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SHORT COMMUNICATION

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# Heterozygosities and allelic frequencies of 811 dinucleotide-repeat marker loci in the Taiwanese population

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**Abstract** To evaluate basic informativeness of commercially available microsatellite markers in the Taiwanese population, 190 unrelated Taiwanese children were genotyped using ABI PRISM Linkage Mapping Set-HD5. The average heterozygosity in Taiwanese was slightly lower than that in Caucasians among these 811 microsatellite markers. There were 50 marker loci with heterozygosities lower than 50%. Moreover, allelic distributions at many of the loci were significantly different in two ethnic groups. The results reported here represent a valuable database for disease genes mapping in the Taiwanese population. This database can be easily accessed at the Web site of Vita Genomics, Inc. (http://www.vitagenomics.com/str.html).

**Keywords** Microsatellite marker · Heterozygosity · Allele frequency · Taiwanese population

## Introduction

Microsatellite markers, the short tandem repeats (STRs) evenly distributed in whole genome, are exploited widely for forensic medicine and used to search for identifying genes associated with diseases. The dinucleotide-repeat microsatellites are more useful than other STR markers because of their high heterozygosities and even distribution in the genome. Such markers can be analyzed by using a very small amount of DNA through amplification with polymerase chain reaction and subsequent electrophoresis. In fact, the technology of analyzing microsatellite polymorphism is adapted to automation and high throughput. Due to their highly polymorphism traits, microsatellite markers have been heavily utilized in areas such as mapping disease loci using linkage analyses, loss of heterozygosity analyses, and association studies.

Genotypic information, including allelic frequency and heterozygosity, is available through various databases. However, most of these data were derived from analyses using Caucasian samples. The data obtained from Asian population currently available are: 358 dinucleotide-repeat marker loci validated in 32 normal Japanese individuals (Yamane-Tanaka et al. 1998), 406 microsatellite marker loci validated in 64 unrelated Japanese subjects (Ikari et al. 2002), and 285 autosomal microsatellite marker loci validated in Chinese Singaporeans (Tan et al. 2002). The significant differences of allelic distributions of certain markers have been found between Caucasians and Japanese (Yamane et al. 1997). Since allelic information often differs between ethnic groups and could drastically influence the statistical analysis, it is not certain that currently available information on Caucasians, Japanese, and Singaporeans could be applied to study the disease genes in other ethnic groups.

Theoretically, multiallelic markers always have more power to detect linkage disequilibrium than biallelic markers due to their multiple alleles and greater heterozygosity (Ott and Rabinowitz 1997; Chapman and Wijsman 1998). Existing sets of microsatellite data, if sufficiently dense, may be useful for estimating the density of additional markers needed for screening a region for disease alleles in an association analysis (Schulze et al. 2002). Therefore, gathering information on additional markers in the Asian population is important for mapping disease genes in Asia by linkage analyses or association studies.

The STR genotyping laboratory was established in March 2002 by Vita Genomics, Inc. To date, we have completed several whole-genome screening projects and

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have built a comprehensive database for microsatellite markers. Here we report allelic distribution, allelic frequency, and heterozygosities of 811 dinucleotide-repeat markers among 190 Taiwanese subjects. The data indicate a high degree of genetic similarity between Taiwanese and Japanese. Our results represent an essential database for mapping genes associated with diseases not only in Taiwanese but also in Japanese populations.

## Materials and methods

### DNA preparation

Genomic DNAs were extracted from 190 unrelated Han-Chinese children living in Taiwan. We collected written informed consent from all subjects recruited. The informed-consent documents for all underage participants were signed by their guardians. DNA was isolated from blood samples using QIAamp DNA blood kit (QIAGEN, Valencia, CA, USA) according to the manufacturer's instructions. The isolated genomic DNA was quality checked by agarose gel electrophoresis analysis, quantity determined spectrophotometrically, and stored at −80°C.

### Microsatellite genotyping

Genotyping was performed using the ABI PRISM Linkage Mapping Sets HD-5 (811 markers, 5 cM average resolution, version 2.5, Applied Biosystems, Foster City, CA, USA). Each marker set included a fluorescence-labeled forward primer and a tailing reverse primer. PCR amplifications were carried out according to the manufacturer's instructions, and the PCR products were separated on ABI 3700 DNA analyzers (Applied Biosystems). The use of GeneScan 500 LIZ (Applied Biosystems) as the internal-size standard assists polymorphic fragment length calling and allows more accurate allele calling and unambiguous comparison of data across experimental conditions. Genotypes were initially scored using GeneScan and Genotyper (Applied Biosystems) software and were then verified independently by three individuals.

Genotypic data derived from Caucasians for each marker were obtained from the Foundation Jean DAUSSET-CEPH (http://www.cephb.fr/). A control individual was derived from CEPH 1347-02. There are differences in the allele size of the STR markers between the CEPH database and our genotyping result because the pair primers of each locus had been redesigned by ABI and the mobility of PCR products were different among the variant sequencers (i.e., ABI373, 377, 3100, 3700, etc.). We corrected the differences comparing control data obtained from CEPH database and our genotyping data. Possible error in genotyping or allele calling was checked by comparing the expected number against the observed number of heterozygosities by the Hardy–Weinberg (HW) equilibrium test utilizing the Popgene (version 1.31) program (ftp://ftp.microsoft.com/Softlib/MSLFILES/HPGL.EXE).

## Results and discussion

Genotyping for all 811 markers was performed on 190 unrelated Han-Chinese children living in Taiwan. We experienced no ambiguous genotypes or unsuccessful amplifications. Based on the results of the chi-square test and likelihood ratio test in the Popgene program of the HW test, most loci we tested met the criteria of HW equilibrium. Nevertheless, there were 38 of 811 loci, or less than 5% of total markers tested, which did not meet HW equilibrium criteria. This could be due to the combination factors of random sampling, original genetic variations of the subjects, and the presence of low-frequency alleles. Heterozygosities were calculated at each of the autosomes and X-chromosome marker loci using 190 individuals and 64 females, respectively. Table 1 summarize heterozygosity of the 811 marker loci for the Taiwanese and Caucasian populations. In general, overall heterozygosities of the markers from Taiwanese contained higher similarity to those from Japanese than to those from Caucasians. Among these 811 markers, there were 400 markers identical to the ones used by Ikari et al. (2002). Between Taiwanese and Japanese, there were only two out of 400 loci with differences in heterozygosities greater than or equal to 20%. On the contrary, the differences between Taiwanese and Caucasians were much higher at the rate of 81 out of 811 markers when compared to the Caucasian data from the manufacture. The significant differences between Japanese and Caucasians have also been observed at the rate of 33 out of 400 markers. The level of heterozygosity in the Taiwanese population ranged from 0.13 (DXS8088) to 0.94 (D6S291). As shown in Table 2, 50 marker loci revealed heterozygosity lower than 50% compared to only five marker loci in Caucasians. The X chromosome has lower average heterozygosity in the Taiwanese population, as shown in Table 3. Although heterozygosity was higher overall in Caucasians, a few markers showed higher heterozygosity in Taiwanese. For example, at D6S291, we observed 94% heterozygosity in Taiwanese as compared to 73% reported in Caucasians.

In conclusion, we constructed a comprehensive database of allelic frequencies and heterozygosities of all 811 microsatellite markers evaluated in this study. We believe that our data provide a useful tool for mapping genes associated with diseases in the Taiwanese population. Moreover, data similarity of the 400 markers between Japanese and Taiwanese suggests a potentially powerful application of this database in the Japanese population. Data are freely available to all researchers and can be accessed at the Web site of Vita Genomics, Inc. (http://www.vitagenomics.com/str.html).

**Table 1** Heterozygosities of the 811 tested short tandem repeat (STR) markers (part 1). *Chr* chromosome, *Het* heterozygosity, *Twn* Taiwanese, *Cau* Caucasian

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| 1 | D1S468 | 81 | 76 |
| | D1S2660 | 32 | 78 |
| | D1S214 | 70 | 78 |
| | D1S450 | 80 | 81 |
| | D1S2667 | 81 | 82 |
| | D1S434 | 65 | 61 |
| | D1S507 | 83 | 78 |
| | D1S2697 | 46 | 70 |
| | D1S2644 | 77 | 80 |
| | D1S199 | 80 | 83 |
| | D1S2864 | 59 | 81 |
| | D1S234 | 82 | 81 |
| | D1S233 | 84 | 85 |
| | D1S255 | 34 | 75 |
| | D1S2892 | 84 | 88 |
| | D1S2713 | 76 | 76 |
| | D1S2797 | 75 | 74 |
| | D1S2652 | 80 | 62 |
| | D1S2890 | 71 | 81 |
| | D1S2873 | 54 | 69 |
| | D1S2737 | 73 | 75 |
| | D1S2846 | 68 | 54 |
| | D1S230 | 59 | 78 |
| | D1S198 | 82 | 79 |
| | D1S2841 | 83 | 78 |
| | D1S500 | 78 | 62 |
| | D1S207 | 80 | 84 |
| | D1S2766 | 77 | 74 |
| | D1S435 | 66 | 73 |
| | D1S2868 | 65 | 76 |
| | D1S2793 | 66 | 77 |
| | D1S206 | 80 | 82 |
| | D1S495 | 82 | 87 |
| | D1S2726 | 68 | 75 |
| | D1S252 | 77 | 81 |
| | D1S498 | 74 | 82 |
| | D1S2635 | 73 | 87 |
| | D1S484 | 70 | 64 |
| | D1S2878 | 80 | 84 |
| | D1S196 | 58 | 74 |
| | D1S452 | 60 | 75 |
| | D1S218 | 82 | 83 |
| | D1S2818 | 65 | 70 |
| | D1S238 | 80 | 86 |
| | D1S2877 | 67 | 71 |
| | D1S412 | 74 | 70 |
| | D1S413 | 68 | 76 |
| | D1S249 | 70 | 87 |
| | D1S2692 | 88 | 86 |
| | D1S245 | 55 | 81 |
| | D1S425 | 54 | 81 |
| | D1S227 | 60 | 69 |
| | D1S213 | 84 | 86 |
| | D1S2833 | 83 | 82 |
| | D1S2709 | 60 | 72 |
| | D1S2800 | 74 | 77 |
| | D1S2850 | 74 | 64 |
| | D1S2670 | 79 | 83 |
| | D1S2785 | 86 | 76 |
| | D1S304 | 59 | 60 |
| | D1S2842 | 65 | 76 |
| | D1S423 | 65 | 60 |
| | D1S2836 | 71 | 79 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| 2 | D2S323 | 59 | 57 |
| | D2S319 | 72 | 73 |
| | D2S2166 | 58 | 85 |
| | D2S2211 | 68 | 74 |
| | D2S162 | 81 | 75 |
| | D2S168 | 75 | 82 |
| | D2S149 | 83 | 74 |
| | D2S305 | 78 | 72 |
| | D2S2150 | 66 | 78 |
| | D2S165 | 86 | 85 |
| | D2S352 | 65 | 83 |
| | D2S367 | 87 | 86 |
| | D2S2163 | 76 | 76 |
| | D2S2259 | 60 | 79 |
| | D2S391 | 70 | 79 |
| | D2S2369 | 53 | 69 |
| | D2S337 | 85 | 88 |
| | D2S2368 | 84 | 83 |
| | D2S303 | 74 | 65 |
| | D2S2110 | 75 | 79 |
| | D2S286 | 80 | 66 |
| | D2S2333 | 83 | 82 |
| | D2S388 | 73 | 78 |
| | D2S2216 | 65 | 76 |
| | D2S2264 | 62 | 77 |
| | D2S293 | 78 | 84 |
| | D2S160 | 74 | 78 |
| | D2S347 | 68 | 80 |
| | D2S2271 | 69 | 83 |
| | D2S112 | 71 | 71 |
| | D2S151 | 79 | 82 |
| | D2S2241 | 71 | 77 |
| | D2S142 | 71 | 76 |
| | D2S306 | 70 | 70 |
| | D2S2330 | 79 | 81 |
| | D2S335 | 84 | 79 |
| | D2S2188 | 75 | 67 |
| | D2S364 | 75 | 80 |
| | D2S118 | 77 | 79 |
| | D2S117 | 85 | 82 |
| | D2S2358 | 63 | 81 |
| | D2S325 | 74 | 82 |
| | D2S2321 | 58 | 76 |
| | D2S2361 | 75 | 76 |
| | D2S2382 | 47 | 81 |
| | D2S163 | 78 | 80 |
| | D2S126 | 82 | 82 |
| | D2S133 | 81 | 69 |
| | D2S2354 | 56 | 81 |
| | D2S362 | 64 | 77 |
| | D2S396 | 89 | 83 |
| | D2S2344 | 77 | 78 |
| | D2S206 | 82 | 80 |
| | D2S2202 | 55 | 68 |
| | D2S338 | 85 | 81 |
| | D2S2285 | 65 | 64 |
| | D2S125 | 83 | 82 |
| | D2S140 | 75 | 78 |
| 3 | D3S1270 | 57 | 75 |
| | D3S1297 | 74 | 82 |
| | D3S3630 | 81 | 82 |
| | D3S3706 | 47 | 64 |
| | D3S1304 | 80 | 80 |
| | D3S3728 | 63 | 68 |
| | D3S1597 | 73 | 80 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D3S1263 | 89 | 86 |
| | D3S2338 | 77 | 86 |
| | D3S3659 | 78 | 65 |
| | D3S1266 | 71 | 73 |
| | D3S1609 | 55 | 64 |
| | D3S3567 | 57 | 70 |
| | D3S1277 | 68 | 82 |
| | D3S3521 | 80 | 83 |
| | D3S3685 | 82 | 89 |
| | D3S1581 | 77 | 88 |
| | D3S1289 | 80 | 81 |
| | D3S1300 | 83 | 82 |
| | D3S1600 | 73 | 72 |
| | D3S1285 | 74 | 73 |
| | D3S3697 | 69 | 88 |
| | D3S1566 | 85 | 84 |
| | D3S3681 | 81 | 83 |
| | D3S1276 | 50 | 72 |
| | D3S3634 | 72 | 78 |
| | D3S1603 | 66 | 71 |
| | D3S1271 | 63 | 73 |
| | D3S3574 | 77 | 85 |
| | D3S2496 | 64 | 77 |
| | D3S1278 | 77 | 87 |
| | D3S1558 | 46 | 78 |
| | D3S1267 | 76 | 88 |
| | D3S3606 | 87 | 82 |
| | D3S1292 | 89 | 85 |
| | D3S3637 | 88 | 90 |
| | D3S1309 | 78 | 76 |
| | D3S1569 | 76 | 80 |
| | D3S1593 | 77 | 77 |
| | D3S1555 | 71 | 79 |
| | D3S1279 | 76 | 85 |
| | D3S3668 | 82 | 83 |
| | D3S1614 | 74 | 83 |
| | D3S3725 | 85 | 84 |
| | D3S1565 | 76 | 64 |
| | D3S3715 | 63 | 79 |
| | D3S3609 | 86 | 87 |
| | D3S3592 | 77 | 80 |
| | D3S1262 | 71 | 80 |
| | D3S3686 | 70 | 80 |
| | D3S1580 | 81 | 84 |
| | D3S1601 | 80 | 85 |
| | D3S2748 | 76 | 74 |
| | D3S1265 | 77 | 86 |
| 4 | D4S2936 | 65 | 83 |
| | D4S412 | 71 | 77 |
| | D4S3023 | 79 | 69 |
| | D4S2935 | 64 | 62 |
| | D4S403 | 61 | 77 |
| | D4S419 | 65 | 77 |
| | D4S2994 | 53 | 82 |
| | D4S3022 | 89 | 88 |
| | D4S391 | 81 | 85 |
| | D4S2912 | 79 | 67 |
| | D4S1587 | 72 | 74 |
| | D4S405 | 73 | 86 |
| | D4S2971 | 74 | 80 |
| | D4S428 | 81 | 76 |
| | D4S1592 | 83 | 72 |
| | D4S398 | 79 | 82 |
| | D4S3004 | 63 | 80 |
| | D4S392 | 79 | 82 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D4S3042 | 79 | 84 |
| | D4S2964 | 73 | 76 |
| | D4S1534 | 81 | 77 |
| | D4S2460 | 57 | 72 |
| | D4S414 | 78 | 89 |
| | D4S2986 | 69 | 80 |
| | D4S1572 | 81 | 84 |
| | D4S406 | 68 | 87 |
| | D4S402 | 72 | 91 |
| | D4S1615 | 57 | 74 |
| | D4S1575 | 28 | 65 |
| | D4S1579 | 32 | 65 |
| | D4S424 | 66 | 83 |
| | D4S1586 | 70 | 77 |
| | D4S2962 | 76 | 82 |
| | D4S413 | 60 | 85 |
| | D4S3046 | 71 | 76 |
| | D4S2952 | 67 | 58 |
| | D4S1597 | 28 | 76 |
| | D4S1595 | 71 | 72 |
| | D4S1539 | 41 | 68 |
| | D4S415 | 75 | 80 |
| | D4S2920 | 70 | 68 |
| | D4S1535 | 78 | 77 |
| | D4S2924 | 75 | 72 |
| | D4S3051 | 71 | 51 |
| | D4S426 | 69 | 76 |
| | D4S2930 | 75 | 80 |
| 5 | D5S1981 | 65 | 73 |
| | D5S417 | 72 | 75 |
| | D5S2088 | 67 | 83 |
| | D5S406 | 67 | 79 |
| | D5S1953 | 45 | 77 |
| | D5S630 | 86 | 89 |
| | D5S416 | 69 | 77 |
| | D5S2031 | 59 | 75 |
| | D5S419 | 85 | 81 |
| | D5S1993 | 74 | 78 |
| | D5S674 | 75 | 78 |
| | D5S426 | 77 | 80 |
| | D5S2021 | 62 | 58 |
| | D5S418 | 83 | 80 |
| | D5S407 | 85 | 86 |
| | D5S1969 | 85 | 86 |
| | D5S427 | 62 | 84 |
| | D5S647 | 76 | 82 |
| | D5S424 | 60 | 76 |
| | D5S672 | 65 | 63 |
| | D5S641 | 83 | 77 |
| | D5S428 | 72 | 76 |
| | D5S618 | 84 | 80 |
| | D5S644 | 80 | 85 |
| | D5S495 | 77 | 82 |
| | D5S433 | 67 | 86 |
| | D5S2084 | 64 | 71 |
| | D5S2027 | 60 | 78 |
| | D5S2055 | 79 | 84 |
| | D5S471 | 73 | 76 |
| | D5S2115 | 70 | 76 |
| | D5S2011 | 81 | 86 |
| | D5S436 | 69 | 83 |
| | D5S2090 | 62 | 83 |
| | D5S410 | 52 | 79 |
| | D5S2049 | 60 | 77 |
| | D5S422 | 81 | 84 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D5S2040 | 80 | 78 |
| | D5S2050 | 72 | 71 |
| | D5S400 | 84 | 82 |
| | D5S1960 | 72 | 80 |
| | D5S2073 | 85 | 79 |
| | D5S408 | 78 | 73 |
| 6 | D6S1617 | 82 | 86 |
| | D6S1574 | 73 | 84 |
| | D6S309 | 78 | 83 |
| | D6S470 | 67 | 80 |
| | D6S1721 | 65 | 78 |
| | D6S259 | 81 | 74 |
| | D6S289 | 79 | 79 |
| | D6S422 | 64 | 77 |
| | D6S1660 | 66 | 77 |
| | D6S276 | 77 | 83 |
| | D6S291 | 94 | 73 |
| | D6S1610 | 78 | 84 |
| | D6S1575 | 84 | 82 |
| | D6S1549 | 64 | 62 |
| | D6S282 | 86 | 88 |
| | D6S1650 | 69 | 80 |
| | D6S452 | 78 | 85 |
| | D6S272 | 76 | 73 |
| | D6S1573 | 78 | 79 |
| | D6S257 | 86 | 87 |
| | D6S460 | 80 | 81 |
| | D6S1609 | 78 | 81 |
| | D6S462 | 52 | 68 |
| | D6S300 | 66 | 77 |
| | D6S1671 | 87 | 89 |
| | D6S434 | 75 | 86 |
| | D6S1698 | 81 | 82 |
| | D6S287 | 63 | 85 |
| | D6S262 | 77 | 82 |
| | D6S1656 | 71 | 74 |
| | D6S270 | 71 | 77 |
| | D6S292 | 83 | 83 |
| | D6S1569 | 65 | 79 |
| | D6S308 | 64 | 75 |
| | D6S1654 | 71 | 82 |
| | D6S441 | 80 | 86 |
| | D6S1577 | 70 | 87 |
| | D6S1581 | 57 | 72 |
| | D6S305 | 79 | 84 |
| | D6S1599 | 88 | 70 |
| | D6S1719 | 81 | 75 |
| | D6S264 | 48 | 70 |
| | D6S1697 | 34 | 55 |
| | D6S446 | 45 | 62 |
| | D6S281 | 82 | 68 |
| 7 | D7S531 | 72 | 77 |
| | D7S517 | 78 | 83 |
| | D7S641 | 68 | 72 |
| | D7S513 | 91 | 83 |
| | D7S2464 | 58 | 66 |
| | D7S664 | 56 | 71 |
| | D7S2557 | 69 | 74 |
| | D7S507 | 86 | 89 |
| | D7S493 | 68 | 88 |
| | D7S516 | 74 | 76 |
| | D7S2496 | 88 | 71 |
| | D7S2252 | 79 | 87 |
| | D7S484 | 78 | 74 |
| | D7S510 | 75 | 77 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D7S691 | 63 | 74 |
| | D7S2427 | 67 | 81 |
| | D7S519 | 73 | 81 |
| | D7S506 | 83 | 88 |
| | D7S502 | 87 | 84 |
| | D7S2476 | 53 | 64 |
| | D7S1870 | 63 | 75 |
| | D7S669 | 85 | 80 |
| | D7S630 | 77 | 73 |
| | D7S657 | 83 | 81 |
| | D7S515 | 75 | 82 |
| | D7S2459 | 69 | 77 |
| | D7S486 | 78 | 81 |
| | D7S530 | 66 | 78 |
| | D7S640 | 88 | 85 |
| | D7S2560 | 76 | 86 |
| | D7S684 | 84 | 81 |
| | D7S2513 | 80 | 74 |
| | D7S661 | 82 | 75 |
| | D7S636 | 93 | 90 |
| | D7S483 | 81 | 83 |
| | D7S798 | 75 | 84 |
| | D7S2465 | 80 | 83 |
| | D7S2423 | 44 | 72 |
| 8 | D8S264 | 85 | 83 |
| | D8S277 | 81 | 73 |
| | D8S503 | 54 | 74 |
| | D8S520 | 71 | 78 |
| | D8S550 | 75 | 87 |
| | D8S552 | 76 | 79 |
| | D8S1827 | 56 | 67 |
| | D8S549 | 49 | 63 |
| | D8S258 | 68 | 70 |
| | D8S1734 | 60 | 67 |
| | D8S1771 | 62 | 75 |
| | D8S1820 | 30 | 74 |
| | D8S1769 | 61 | 83 |
| | D8S505 | 78 | 79 |
| | D8S532 | 76 | 84 |
| | D8S285 | 74 | 78 |
| | D8S260 | 81 | 81 |
| | D8S543 | 69 | 75 |
| | D8S1705 | 76 | 84 |
| | D8S275 | 50 | 76 |
| | D8S270 | 69 | 79 |
| | D8S1778 | 83 | 87 |
| | D8S1762 | 71 | 77 |
| | D8S1784 | 72 | 67 |
| | D8S1779 | 75 | 76 |
| | D8S514 | 70 | 77 |
| | D8S1799 | 80 | 84 |
| | D8S1720 | 66 | 81 |
| | D8S284 | 83 | 83 |
| | D8S256 | 77 | 84 |
| | D8S272 | 80 | 81 |
| | D8S1837 | 80 | 80 |
| | D8S1743 | 45 | 82 |
| | D8S1836 | 82 | 84 |
| 9 | D9S1858 | 69 | 58 |
| | D9S1779 | 52 | 64 |
| | D9S288 | 84 | 84 |
| | D9S1810 | 38 | 78 |
| | D9S286 | 80 | 88 |
| | D9S168 | 66 | 76 |
| | D9S269 | 56 | 75 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D9S285 | 59 | 78 |
| | D9S157 | 78 | 84 |
| | D9S171 | 31 | 79 |
| | D9S259 | 43 | 68 |
| | D9S169 | 80 | 84 |
| | D9S161 | 54 | 78 |
| | D9S1853 | 64 | 64 |
| | D9S1817 | 82 | 88 |
| | D9S1874 | 85 | 83 |
| | D9S273 | 61 | 74 |
| | D9S175 | 72 | 85 |
| | D9S1834 | 55 | 70 |
| | D9S1674 | 81 | 73 |
| | D9S1843 | 70 | 81 |
| | D9S167 | 82 | 87 |
| | D9S1812 | 69 | 68 |
| | D9S283 | 70 | 80 |
| | D9S1796 | 81 | 79 |
| | D9S1781 | 80 | 79 |
| | D9S287 | 67 | 67 |
| | D9S1690 | 74 | 78 |
| | D9S271 | 67 | 65 |
| | D9S1677 | 88 | 81 |
| | D9S289 | 81 | 75 |
| | D9S1776 | 71 | 84 |
| | D9S1682 | 63 | 68 |
| | D9S290 | 69 | 83 |
| | D9S164 | 82 | 80 |
| | D9S1818 | 68 | 72 |
| | D9S1826 | 79 | 69 |
| | D9S158 | 48 | 69 |
| | D9S1838 | 78 | 83 |
| 10 | D10S249 | 77 | 75 |
| | D10S1745 | 76 | 85 |
| | D10S591 | 57 | 71 |
| | D10S189 | 75 | 73 |
| | D10S1649 | 78 | 84 |
| | D10S547 | 49 | 74 |
| | D10S570 | 77 | 81 |
| | D10S191 | 84 | 82 |
| | D10S1653 | 78 | 78 |
| | D10S548 | 63 | 70 |
| | D10S197 | 76 | 75 |
| | D10S213 | 79 | 83 |
| | D10S208 | 79 | 80 |
| | D10S1780 | 72 | 66 |
| | D10S578 | 62 | 66 |
| | D10S196 | 68 | 79 |
| | D10S1790 | 68 | 84 |
| | D10S1652 | 66 | 78 |
| | D10S581 | 84 | 80 |
| | D10S210 | 81 | 79 |
| | D10S537 | 79 | 83 |
| | D10S580 | 60 | 73 |
| | D10S1730 | 45 | 83 |
| | D10S1686 | 72 | 86 |
| | D10S1765 | 79 | 84 |
| | D10S185 | 77 | 77 |
| | D10S1709 | 76 | 74 |
| | D10S192 | 84 | 78 |
| | D10S597 | 50 | 64 |
| | D10S1693 | 76 | 80 |
| | D10S587 | 80 | 80 |
| | D10S1656 | 79 | 75 |
| | D10S575 | 75 | 63 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D10S217 | 84 | 82 |
| | D10S1655 | 57 | 68 |
| | D10S1651 | 59 | 80 |
| | D10S212 | 28 | 72 |
| 11 | D11S1363 | 69 | 59 |
| | D11S4046 | 77 | 86 |
| | D11S4146 | 81 | 70 |
| | D11S1760 | 85 | 75 |
| | D11S1338 | 71 | 74 |
| | D11S4149 | 52 | 77 |
| | D11S4116 | 82 | 80 |
| | D11S902 | 81 | 80 |
| | D11S4190 | 80 | 82 |
| | D11S915 | 81 | 81 |
| | D11S904 | 74 | 83 |
| | D11S914 | 57 | 71 |
| | D11S935 | 73 | 73 |
| | D11S4102 | 62 | 77 |
| | D11S905 | 79 | 75 |
| | D11S4191 | 89 | 87 |
| | D11S987 | 82 | 82 |
| | D11S4162 | 52 | 64 |
| | D11S1314 | 82 | 78 |
| | D11S4207 | 83 | 89 |
| | D11S937 | 83 | 88 |
| | D11S901 | 66 | 82 |
| | D11S4147 | 65 | 81 |
| | D11S4175 | 85 | 89 |
| | D11S917 | 65 | 80 |
| | D11S898 | 33 | 85 |
| | D11S4090 | 83 | 83 |
| | D11S908 | 43 | 76 |
| | D11S4127 | 72 | 71 |
| | D11S925 | 79 | 84 |
| | D11S4094 | 70 | 80 |
| | D11S4151 | 53 | 79 |
| | D11S912 | 78 | 80 |
| | D11S4126 | 63 | 59 |
| | D11S1320 | 44 | 68 |
| | D11S968 | 62 | 81 |
| 12 | D12S352 | 78 | 73 |
| | D12S1725 | 74 | 79 |
| | D12S99 | 83 | 84 |
| | D12S336 | 74 | 82 |
| | D12S1697 | 78 | 83 |
| | D12S358 | 78 | 76 |
| | D12S364 | 84 | 87 |
| | D12S310 | 63 | 69 |
| | D12S1682 | 82 | 78 |
| | D12S1617 | 84 | 80 |
| | D12S1640 | 70 | 54 |
| | D12S345 | 85 | 87 |
| | D12S1663 | 53 | 78 |
| | D12S85 | 81 | 69 |
| | D12S368 | 61 | 81 |
| | D12S83 | 83 | 82 |
| | D12S313 | 79 | 79 |
| | D12S326 | 69 | 80 |
| | D12S1708 | 61 | 72 |
| | D12S351 | 74 | 75 |
| | D12S346 | 73 | 84 |
| | D12S78 | 82 | 92 |
| | D12S1613 | 59 | 62 |
| | D12S1583 | 77 | 88 |
| | D12S1646 | 81 | 96 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D12S79 | 60 | 72 |
| | D12S1718 | 40 | 44 |
| | D12S86 | 72 | 90 |
| | D12S304 | 72 | 56 |
| | D12S324 | 64 | 69 |
| | D12S1675 | 74 | 74 |
| | D12S1659 | 52 | 79 |
| | D12S367 | 74 | 76 |
| | D12S1723 | 79 | 67 |
| | D12S1638 | 66 | 69 |
| 13 | D13S1236 | 85 | 67 |
| | D13S175 | 71 | 76 |
| | D13S1243 | 72 | 78 |
| | D13S1304 | 66 | 73 |
| | D13S217 | 78 | 68 |
| | D13S289 | 68 | 67 |
| | D13S171 | 64 | 73 |
| | D13S219 | 73 | 64 |
| | D13S218 | 64 | 66 |
| | D13S263 | 78 | 84 |
| | D13S153 | 90 | 81 |
| | D13S1320 | 39 | 76 |
| | D13S1296 | 85 | 86 |
| | D13S156 | 78 | 80 |
| | D13S1306 | 79 | 85 |
| | D13S170 | 85 | 90 |
| | D13S265 | 61 | 70 |
| | D13S1241 | 81 | 82 |
| | D13S159 | 77 | 90 |
| | D13S158 | 76 | 82 |
| | D13S1322 | 28 | 63 |
| | D13S173 | 74 | 82 |
| | D13S1265 | 83 | 80 |
| | D13S285 | 86 | 81 |
| | D13S293 | 59 | 50 |
| 14 | D14S261 | 64 | 75 |
| | D14S1023 | 74 | 82 |
| | D14S283 | 78 | 81 |
| | D14S990 | 77 | 85 |
| | D14S972 | 67 | 75 |
| | D14S275 | 53 | 70 |
| | D14S1040 | 68 | 73 |
| | D14S70 | 74 | 75 |
| | D14S75 | 83 | 78 |
| | D14S288 | 88 | 83 |
| | D14S276 | 76 | 76 |
| | D14S980 | 87 | 87 |
| | D14S274 | 52 | 72 |
| | D14S63 | 73 | 76 |
| | D14S258 | 65 | 79 |
| | D14S1036 | 71 | 79 |
| | D14S74 | 75 | 79 |
| | D14S1037 | 63 | 82 |
| | D14S68 | 79 | 91 |
| | D14S1044 | 63 | 65 |
| | D14S280 | 71 | 68 |
| | D14S1050 | 75 | 81 |
| | D14S1054 | 74 | 76 |
| | D14S65 | 76 | 79 |
| | D14S985 | 73 | 76 |
| | D14S1051 | 20 | 32 |
| | D14S292 | 72 | 73 |
| | D14S1007 | 73 | 77 |
| 15 | D15S128 | 80 | 79 |
| | D15S986 | 78 | 71 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D15S975 | 77 | 45 |
| | D15S1002 | 78 | 79 |
| | D15S1019 | 64 | 59 |
| | D15S165 | 31 | 80 |
| | D15S1007 | 82 | 87 |
| | D15S1040 | 77 | 77 |
| | D15S118 | 67 | 76 |
| | D15S1012 | 58 | 72 |
| | D15S994 | 70 | 73 |
| | D15S978 | 83 | 83 |
| | D15S1016 | 83 | 88 |
| | D15S117 | 71 | 79 |
| | D15S1033 | 78 | 70 |
| | D15S1036 | 72 | 80 |
| | D15S153 | 81 | 87 |
| | D15S988 | 74 | 80 |
| | D15S131 | 77 | 84 |
| | D15S205 | 87 | 88 |
| | D15S979 | 82 | 85 |
| | D15S127 | 80 | 87 |
| | D15S130 | 77 | 71 |
| | D15S1014 | 73 | 73 |
| | D15S212 | 78 | 71 |
| | D15S120 | 75 | 75 |
| 16 | D16S521 | 61 | 71 |
| | D16S3027 | 83 | 88 |
| | D16S423 | 84 | 75 |
| | D16S418 | 80 | 83 |
| | D16S404 | 75 | 82 |
| | D16S3075 | 82 | 80 |
| | D16S3102 | 74 | 69 |
| | D16S500 | 77 | 80 |
| | D16S3103 | 44 | 82 |
| | D16S3041 | 83 | 82 |
| | D16S3046 | 74 | 74 |
| | D16S403 | 74 | 86 |
| | D16S3068 | 71 | 78 |
| | D16S3100 | 69 | 67 |
| | D16S3136 | 59 | 70 |
| | D16S415 | 70 | 74 |
| | D16S3034 | 58 | 65 |
| | D16S3140 | 82 | 82 |
| | D16S3057 | 75 | 73 |
| | D16S514 | 68 | 82 |
| | D16S503 | 56 | 81 |
| | D16S3066 | 62 | 80 |
| | D16S515 | 85 | 80 |
| | D16S3049 | 69 | 77 |
| | D16S516 | 60 | 73 |
| | D16S3040 | 74 | 74 |
| | D16S505 | 86 | 76 |
| | D16S3091 | 83 | 74 |
| | D16S520 | 80 | 84 |
| 17 | D17S849 | 75 | 67 |
| | D17S831 | 87 | 82 |
| | D17S1828 | 77 | 80 |
| | D17S1876 | 51 | 84 |
| | D17S938 | 84 | 76 |
| | D17S1791 | 60 | 85 |
| | D17S1852 | 81 | 87 |
| | D17S799 | 68 | 68 |
| | D17S921 | 67 | 72 |
| | D17S1857 | 44 | 64 |
| | D17S1824 | 79 | 83 |
| | D17S798 | 55 | 80 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D17S927 | 74 | 77 |
| | D17S1868 | 82 | 73 |
| | D17S1795 | 49 | 72 |
| | D17S787 | 80 | 81 |
| | D17S957 | 50 | 45 |
| | D17S944 | 42 | 75 |
| | D17S1816 | 83 | 83 |
| | D17S949 | 80 | 80 |
| | D17S1862 | 88 | 83 |
| | D17S1807 | 83 | 86 |
| | D17S785 | 74 | 83 |
| | D17S1847 | 76 | 66 |
| | D17S836 | 71 | 63 |
| | D17S784 | 63 | 77 |
| | D17S928 | 83 | 76 |
| 18 | D18S59 | 81 | 82 |
| | D18S476 | 57 | 76 |
| | D18S63 | 68 | 80 |
| | D18S1132 | 81 | 67 |
| | D18S452 | 79 | 83 |
| | D18S464 | 59 | 65 |
| | D18S1150 | 60 | 71 |
| | D18S53 | 80 | 80 |
| | D18S453 | 73 | 82 |
| | D18S1107 | 74 | 72 |
| | D18S478 | 61 | 64 |
| | D18S56 | 72 | 75 |
| | D18S1102 | 76 | 79 |
| | D18S468 | 74 | 80 |
| | D18S450 | 71 | 79 |
| | D18S474 | 80 | 82 |
| | D18S1127 | 86 | 87 |
| | D18S1129 | 78 | 85 |
| | D18S64 | 80 | 75 |
| | D18S1147 | 85 | 85 |
| | D18S68 | 81 | 80 |
| | D18S465 | 75 | 78 |
| | D18S61 | 82 | 88 |
| | D18S469 | 60 | 65 |
| | D18S1161 | 75 | 83 |
| | D18S462 | 69 | 70 |
| | D18S70 | 81 | 84 |
| 19 | D19S886 | 69 | 64 |
| | D19S209 | 80 | 78 |
| | D19S894 | 83 | 77 |
| | D19S216 | 59 | 76 |
| | D19S884 | 82 | 86 |
| | D19S865 | 84 | 89 |
| | D19S221 | 83 | 87 |
| | D19S226 | 87 | 86 |
| | D19S566 | 76 | 87 |
| | D19S931 | 64 | 78 |
| | D19S414 | 61 | 78 |
| | D19S220 | 87 | 87 |
| | D19S420 | 76 | 79 |
| | D19S903 | 80 | 79 |
| | D19S902 | 84 | 80 |
| | D19S904 | 50 | 65 |
| | D19S571 | 42 | 83 |
| | D19S888 | 75 | 82 |
| | D19S921 | 80 | 78 |
| | D19S572 | 85 | 81 |
| | D19S418 | 55 | 66 |
| | D19S210 | 62 | 75 |
| 20 | D20S117 | 85 | 85 |
| | D20S906 | 31 | 78 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | D20S842 | 87 | 86 |
| | D20S889 | 77 | 84 |
| | D20S882 | 75 | 72 |
| | D20S846 | 77 | 78 |
| | D20S115 | 52 | 67 |
| | D20S851 | 82 | 74 |
| | D20S186 | 86 | 86 |
| | D20S898 | 51 | 81 |
| | D20S112 | 73 | 82 |
| | D20S912 | 75 | 81 |
| | D20S871 | 83 | 89 |
| | D20S195 | 76 | 81 |
| | D20S107 | 77 | 80 |
| | D20S861 | 62 | 67 |
| | D20S119 | 76 | 83 |
| | D20S178 | 75 | 83 |
| | D20S891 | 85 | 85 |
| | D20S887 | 83 | 83 |
| | D20S196 | 87 | 81 |
| | D20S902 | 73 | 76 |
| | D20S100 | 75 | 77 |
| | D20S171 | 78 | 78 |
| | D20S173 | 65 | 67 |
| 21 | D21S1911 | 68 | 69 |
| | D21S1904 | 78 | 53 |
| | D21S1256 | 63 | 65 |
| | D21S1899 | 66 | 86 |
| | D21S1884 | 72 | 59 |
| | D21S1922 | 36 | 65 |
| | D21S1914 | 80 | 86 |
| | D21S263 | 83 | 75 |
| | D21S1919 | 79 | 82 |
| | D21S1255 | 62 | 80 |
| | D21S1252 | 79 | 80 |
| | D21S266 | 84 | 59 |
| 22 | D22S420 | 73 | 77 |
| | D22S539 | 56 | 58 |
| | D22S1174 | 80 | 74 |
| | D22S315 | 81 | 78 |
| | D22S1154 | 53 | 73 |
| | D22S1163 | 65 | 75 |
| | D22S280 | 77 | 82 |
| | D22S277 | 86 | 85 |
| | D22S283 | 82 | 89 |
| | D22S423 | 81 | 82 |
| | D22S274 | 79 | 77 |
| | D22S1170 | 72 | 64 |
| | D22S1169 | 73 | 79 |
| X | DXS1060 | 85 | 84 |
| | DXS1223 | 52 | 75 |
| | DXS8051 | 84 | 88 |
| | DXS7108 | 62 | 75 |
| | DXS1224 | 55 | 61 |
| | DXS987 | 80 | 83 |
| | DXS8019 | 87 | 80 |
| | DXS7593 | 77 | 70 |
| | DXS1226 | 84 | 84 |
| | DXS1061 | 65 | 73 |
| | DXS1214 | 75 | 79 |
| | DXS8090 | 71 | 81 |
| | DXS8102 | 42 | 65 |
| | DXS1068 | 65 | 79 |
| | DXS8015 | 50 | 74 |
| | DXS993 | 68 | 79 |
| | DXS8080 | 42 | 68 |
| | DXS8083 | 43 | 74 |

**Table 1** (Continued)

| Chr | Marker | Het | |
|---|---|---|---|
| | | Twn | Cau |
| | DXS1055 | 68 | 72 |
| | DXS1039 | 68 | 61 |
| | DXS991 | 78 | 80 |
| | DXS1216 | 46 | 61 |
| | DXS986 | 89 | 77 |
| | DXS1196 | 72 | 79 |
| | DXS1217 | 51 | 62 |
| | DXS990 | 65 | 74 |
| | DXS8077 | 86 | 60 |
| | DXS8020 | 67 | 78 |
| | DXS1106 | 27 | 67 |
| | DXS1059 | 67 | 72 |
| | DXS8088 | 13 | 62 |
| | DXS8055 | 21 | 65 |
| | DXS8064 | 37 | 56 |
| | DXS8067 | 73 | 70 |
| | DXS1001 | 81 | 82 |
| | DXS8009 | 73 | 52 |
| | DXS1047 | 82 | 81 |
| | DXS1062 | 75 | 74 |
| | DXS984 | 32 | 72 |
| | DXS1205 | 74 | 72 |
| | DXS1227 | 54 | 73 |
| | DXS8106 | 69 | 69 |
| | DXS8043 | 76 | 80 |
| | DXS8091 | 55 | 78 |
| | DXS8045 | 60 | 49 |
| | DXS998 | 44 | 57 |
| | DXS8069 | 68 | 62 |
| | DXS1073 | 64 | 80 |

**Table 2** Comparison of heterozygosities at 811 test loci between Taiwanese and Caucasians. *ABI* Applied Biosystems, Inc., Foster City, CA, USA

| Observed heterozygosity (%) | No. of markers in each category among Taiwanese tested | No. of markers in each category in ABI (Caucasian) |
|---|---|---|
| 11–20 | 1 | 0 |
| 21–30 | 7 | 0 |
| 31–40 | 14 | 1 |
| 41–50 | 28 | 4 |
| 51–60 | 76 | 19 |
| 61–70 | 168 | 103 |
| 71–80 | 302 | 320 |
| 81–90 | 212 | 356 |
| 91–100 | 3 | 8 |

**Table 3** Comparison of averaged ethnic heterozygosities between autosome and sex chromosome. *VITA* Vita Genomics, Inc., Wugu Shiang, Taiwan, *ABI* Applied Biosystems, Inc., Foster City, CA, USA

| | Taiwanese (VITA) | Caucasian (ABI) |
|---|---|---|
| CH 1–22 | 0.72 | 0.77 |
| CH X | 0.63 | 0.72 |

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## References

Chapman NH, Wijsman EM (1998) Genome screens using linkage disequilibrium tests: optimal marker characteristics and feasibility. Am J Hum Genet 63:1872–1885

Ikari K, Onda H, Furushima K, Maeda S, Harata S, Takeda J (2002) Establishment of an optimized set of 406 microsatellite markers covering the whole genome for the Japanese population. J Hum Genet 46:207–210

Ott J, Rabinowitz D (1997) The effect of marker heterozygosity on the power to detect linkage disequilibrium. Genetics 147:927–930

Schulze TG, Chen YS, Akula N, Henessy K, Badner JA, McInnis MG, DePaulo JR, Schumacher J, Cichon S, Propping P, Maier W, Rietschel M, Nothen MM, McMahan FJ (2002) Can long-range microsatellite data be used to predict short-range linkage disequilibrium? Hum Mol Genet 11(12):1363–1372

Tan EC, Wu H, Yong R, Tan S, Chang J, Gan L, Yap E (2002) Heterozygosities and allelic frequencies of a set of microsatellite markers used for genome-wide scans in a Chinese population. J Hum Genet 47:623–631

Yamane Y, Nakamura Y, Isomura M (1997) Allelic frequencies of twelve dinucleotide repeat marker loci on chromosome 13 in the normal Japanese population. Jpn J Hum Genet 42(4):533–537

Yamane-Tanaka Y, Kogawa K, Tanaka T, Nakamura Y, Isomura M (1998) Heterozygosities and allelic frequencies of 358 dinucleotide-repeat marker loci in the Japanese population. J Hum Genet 43:165–168