Single- and Multiple-Locus Measures of Genetic Distance between Groups
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Harris, H., D. A. Hopkinson, and Y. H. Edward. 1977. Polymorphism and the subunit structure of enzymes: a contribution to the neutralist-selectionist controversy. Proc. Nat. Acad. Sci. USA 74:698–701.

Hedrick, P. W. 1971. A new approach to measuring genetic similarity. Evolution 25:276–280.

Lewontin, R. C. 1972. The apportionment of human diversity. Evolut. Biol. 6:381–398.

Mitton, J. B. 1977. Genetic differentiation of races of man as judged by single-locus and multilocus analyses. Amer. Natur. 111:203–212.

Nei, M. 1973*a*. Analysis of gene diversity in subdivided populations. Proc. Nat. Acad. Sci. USA 70:3321–3323.

———. 1973*b*. The theory and estimation of genetic distance. Pages 45–54 *in* N. E. Morton, ed. Genetic structure of populations. University of Hawaii Press, Honolulu.

———. 1975. Molecular population genetics and evolution. North-Holland, Amsterdam.

Nei, M., and A. K. Roychoudhury. 1972. Gene differences between Caucasian, Negro, and Japanese populations. Science 177:434–436.

———. 1974. Genetic variation within and between the three major races of man, Caucasoids, Negroids, and Mongoloids. Amer. J. Human Genet. 26:421–443.

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SINGLE- AND MULTIPLE-LOCUS MEASURES OF GENETIC DISTANCE BETWEEN GROUPS

In a recent article, J. B. Mitton (1977) contrasts single- and multilocus estimates of the amount of genetic diversity between groups relative to the diversity within groups. He concludes that a multilocus comparison for human blood groups shows a greater between-population component of diversity than do single-locus comparisons, and that the multilocus comparison is the better one to use. Unfortunately, his result is completely caused by a numerical artifact which destroys the meaning of the comparison. Mitton uses a multiplicative measure of multilocus similarity. That is, if the probability of identity between two individuals from the same race at locus i is p_i, the multiplicative measure of identity is $\prod_i p_i$, where the product is over all loci. Similarly, if P_i is the probability of identity for individuals from different races, then $\prod_i P_i$ is the multiplicative probability of between-population identity. We can then calculate the relative intragroup identity as

$$\frac{\prod_i p_i}{\prod_i P_i}, \tag{1}$$

which can then be averaged over all pairwise population comparisons. While Mitton himself does not actually calculate the ratio, he gives the relative proportion of all

variation that is within and between races. The explicit formation of the ratio reveals the artifact. However, it is transparently obvious that the ratio (1) is necessarily smaller than the average of the separate ratios p_i/P_i, as shown in Mitton's tables 1 and 2. This is because p_i/P_i is necessarily smaller than one for every i (except in the case where the genotypic distributions in the two races are identical, when $p_i/P_i = 1$), and the product of a series of numbers less than unity must always be less than their average. Indeed, the product approaches zero as the number of loci increases, so that when enough loci are looked at the multilocus identity between groups will be arbitrarily small as compared to the identity between individuals within populations.

Dr. Mitton is aware of this simple artifact since I pointed it out to him in a letter of January 5, 1976, when he sent me a copy of his manuscript, and in his published paper he tries to get around it by saying, "A possible difficulty with the multi-locus measure of genotypic identity employed here is that as the number of loci included in the calculations becomes large, the probability of identity between populations becomes vanishingly small. With the present limitations upon available data, this is not of pressing importance at this time." However, that remark completely misses the point. For any number of loci, large or small, the multiplicative measure used by Mitton necessarily gives a smaller proportion of the variation within groups than does the average of the single-locus values, and the magnitude of the difference depends upon the number of loci examined. The correct way to use all of the information from all of the loci is to use some kind of an arithmetic average, rather than a multiplicative one. Otherwise, the result is a tautology without any meaning for the real world.

LITERATURE CITED

Mitton, J. B. 1977. Genetic differentiation of races of man as judged by single-locus and multilocus analyses. Amer. Natur. 111:203–212.

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ARE HUMAN RACES "SUBSTANTIALLY" DIFFERENT GENETICALLY?

Recently in this journal J. B. Mitton (1977) addressed the problem of measuring genetic differences between human races. His main conclusion is incorrect or, at best, misleading. Because the issue may have social and political implications, and because publication in a reputable scientific journal adds weight to his conclusion, we feel it necessary to point out errors in Mitton's paper and to reevaluate his conclusions.