

## Allele Frequencies for 26 MiniSTR Loci with U.S. Caucasian, African American, and Hispanic Populations\*

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**POPULATIONS**: U.S. Caucasian, African American, and Hispanic

**KEYWORDS**: forensic science, population genetics, DNA typing, DNA profiling, short tandem repeats, STR, miniSTR, D1GATA113E02, D1S1627, D1S1677, D2S441, D2S1776, D3S3053, D3S4529, D4S2364, D4S2408, D5S2500, D6S474, D6S1017, D8S1115, D9S1122, D9S2157, D10S1248, D10S1435, D11S4463, D12ATA63A05, D14S1434, D17S974, D17S1301, D18S853, D20S482, D20S1082, D22S1045, U.S. Caucasian, African American, and U.S. Hispanic populations

A set of 665 U.S. population blood samples with self-identified ethnicities, including 265 Caucasian, 260 African American, and 140 Hispanic, were extracted for DNA, quantified, diluted to approximately 1 ng/ $\mu$ L, and separated into seven 96-well plates as previously described (1). Twenty new miniSTR markers were identified and chosen based on their size and location on certain chromosomes and are described in an accompanying publication (2, co-submitted). The candidate loci are all either located on chromosomes that differ from the 13 CODIS core loci or are at least ~ 50 MB apart from an existing CODIS locus on the same chromosome, and therefore likely unlinked from that particular marker. These 20 new loci were selected following the criteria (i.e. high heterozygosity and low allele spread) described in Coble and Butler (3). They are listed on <http://www.cstl.nist.gov/biotech/strbase/newSTRs.htm>. Also, an additional 190 samples were tested with the original 6 miniSTR loci (NC01 and NC02) described in the Coble 2005 paper (3). A revised nomenclature is used for several of these loci (2).

PCR amplification was carried out on a GeneAmp<sup>®</sup> 9700 (Applied Biosystems, Foster City, CA) using 1 ng of population sample DNA, 1X GeneAmp<sup>®</sup> PCR Gold buffer (Applied Biosystems), 2  $\mu$ M MgCl<sub>2</sub> (Applied Biosystems), 250  $\mu$ M dNTPs (USB Corporation, Cleveland, OH), 0.2  $\mu$ M primers (2), 1 U AmpliTaq Gold DNA polymerase (Applied Biosystems), and 0.16 mg/mL BSA (Sigma-Aldrich, St. Louis, MO), in a 10  $\mu$ L total reaction volume. The PCR amplification conditions using the 9700 were as follows: denaturation for 10 min at 95°C, amplification for 28 cycles of 1 min at 94°C, 1 min at 59°C, and 1 min at 72°C, extension for 45 min at 60°C, and a final soak at 25°C.

Amplification products were diluted in Hi-Di<sup>™</sup> formamide (Applied Biosystems) by adding 1  $\mu$ L PCR product and 0.35  $\mu$ L GS500-LIZ internal size standard (Applied

Biosystems) to 14  $\mu$ L of Hi-Di. The samples were analyzed on the 16-capillary ABI Prism<sup>®</sup> 3100 Genetic Analyzer without prior denaturation of samples. POP<sup>™</sup>-6 (Applied Biosystems) rather than POP<sup>™</sup>-4 was utilized for higher resolution separations on a 36 cm array. Samples were injected electrokinetically for 10 s at 3 kV. Bins and panels were created in GeneMapper<sup>ID</sup> from population information (data not shown) and used to determine allele calls for the population samples. At least two separate alleles were sequenced at each STR locus to provide appropriate allele repeat numbers (2).

A total of 665 unique miniSTR profiles were evaluated for each new marker: 663 males and 2 females. The resultant data were evaluated using the PowerMarker statistics program (4). The allele frequencies, observed heterozygosities, Hardy-Weinberg exact test *p*-values and Polymorphism Information Content (PIC) in the three U.S. populations are listed in Table 1. The complete dataset is available at

<http://www.cstl.nist.gov/biotech/strbase/NISTpop.htm> .

## References

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TABLE 1 -- U.S. Caucasian, African American, and Hispanic allele frequencies for 26 new miniSTR loci

D1GATA113					D1S1627					D1S1677				
Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.
7	0.1483	0.1475	0.1142	0.2122	10	0.1220	0.1355	0.1202	0.1000	9	0.0008			0.0019
8	0.0168		0.0394	0.0072	11	0.1477	0.1660	0.1550	0.1000	10	0.0061	0.0076		0.0078
9	0.0183		0.0453	0.0036	12	0.0447	0.0153	0.0853	0.0250	11	0.0083	0.0076	0.0078	0.0107
10	0.0199	0.0057	0.0295	0.0288	13	0.3492	<b>0.3760</b>	<b>0.3178</b>	<b>0.3571</b>	12	0.1053	0.0817	0.1206	0.1214
11	0.1804	0.2069	0.1535	0.1799	14	0.3159	0.3015	0.2926	0.3857	13	0.2167	0.2395	0.1634	0.2714
12	0.5482	<b>0.5728</b>	<b>0.5551</b>	<b>0.4892</b>	15	0.0182	0.0057	0.0252	0.0286	14	0.3068	<b>0.3517</b>	0.2549	<b>0.3179</b>
13	0.0680	0.0670	0.0630	0.0791	16	0.0023		0.0039	0.0036	15	0.2598	0.2357	<b>0.3152</b>	0.2036
N	654	261	254	139	N	660	262	258	140	16	0.0705	0.0551	0.0973	0.0500
H(ob)	0.6682	0.6322	0.6732	0.7266	H(ob)	0.7455	0.7366	0.7829	0.6929	17	0.0220	0.0171	0.0253	0.0250
P	0.5803	0.5971	0.9676	0.7490	P	0.3532	0.5662	0.8207	0.0986	18	0.0015			0.0039
PIC	0.6011	0.5550	0.6177	0.6316	PIC	0.6967	0.6734	0.7310	0.6522	19	0.0023	0.0038		0.0019
										N	660	263	257	140
										H(ob)	0.7455	0.7490	0.7432	0.7429
										P	0.2724	0.7058	0.0191	0.5968
										PIC	0.7398	0.7140	0.7527	0.7286

  

D2S441					D2S1776					D3S3053				
Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.
9	0.0008	0.0019			7	0.0015		0.0039		7	0.0008	0.0019		
10	0.1833	0.2015	0.0837	0.3321	8	0.0436	0.0766	0.0217	0.0216	8	0.0185	0.0447	0.0020	
11	0.3508	<b>0.3498</b>	<b>0.3696</b>	<b>0.3179</b>	9	0.1139	0.0881	0.1398	0.1151	9	0.1726	0.2412		0.1992
11.3	0.0523	0.0608	0.0525	0.0357	10	0.1598	0.1782	0.1535	0.1367	10	0.1279	0.1304	0.1892	0.0107
12	0.0932	0.0532	0.1712	0.0250	11	0.3066	<b>0.3218</b>	<b>0.3209</b>	0.2518	11	0.3945	<b>0.4105</b>	<b>0.4243</b>	<b>0.3107</b>
12.3	0.0038	0.0019	0.0058	0.0036	12	0.2966	0.2644	0.2953	<b>0.3597</b>	12	0.1680	0.1498	0.1713	0.1964
13	0.0303	0.0285	0.0409	0.0143	13	0.0673	0.0651	0.0551	0.0935	13	0.0470	0.0214	0.0139	0.1536
13.3	0.0008		0.0019		14	0.0099	0.0057	0.0079	0.0216	14	0.0455			0.2107
14	0.2417	0.2452	0.2529	0.2143	15	0.0008		0.0020		15	0.0223			0.1036
14.3	0.0008		0.0019		N	654	261	254	139	16	0.0023			0.0107
15	0.0409	0.0570	0.0195	0.0500	H(ob)	0.7630	0.8008	0.7402	0.7338	17	0.0008			0.0036
16	0.0008			0.0036	P	0.3490	0.3671	0.3763	0.2598	N	660	257	251	140
17	0.0008			0.0036	PIC	0.7389	0.7438	0.7262	0.732	H(ob)	0.7381	0.7198	0.7131	0.8143
N	660	263	257	140						P	0.0000	0.5148	0.8156	0.4772
H(ob)	0.7742	0.7795	0.7977	0.7214						PIC	0.7359	0.6918	0.6698	0.7535
P	0.1966	0.7857	0.1520	0.0399										
PIC	0.7382	0.7319	0.7235	0.6940										

  

D3S4529					D4S2364					D4S2408				
Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.
11	0.0008	0.0020			7	0.0008	0.0019			7	0.0015			0.0039
12	0.0439	0.0402	0.0484	0.0429	8	0.1742	0.1673	0.1459	0.2393	8	0.1904	0.2222	0.1417	0.2194
13	0.2379	<b>0.3695</b>	0.0911	0.2643	9	0.6265	<b>0.5494</b>	<b>0.7646</b>	<b>0.5179</b>	9	0.2791	<b>0.3161</b>	0.1870	<b>0.3777</b>
14	0.2068	0.1145	<b>0.2907</b>	0.2214	10	0.1970	0.2795	0.0895	0.2393	10	0.2301	0.2375	0.2441	0.1906
15	0.2424	0.2209	0.2364	<b>0.2821</b>	11	0.0015	0.0019		0.0036	11	0.2378	0.1973	<b>0.3189</b>	0.1655
16	0.2083	0.1968	0.2558	0.1500	N	660	263	257	140	12	0.0596	0.0249	0.1024	0.0468
17	0.0583	0.0542	0.0756	0.0393	H(ob)	0.5106	0.5513	0.3852	0.6643	13	0.0015	0.0019	0.0020	
18	0.0015	0.0020	0.0019		P	0.0761	0.0227	0.7511	0.6312	N	654	261	254	139
N	660	249	258	140	PIC	0.4817	0.5236	0.3515	0.5493	H(ob)	0.7217	0.7088	0.7520	0.6906
H(ob)	0.7606	0.7229	0.7519	0.8286						P	0.0116	0.1441	0.8213	0.1667
P	0.2439	0.2428	0.5752	0.7017						PIC	0.7346	0.7117	0.7373	0.7021
PIC	0.7607	0.7226	0.7431	0.7394										

D5S2500					D6S474					D6S1017				
Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.
14	0.2748	0.2943	<b>0.2819</b>	0.2250	11	0.0031			0.0143	7	0.0881	0.0019	0.2124	0.0214
15	0.0023		0.0058		12					8	0.2440	0.2113	<b>0.2548</b>	0.2857
16					13	0.0031			0.0107	9	0.0505	0.0094	0.0792	0.0750
17	0.3072	<b>0.3547</b>	0.2259	<b>0.3679</b>	14	0.2180	0.2704	<b>0.2749</b>	0.0214	10	0.3780	<b>0.4792</b>	0.2510	<b>0.4214</b>
18	0.2011	0.2302	0.1564	0.2286	15	0.2311	0.2101	0.2371	0.2607	11	0.0324	0.0528	0.0135	0.0286
19	0.0075	0.0075	0.0077	0.0071	16	0.2173	0.1420	0.1514	<b>0.4750</b>	12	0.1642	0.2094	0.1429	0.1179
20	0.1130	0.0057	0.2645	0.0357	17	0.2435	<b>0.2802</b>	0.2450	0.1679	13	0.0399	0.0340	0.0425	0.0464
21	0.0008		0.0019		18	0.0747	0.0895	0.0737	0.0500	14	0.0030	0.0019	0.0039	0.0036
22	0.0023		0.0019	0.0071	19	0.0085	0.0078		0.0139	N	664	256	259	140
23	0.0700	0.0811	0.0328	0.1179	20	0.0008			0.0020	H(ob)	0.7395	0.6981	0.8069	0.6929
24	0.0211	0.0264	0.0212	0.0107	N	660	257	251	140	P	0.2462	0.2855	0.9903	0.7511
N	664	265	259	140	H(ob)	0.7596	0.8016	0.7649	0.6786	PIC	0.7237	0.6306	0.7683	0.6766
H(ob)	0.7470	0.7472	0.7568	0.7286	P	0.0006	0.2105	0.4592	0.6923					
P	0.0146	0.6897	0.6766	0.6364	PIC	0.7524	0.7397	0.7441	0.6256					
PIC	0.7357	0.6789	0.7366	0.7059										

D8S1115					D9S1122					D9S2157				
Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.
9	0.3464	0.1698	<b>0.5695</b>	0.2679	9	0.0144	0.0096	0.0232	0.0071	7	0.0908	0.1065	0.0891	0.0643
10	0.0075		0.0193		10	0.0175	0.0173	0.0154	0.0214	8	0.0030	0.0057	0.0019	
11	0.0241		0.0579	0.0071	11	0.1692	0.1808	0.1795	0.1286	9	0.0877	0.0875	0.0872	0.0893
12					12	0.3900	<b>0.4038</b>	<b>0.3707</b>	<b>0.4000</b>	9.1	0.0076	0.0057	0.0058	0.0143
13	0.0226	0.0038	0.0483	0.0107	13	0.3232	0.3212	0.3031	0.3643	10	0.0575	0.0095	0.1298	0.0143
14	0.0316	0.0189	0.0386	0.0429	14	0.0721	0.0635	0.0830	0.0679	11	0.2814	<b>0.2966</b>	<b>0.2558</b>	<b>0.3000</b>
15	0.0286	0.0585	0.0039	0.0179	15	0.0091	0.0038	0.0154	0.0071	12	0.0620	0.0570	0.0775	0.0429
16	0.3426	<b>0.5415</b>	0.0965	<b>0.4214</b>	16	0.0038		0.0077	0.0036	13	0.1815	0.2567	0.0814	0.2250
17	0.1273	0.1415	0.1120	0.1286	17	0.0008			0.0019	14	0.1006	0.1065	0.0988	0.0929
18	0.0467	0.0396	0.0367	0.0786	N	659	260	259	140	15	0.0666	0.0437	0.0717	0.1000
19	0.0196	0.0226	0.0154	0.0214	H(ob)	0.7344	0.7423	0.7529	0.6857	16	0.0499	0.0152	0.0891	0.0429
20	0.0030	0.0038	0.0019	0.0036	P	0.7938	0.9674	0.4737	0.9547	17	0.0106	0.0095	0.0097	0.0143
N	664	265	259	140	PIC	0.6592	0.6430	0.6863	0.6302	18				
H(ob)	0.6627	0.6604	0.6293	0.7286						19	0.0008		0.0019	
P	0.0005	0.1869	0.8742	0.5776						N	660	263	258	140
PIC	0.7022	0.6182	0.6239	0.6866						H(ob)	0.8442	0.8403	0.8837	0.7786
										P	0.6062	0.8568	0.3648	0.5926
										PIC	0.8319	0.7866	0.8537	0.8044

D10S1248					D10S1435					D11S4463				
Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.
8	0.0015		0.0039		5	0.0015		0.0039		10	0.0015		0.0039	
9	0.0015		0.0039		6					11	0.0399	0.0170	0.0695	0.0286
10	0.0015		0.0039		7	0.0045	0.0113			12	0.0738	0.0509	0.0985	0.0714
11	0.0144		0.0370		8					13	0.3042	<b>0.3604</b>	0.2336	<b>0.3286</b>
12	0.0740	0.0358	0.1206	0.0607	9	0.0023	0.0038		0.0036	14	0.3396	0.3528	<b>0.3340</b>	0.3250
13	0.2817	<b>0.3302</b>	0.2412	0.2643	10	0.0053	0.0094		0.0071	15	0.1664	0.1642	0.1795	0.1464
14	0.2908	0.2887	<b>0.2782</b>	<b>0.3179</b>	11	0.1425	0.1830	0.1163	0.1143	16	0.0648	0.0491	0.0734	0.0786
15	0.2062	0.1925	0.2043	0.2357	12	0.3356	<b>0.3264</b>	<b>0.3391</b>	<b>0.3464</b>	17	0.0098	0.0057	0.0077	0.0214
16	0.1027	0.1245	0.0798	0.1036	13	0.2881	0.2623	0.3023	0.3107	N	664	265	259	140
17	0.0227	0.0245	0.0253	0.0143	13.3	0.0023			0.0107	H(ob)	0.7304	0.6755	0.7799	0.7429
18	0.0015	0.0019	0.0019		14	0.1712	0.1830	0.1570	0.1750	P	0.7148	0.1991	0.6367	0.4182
19	0.0015	0.0019		0.0036	14.3	0.0023	0.0038	0.0000	0.0036	PIC	0.7148	0.6643	0.7506	0.7145
N	663	265	257	140	15	0.0219	0.0113	0.0349	0.0179					
H(ob)	0.7915	0.7849	0.8249	0.7429	16	0.0060	0.0019	0.0116	0.0036					
P	0.0789	0.8021	0.0456	0.2857	17	0.0128	0.0019	0.0271	0.0071					
PIC	0.7424	0.7127	0.771	0.7191	18	0.0015	0.0019		0.0019					
					19	0.0023			0.0058					
					N	663	265	258	140					
					H(ob)	0.7662	0.7698	0.7984	0.7000					
					P	0.8561	0.6775	0.5520	0.7229					
					PIC	0.7143	0.7167	0.7148	0.6960					

D12ATA63					D14S1434					D17S974				
Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.
10	0.0008			0.0036	9	0.0023		0.0039	0.0036	5	0.0015	0.0019	0.0019	
11	0.0076	0.0019	0.0154	0.0036	10	0.2069	0.1660	0.2607	0.1857	6	0.0008		0.0019	
12	0.1464	0.1385	0.1525	0.1500	11	0.0287	0.0283	0.0253	0.0357	7	0.0407	0.0245	0.0579	0.0393
13	0.1624	0.2154	0.1004	0.1786	12	0.0536	0.0189	0.0953	0.0429	8	0.0881	0.0434	0.1332	0.0893
14	0.0744	0.0173	0.1564	0.0286	13	0.3172	<b>0.3849</b>	0.2393	0.3321	9	0.3712	<b>0.4189</b>	<b>0.3224</b>	<b>0.3714</b>
15	0.2420	0.1615	<b>0.3340</b>	0.2214	14	0.3716	0.3830	<b>0.3521</b>	<b>0.3857</b>	10	0.2907	0.3283	0.2259	0.3393
16	0.0683	0.0577	0.0772	0.0714	15	0.0144	0.0094	0.0195	0.0143	11	0.1649	0.1415	0.2027	0.1393
17	0.2132	<b>0.2981</b>	0.1004	<b>0.2643</b>	16	0.0045	0.0075	0.0039		12	0.0422	0.0415	0.0541	0.0214
18	0.0736	0.0981	0.0521	0.0679	17	0.0008	0.0019			N	664	265	259	140
19	0.0076	0.0096	0.0058	0.0071	N	663	265	257	140	H(ob)	0.7319	0.7019	0.7568	0.7429
20	0.0038	0.0019	0.0058	0.0036	H(ob)	0.6964	0.7208	0.6848	0.6714	P	0.9278	0.5242	0.6173	0.9528
N	659	260	259	140	P	0.4221	0.9052	0.1506	0.9944	PIC	0.6983	0.6408	0.7469	0.6705
H(ob)	0.8285	0.8423	0.7876	0.8786	PIC	0.6641	0.6157	0.6967	0.6504					
P	0.0584	0.0585	0.3194	0.7136										
PIC	0.8111	0.7798	0.7899	0.7912										

D17S1301					D18S853					D20S482				
Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.
9	0.0038	0.0057	0.0039		9	0.0008	0.0019			9	0.0123	0.0136	0.0040	0.0250
10	0.0279	0.0396	0.0154	0.0286	10	0.0286	0.0321	0.0328	0.0143	10	0.0655	0.0019	0.0100	0.2821
11	0.2914	0.3679	0.1988	0.3179	11	0.3833	<b>0.5585</b>	0.1892	<b>0.4107</b>	11	0.0416	0.0214	0.0239	0.1107
12	0.4503	<b>0.4113</b>	<b>0.4981</b>	<b>0.4357</b>	12	0.1017	0.1000	0.1139	0.0821	12	0.1009	0.0214	0.0398	<b>0.3571</b>
13	0.1777	0.1340	0.2143	0.1929	13	0.1679	0.1038	0.2259	0.1821	13	0.1834	0.1965	0.1554	0.2107
14	0.0452	0.0396	0.0637	0.0214	14	0.2372	0.1755	<b>0.2954</b>	0.2464	14	0.3752	<b>0.4358</b>	<b>0.5139</b>	0.0143
15	0.0038	0.0019	0.0058	0.0036	15	0.0768	0.0283	0.1351	0.0607	15	0.1641	0.2140	0.2032	
N	664	265	259	140	16	0.0038		0.0077	0.0036	16	0.0555	0.0914	0.0498	
H(ob)	0.6491	0.7170	0.6255	0.5643	N	664	265	259	140	17	0.0008	0.0019		
P	0.6597	0.5632	0.7422	0.0338	H(ob)	0.7108	0.6453	0.7722	0.7214	18				
PIC	0.6234	0.6155	0.6132	0.6098	P	0.1395	0.6630	0.4394	0.9546	19	0.0008	0.0019		
					PIC	0.7155	0.5997	0.7630	0.6854	N	660	257	251	140
										H(ob)	0.6918	0.6887	0.6733	0.7286
										P	0.0000	0.1595	0.2887	0.2909
										PIC	0.7523	0.6754	0.6260	0.69

D20S1082					D22S1045				
Allele	Total	Cauc.	Afr. Am.	Hisp.	Allele	Total	Cauc.	Afr. Am.	Hisp.
8	0.0008		0.0019		8	0.0038		0.0097	
9					9				
10	0.0045		0.0116		10	0.0204		0.0428	0.0179
11	0.4639	<b>0.5604</b>	<b>0.3263</b>	<b>0.5357</b>	11	0.1193	0.1396	0.1304	0.0607
12	0.0633	0.0698	0.0695	0.0393	12	0.0317	0.0151	0.0564	0.0179
13	0.0489	0.0057	0.1100	0.0179	13	0.0076	0.0094	0.0039	0.0107
14	0.1642	0.1132	0.2413	0.1179	14	0.0597	0.0585	0.0798	0.0250
15	0.2003	0.1925	0.1815	0.2500	15	0.3293	0.3321	<b>0.2588</b>	<b>0.4536</b>
16	0.0512	0.0509	0.0579	0.0393	16	0.2832	<b>0.3623</b>	0.1868	0.3107
17	0.0030	0.0075			17	0.1337	0.0792	0.2101	0.0964
N	664	265	259	140	18	0.0091	0.0038	0.0156	0.0071
H(ob)	0.6958	0.6528	0.7915	0.6000	19	0.0023		0.0058	
P	0.0789	0.2827	0.5150	0.1146	N	663	265	257	140
PIC	0.6725	0.5908	0.7504	0.5851	H(ob)	0.7840	0.7849	0.8171	0.7214
					P	0.0453	0.9191	0.2013	0.1133
					PIC	0.7418	0.6853	0.8027	0.6348

N: sample size; H(ob): observed heterozygosity; P: Hardy-Weinberg equilibrium, exact test; PIC: polymorphism information content