	1st	1161	TCA	19S	2nd
1062	TTC	15F	1st	1162	CCA	16P	2nd
1063	TTG	47L	3rd	1163	GAT	54D	4th
1064	CAT	52H	4th	1164	GTT	62V	4th
1065	GTG	46V	3rd	1165	GAT	54D	4th
1066	ACT	49T	4th	1166	TTA	31L	2nd
1067	TAT	55Y	4th	1167	GGT	58G	4th
1068	GTC	14V	1st	1168	GAC	6D	1st
1069	CCT	48P	4th	1169	ATC	13I	1st
1070	GCA	18A	2nd	1170	TCT	51S	4th
1071	CAA	20Q	2nd	1171	GGC	10G	1st
1072	GAA	22E	2nd	1172	ATT	61I	4th
1073	AAG	37K	3rd	1173	AAT	53N	4th
1074	AAC	5N	1st	1174	GCT	50A	4th
1075	TTC	15F	1st	1175	TCA	19S	2nd
1076	ACA	17T	2nd	1176	GTT	62V	4th
1077	ACT	49T	4th	1177	GTA	30V	2nd
1078	GCT	50A	4th	1178	AAC	5N	1st
1079	CCT	48P	4th	1179	ATT	61I	4th
1080	GCC	2A	1st	1180	CAA	20Q	2nd
1081	ATT	61I	4th	1181	AAA	21K	2nd
1082	TGT	59C	4th	1182	GAA	22E	2nd
1083	CAT	52H	4th	1183	ATT	61I	4th
1084	GAT	54D	4th	1184	GAC	6D	1st

1085	GGA	26G	2nd	1185	CGC	8R	1st
1086	AAA	21K	2nd	1186	CTC	12L	1st
1087	GCA	18A	2nd	1187	AAT	53N	4th
1088	CAC	4H	1st	1188	GAG	38E	3rd
1089	TTT	63F	4th	1189	GTT	62V	4th
1090	CCT	48P	4th	1190	GCC	2A	1st
1091	CGT	56R	4th	1191	AAG	37K	3rd
1092	GAA	22E	2nd	1192	AAT	53N	4th
1093	GGT	58G	4th	1193	TTA	31L	2nd
1094	GTC	14V	1st	1194	AAT	53N	4th
1095	TTT	63F	4th	1195	GAA	22E	2nd
1096	GTT	62V	4th	1196	TCT	51S	4th
1097	TCA	19S	2nd	1197	CTC	12L	1st
1098	AAT	53N	4th	1198	ATC	13I	1st
1099	GGC	10G	1st	1199	GAT	54D	4th
1100	ACA	17T	2nd	1200	CTC	12L	1st

Class 7: Amino acids 1201--1274

Amino acid No. 1201-1274	Codons	Codon No. • Amino acid	Plane No. in Figure 1
1201	CAA	20Q	2nd
1202	GAA	22E	2nd
1203	CTT	60L	4th
1204	GGA	26G	2nd
1205	AAG	37K	3rd
1206	TAT	55Y	4th
1207	GAG	38E	3rd
1208	CAG	36Q	3rd
1209	TAT	55Y	4th
1210	ATA	29I	2nd
1211	AAA	21K	2nd
1212	TGG	43W	3rd
1213	CCA	16P	2nd
1214	TGG	43W	3rd
1215	TAC	7Y	1st
1216	ATT	61I	4th
1217	TGG	43W	3rd
1218	CTA	28L	2nd
1219	GGT	58G	4th

1220	TTT	63F	4th
1221	ATA	29I	2nd
1222	GCT	50A	4th
1223	GGC	10G	1st
1224	TTG	47L	3rd
1225	ATT	61I	4th
1226	GCC	2A	1st
1227	ATA	29I	2nd
1228	GTA	30V	2nd
1229	ATG	45M	3rd
1230	GTG	46V	3rd
1231	ACA	17T	2nd
1232	ATT	61I	4th
1233	ATG	45M	3rd
1234	CTT	60L	4th
1235	TGC	11C	1st
1236	TGT	59C	4th
1237	ATG	45M	3rd
1238	ACC	1T	1st
1239	AGT	57S	4th
1240	TGC	11C	1st
1241	TGT	59C	4th
1242	AGT	57S	4th
1243	TGT	59C	4th
1244	CTC	12L	1st
1245	AAG	37K	3rd
1246	GGC	10G	1st
1247	TGT	59C	4th
1248	TGT	59C	4th
1249	TCT	51S	4th
1250	TGT	59C	4th
1251	GGA	26G	2nd
1252	TCC	3S	1st
1253	TGC	11C	1st
1254	TGC	11C	1st
1255	AAA	21K	2nd
1256	TTT	63F	4th
1257	GAT	54D	4th
1258	GAA	22E	2nd
1259	GAC	6D	1st
1260	GAC	6D	1st
1261	TCT	51S	4th

1262	GAG	38E	3rd
1263	CCA	16P	2nd
1264	GTG	46V	3rd
1265	CTC	12L	1st
1266	AAA	21K	2nd
1267	GGA	26G	2nd
1268	GTC	14V	1st
1269	AAA	21K	2nd
1270	TTA	31L	2nd
1271	CAT	52H	4th
1272	TAC	7Y	1st
1273	ACA	17T	2nd
1274	TAA	23stop	2nd

Table S2: Full table of constituent-codon members of the same planes-linkage value in the 1st–4th planes of Figure 1.

Plane No. in Figure 1	Linkage number	Codon No.						Total number
The 1st plane	3	5, 2, 1	13, 9, 5	15, 5, 15	14, 5, 5	10, 15, 13	14, 5, 5	8
		6, 8, 12	3, 11, 11					
The 2nd plane	5	29, 17, 16, 26, 17	19, 20, 29, 31, 16	18, 31, 20, 29, 16	26, 20 19, 21, 25			4
	4	30, 22, 21, 26	20, 16, 17, 22	25, 30, 30, 30	21, 17, 16, 16	16, 19, 21, 16		5
	3	29, 29, 25	22, 26, 21	31, 22, 16	28, 31, 21	19, 22, 17	21, 31, 16	18
		31, 20, 19	18, 16, 18	17, 19, 30	17, 20, 31	20, 20, 31	18, 20, 22	
		26, 21, 18	30, 17, 20	22, 16, 20	30, 29, 26	17, 19, 16	20, 21, 22	
The 3rd plane	3	37, 38, 38						1
The 4th plane	8	63, 53, 54, 58, 62, 55, 63, 50	50, 51, 50, 53, 60, 50, 50, 49					2
	7	54, 63, 58, 58, 63, 53, 63						1
	6	50, 49, 53, 62, 62, 61	53, 61, 54, 58, 55, 63	49, 48, 58, 54, 51, 51	59, 62, 50, 54, 55, 51	61, 50, 54, 55, 53, 55	62, 58, 58, 53, 55, 53	8
		53, 63, 49, 61, 57, 62	60, 58, 54, 61, 50, 50					
	5	63, 62, 63,	61, 63, 58,	48, 59, 53,	49, 53, 58,	59, 51, 63,	62, 50, 62,	9

		60, 62	49, 49	58, 62	62, 58	58, 58	60, 55	
		48, 62, 50, 51, 52	58, 51, 53, 62, 63	63, 53, 57, 50, 61				
	4	59, 62, 53, 60	56, 58, 62, 55	60, 61, 62, 53	63, 59, 53, 54	62, 55, 51, 57	63, 48, 53, 61	20
		51, 62, 55, 50	53, 60, 54, 51	58, 63, 53, 59	58, 62, 60, 49	49, 49, 54, 50	60, 49, 48, 49	
		56, 62, 55, 51	49, 53, 51, 48	61, 59, 58, 54	63, 53, 58, 61	62, 54, 63, 59	61, 59, 52, 54	
		62, 55, 54, 48	59, 59, 51, 59					
	3	49, 53, 51	53, 62, 49	53, 58, 49	58, 62, 55	48, 63, 60	48, 61, 53	33
		50, 58, 50	50, 55, 55	58, 55, 60	51, 61, 62	48, 63, 58	51, 48, 49	
		63, 49, 53	54, 54, 63	60, 51, 63	49, 62, 59	51, 49, 53	53, 49, 51	
		50, 57, 55	57, 63, 59	55, 58, 54	60, 49, 62	49, 51, 58	53, 63, 58	
		55, 52, 60	48, 52, 58	49, 50, 48	63, 48, 56	53, 63, 55	59, 54, 62	
		54, 62, 54	61, 53, 50	59, 57, 59				

Table S3: Full details of the aggregative population of the genetic code organization in the S-protein gene.

S-protein code 1–1274										
Codon No• Amino acid	Codons	①	②	③	④	⑤	⑥	⑦	Sum ①–⑦	Amino acid replacements ^a
0P	CCC	1	0	1	2	0	0	0	4	P25S
1T	ACC	3	2	0	3	1	0	1	10	T723I, T732S, T732I, T778I
2A	GCC	0	1	1	2	1	2	1	8	
3S	TCC	4	3	0	1	2	1	1	12	S94F, S940F
4H	CAC	1	1	0	0	0	2	0	4	H146Q, H1101Y
5N	AAC	5	6	4	7	6	6	0	34	
6D	GAC	3	2	3	2	3	4	2	19	D178N, D936N, D936H, D1118Y, D1168G, D1259H, D1260Y
7Y	TAC	3	0	4	4	1	0	2	14	
8R	CGC	0	0	0	0	0	1	0	1	
9S	AGC	0	1	1	1	2	0	0	5	S477R, S477I , S813I
10G	GGC	1	0	3	2	4	3	2	15	G932S
11C	TGC	1	2	1	3	1	0	4	12	C1235F
12L	CTC	0	3	1	0	3	3	2	12	L216F
13I	ATC	0	3	2	1	4	4	0	14	
14V	GTC	5	3	4	3	1	4	1	21	V70I, V367F , V1068F

15F	TTC	7	1	4	0	2	4	0	18	
The 1st plane subtotal									203 (16%: 203/1274)	
16P	CCA	3	3	7	3	5	2	2	25	P9L, P1162S, P1162R
17T	ACA	2	5	7	10	6	8	2	40	T19I, T33I, T299I, T323I , T547I, T716I, T791I, T1006I, T1117I
18A	GCA	1	5	2	6	9	4	0	27	A27S, A27V, A522V, A647S, A684V, A1070S
19S	TCA	2	4	2	5	6	7	0	26	S698L, S704L, S982A
20Q	CAA	2	4	7	9	14	9	1	46	Q23H, Q957R
21K	AAA	6	5	6	4	8	5	4	38	
22E	GAA	5	6	4	7	3	7	2	34	E180V, E309Q, E484K , E654Q, E1202Q
23Stop	TAA	0	0	0	0	0	0	1	1	
24R	CGA	0	0	0	0	0	0	0	0	
25R	AGA	4	5	6	0	2	3	0	20	R102I, R102S, R346K , R357K
26G	GGA	1	3	2	2	1	4	3	16	
27Stop	TGA	0	0	0	0	0	0	0	0	
28L	CTA	3	2	1	1	2	0	1	10	
29I	ATA	3	2	2	5	2	1	3	18	
30V	GTA	0	3	4	2	0	5	1	15	V687L, V1104L, V1177I
31L	TTA	5	6	3	3	5	5	1	28	
The 2nd plane subtotal									344 (27%: 344/1274)	
32P	CCG	0	0	0	0	0	0	0	0	
33T	ACG	0	2	0	0	1	0	0	3	
34A	GCG	1	0	0	0	1	0	0	2	A879V
35S	TCG	1	1	0	0	0	0	0	2	S221L
36Q	CAG	5	1	2	4	1	2	1	16	Q14H, Q52R, Q173K, Q218H, Q1208H
37K	AAG	4	4	5	1	2	5	2	23	K558N, K1073T
38E	GAG	2	0	3	1	2	4	2	14	E96D
39Stop	TAG	0	0	0	0	0	0	0	0	
40R	CGG	0	0	0	2	0	0	0	2	
41R	AGG	2	3	1	0	3	1	0	10	R190M
42G	GGG	1	0	1	1	0	0	0	3	
43W	TGG	3	2	1	1	1	1	3	12	W152R
44L	CTG	0	0	2	0	1	0	0	3	L452R

45M	ATG	3	0	0	3	3	2	3	14	M731I, M740V, M1237T
46V	GTG	1	3	0	1	3	3	2	13	V213L, V382L , V1122L
47L	TTG	3	5	2	2	4	3	1	20	L141F, L1063F, L1224F
The 3rd plane subtotal									137 (11%: 137/1274)	
48P	CCT	5	8	5	3	1	7	0	29	P251S, P330S , P384L , P384S , P479S , P631S, P681H, P681L
49T	ACT	10	9	8	9	3	5	0	44	T51I, T76I, T76N, T95I, T240I, T676I, T678I, T719I, T747I, T1027I
50A	GCT	3	8	5	8	10	7	1	42	A67S, A243S, A575S, A672V, A706V, A771S, A846V, A892V, A899S, A1020V
51S	TCT	6	8	7	7	3	4	2	37	S71F, S884F
52H	CAT	3	1	1	2	0	5	1	13	H69Y, H245Y
53N	AAT	13	7	12	7	7	8	0	54	N440K , N501Y
54D	GAT	5	7	8	5	9	8	1	43	D80G, D111N, D198G, D253G, D574Y, D614G, D796Y, D796H, D839Y, D1084Y, D1153Y
55Y	TAT	6	12	6	5	3	6	2	40	Y453F
56R	CGT	1	1	1	4	1	1	0	9	R214L
57S	AGT	4	1	1	5	3	1	2	17	S689I, S929T
58G	GGT	7	7	13	7	8	4	1	47	G142V, G184S, G252V, G257D, G261V, G446V , G639S, G1124V, G1167A, G1219V
59C	TGT	3	4	5	5	1	4	6	28	C1243F
60L	CTT	6	3	6	4	11	4	2	36	L5F, L822F, L938F
61I	ATT	4	5	6	9	10	7	3	44	I233V, I720V, I818V
62V	GTT	13	4	8	10	6	7	0	48	V3G, V6A, V6F, V90F, V1040F
63F	TTT	14	13	9	6	8	7	2	59	F490S , F565L, F888L
The 4th plane subtotal									590 (46%: 590/1274)	

^aFull details of 154 amino acid replacements in the S-protein of the first 2000 of 46,251 variants extracted from the CoV-GLUE, Amino acid variation database. Variants listed in boldface indicate amino acid replacements in the receptor-binding domain of the S-protein.

Table S4: Full details of the 154 amino acid replacements in the S-protein in the first 2000 of 46,251 variants in Table 4.

Codon No• Amino acid	Amino acid replacements ^a		Replacement- related plane No. in Figure 1
0P	P25S	CCC 0 → 3 TCC	1st→1st
1T	T732S	ACC 1 → 3 TCC	
	T723I	ACC 1 → 13 ATC	
	T732I		
	T778I		
2A	non		
3S	S94F	TCC 3 → 15 TTC	1st→1st
	S940F		
4H	H146Q	CAC 4 →20 CAA, 36 CAG	1st →2nd, 3rd
	H1101Y	CAC 4 → 7 TAC	1st→1st
5N	non		
6D	D936H	GAC 6 → 4 CAC	1st→1st
	D1259H		
	D178N	GAC 6 → 5 AAC	
	D936N		
	D1118Y	GAC 6 → 7 TAC	
	D1260Y		
	D1168G	GAC 6 → 10 GGC	
7Y	non		
8R	non		
9S	S477R	AGC 9 → 8 CGC	1st→1st
	S477I	AGC 9 → 13 ATC	
	S813I		
10G	G932S	GGC 10 → 9 AGC	
11C	C1235F	TGC 11 →15 TTC	
	C1253F		
12L	L216F	CTC 12 →15 TTC	
13I	non		
14V	V70I	GTC 14 →13 ATC	1st→1st
	V367F	GTC 14 →15 TTC	
	V1068F		
15F	non		
16P	P1162S	CCA 16 →19 TCA	2nd→2nd
	P1162R	CCA 16 →24 CGA	
	P9L	CCA 16 →28 CTA	

17T	T33I	ACA 17 →29 ATA	
	T19I		
	T299I		
	T323I		
	T547I		
	T716I		
	T791I		
	T1006I		
	T1117I		
18A	A27S	GCA 18 →19 TCA	
	A647S		
	A1070S		
	A27V	GCA 18 →30 GTA	
	A522V		
	A684V		
19S	S982A	TCA 19 →18 GCA	
	S698L	TCA 19 →31 TTA	
	S704L		
20Q	Q23H	CAA 20 →4 CAC, 52CAT	2nd→1st, 4th
	Q957R	CAA 20 →24 CGA	2nd→2nd
21K	non		
22E	E309Q	GAA 22→20 CAA	2nd→2nd
	E654Q		
	E1202Q		
	E180V	GAA 22 →30 GTA	
23stop			
24R	non		
25R	R102S	AGA 25 →9 AGC, 57 AGT	2nd→1st, 4th
	R346K	AGA 25→21 AAA	2nd→2nd
	R357K		
	R102I	AGA 25 →29 ATA	
26G	G1251V	GGA 26 →30 GTA	
27stop			
28L	non		
29I	non		
30V	V687L	GTA 30→28 CTA, 31 TTA	2nd→2nd, 2nd
	V1177I	GTA 30 →29 ATA	2nd→2nd
	V1104L	GTA 30 →31 TTA	
31L	non		

32P	non			
33T	non			
34A	A879V	GCG 34 →46 GTG	3rd→3rd	
35S	S221L	TCG 35 →47 TTG		
36Q	Q14H	CAG 36 →4 CAC, 52 CAT	3rd→1st, 4th	
	Q218H			
	Q1208H			
	Q173K	CAG 36→ 37AAG	3rd→3rd	
	Q52R	CAG 36 →40 CGG		
37K	K558N	AAG 37 →5 AAC, 53 AAT	3rd→1st, 4th	
	K1073T	AAG 37→33 ACG	3rd→3rd	
38E	E96D	GAG 38 →6 GAC, 54 GAT	3rd→1st, 4th	
39stop				
40R	non			
41R	R190M	AGG 41 →45 ATG	3rd→3rd	
42G	non			
43W	W152R	TGG 43→40 CGG, 41 AGG	3rd→3rd, 3rd	
44L	non			
45M	M731I	ATG 45→13 ATC, 29 ATA, 61 ATT	3rd→1st, 2nd, 4th	
	M740V	ATG 45 →46 GTG	3rd→3rd	
	M1237T	ATG 45 →33 ACG	3rd→3rd	
46V	V213L	GTG 46→44 CTG, 47 TTG	3rd→3rd, 3rd	
	V382L			
	V1122L			
47L	L141F	TTG 47 →15 TTC, 63 TTT	3rd→1st, 4th	
	L1063F			
	L1224F			
48P	P251S	CCT 48 →51 TCT	4th→4th	
	P330S			
	P384S			
	P479S			
	P631S	CCT 48 →60 CTT		
	P384L			
	P681L			
P681H	CCT 48 →52 CAT			
49T	T76N	ACT 49 →53 AAT		
	T51I	ACT 49 →61 ATT		
	T76I			

	T240I		
	T676I		
	T678I		
	T719I		
	T747I		
50A	A67S	GCT 50 →51 TCT	
	A243S		
	A575S		
	A771S		
	A899S		
	A672V	GCT 50 →62 GTT	
	A706V		
	A846V		
	A892V		
	A1020V		
51S	S71F	TCT 51 → 63 TTT	
	S884F		
52H	H69Y	CAT 52 →55 TAT	
	H245Y		
53N	N440K	AAT 53→21 AAA, 37 AAG	4th→2nd, 3rd
	N501Y	AAT 53 →55 TAT	4th→4th
54D	D796H	GAT 54 →52 CAT	4th→4th
	D111N	GAT 54 →53 AAT	
	D796Y	GAT 54 →55 TAT	
	D574Y		
	D839Y		
	D1084Y		
	D1153Y		
	D80G	GAT 54 →58 GGT	
	D198G		
	D614G		
55Y	Y453F	TAT 55 →63 TTT	
56R	R214L	CGT 56 →60 CTT	
57S	S689I	AGT 57 →61 ATT	
	S929T	AGT 57 →49 ACT	
58G	G1167A	GGT 58 →50 GCT	
	G257D	GGT 58 →54 GAT	
	G184S	GGT 58 →57 AGT	
	G639S		
	G142V	GGT 58 →62 GTT	
	G252V		

	G261V	
	G446V	
	G1124V	
	G1219V	
59C	C1243F	TGT 59 → 63 TTT
	C1247F	
	C1250F	
60L	L822F	CTT 60 → 63 TTT
	L938F	
61I	I233V	ATT 61 → 62 GTT
	I720V	
	I818V	
62V	V6A	GTT 62 → 50 GCT
	V3G	GTT 62 → 58 GGT
	V6F	GTT 62 → 63 TTT
	V90F	
	V1040F	
63F	F490S	TTT 63 → 51 TCT
	F565L	TTT 63 → 60 CTT
	F888L	

^aSome amino acid replacements (e.g., H146Q, Q23H, and V213L) have more than one mutant, probably a single point mutation. Only one of them is an actual mutant. Variants listed in boldface indicate amino acid replacements within the receptor-binding domain.

Table S5: Full details for the real Alpha to Omicron lineages of SARS-CoV-2.

Lineage	Amino acid replacement ^a	Replacement-related plane No. in Figure 1
B.1.1.7 (α)	GAC 6 → 4 CAC (D1118H)	1st → 1st
	ACA 17 → 29 ATA (T716I)	2nd → 2nd
	TCA 19 → 18 GCA (S982A)	
	CCT 48 → 52 CAT (P681H)	4th → 4th
	GCT 50 → 54 GAT (A570D)	
	AAT 53 → 55 TAT (N501Y)	
	GAT 54 → 58 GGT (D614G)	
B.1.351 (β)	GCA 18 → 30 GTA (A701V)	2nd → 2nd
	GAA 22 → 21 AAA (E484K)	
	AAG 37 → 5 AAC, 53AAT (K417N)	3rd → 1st, 4th
	AAT 53 → 55 TAT (N501Y)	4th → 4th
	GAT 54 → 50 GCT (D80A)	
	GAT 54 → 58 GGT (D215G, D614G)	

P.1 (γ)	ACC 1 → 5 AAC (T20N)	1st → 1st
	GAA 22 → 21 AAA (E484K)	2nd → 2nd
	AAG 37 → 33 ACG (K417T)	3rd → 3rd
	AGG 41 → 9 AGC, 57 AGT (R190S)	3rd→1st, 4th
	CCT 48 → 51TCT (P26S)	4th → 4th
	ACT 49 → 61ATT (T1027I)	
	CAT 52 → 55TAT (H655Y)	
	AAT 53 → 55 TAT (N501Y)	
	GAT 54 → 55 TAT (D138Y)	
	GAT 54 → 58 GGT (D614G)	
	CTT 60 → 63 TTT (L18F)	
	GTT 62 → 63 TTT (V1176F)	
B.1.617.2 (δ)	ACA 17 → 21 AAA (T478K)	2nd → 2nd
	ACA 17 → 25 AGA (T19R)	
	GAG 38 → 42 GGG (E156G)	3rd → 3rd
	CTG 44 → 40 CGG (L452R)	
	CCT 48 → 56 CGT (P681R)	4th → 4th
	GAT 54 → 58 GGT (D614G)	
	GAT 54 → 53 AAT (D950N)	
C.37 (λ)	GGT 58 → 54 GAT (G142D)	
	CTG 44 → 36 CAG(L452Q)	3rd → 3rd
	ACT 49 → 53 AAT(T859N)	4th → 4th
	ACT 49 → 61 ATT(T76I)	
	GAT 54 → 58 GGT (D614G)	
	GGT 58 → 62 GTT(G75V)	
B.1.1.529 (o)	TTT 63 → 51 TCT(F490S)	
	TCC 3 → 15 TTC (S375F)	1st → 1st
	AAC 5 → 21 AAA, 37 AAG (N764K)	1st→2nd, 3rd
	TAC 7 → 4 CAC (Y505H)	1st → 1st
	AGC 9 → 5 AAC (S477N)	
	ACA 17 → 21 AAA (T478K)	2nd → 2nd
	TCA 19 → 16 CCA (S373P)	
	CAA 20 → 4 CAC, 52CAT (Q954H)	2nd →1st, 4th
	CAA 20 → 24 CGA (Q498R)	2nd → 2nd
	GAA 22 → 18 GCA (E484A)	
	AAG 37 → 5 AAC, 53AAU(K417N)	3rd→1st, 4th
	CCT 48 → 52 CAT (P681H)	4th →4th
	CAT 52 → 55 TAT (H655Y)	4th →4th 4th→2nd, 3rd
	AAT 53→21 AAA, 37 AAG (N440K ,N679K,N969K)	
	AAT 53 → 55 TAT (N501Y)	4th → 4th
	GAT 54→ 55 TAT (D796Y)	4th → 4th

	GAT 54→ 58 GGT (D614G)	
	GGT 58→ 54 GAT (G142D, G339D)	

^aSome amino acid replacements (e.g., H146Q, Q23H, V213L) had more than one mutant, probably a single point mutation. Only one of them is an actual mutant. Variants listed in boldface indicate amino acid replacements within the receptor-binding domain of the S-protein.