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Race, Social Class, and IQ

Population differences in heritability of IQ scores were found for racial and social class groups.

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The heritability of intelligence in white, middle-class populations of school-aged children and adults has been repeatedly estimated to account for 60 to 80 percent of the total variance in general intelligence scores, however measured (*1–4*). Yet Jensen (*3*, pp. 64–65) has noted many limitations to the available data on heritability.

> It is sometimes forgotten that such [heritability] estimates actually represent *average* values in a population that has been sampled and that they do not necessarily apply either to differences *within* various subpopulations or to differences *between* subpopulations. . . . All the major heritability studies have been based on samples of white European and North American populations, and our knowledge of intelligence in different racial and cultural groups within these populations is nil. For example, no adequate heritability studies have been based on samples of the Negro population of the United States [italics added].

After carefully examining the intelligence data on the black and white populations, Jensen (*3, 4*) hypothesized that the average genetic potential of the black population may not be equal to that of the white population. Others (*5, 6*) have interpreted the same racial differences in mean IQ (intelligence quotient) within an environmental framework, often naively and without good evidence for their competing hypotheses. Dislike of a genetic hypothesis to account for racial differences in mean IQ scores does not equal disproof of that hypothesis. Evidence for genetic or environmental hypotheses must come from a critical examination of both explanations, with data that support one.

As every behavioral geneticist knows, the heritability of a behavioral characteristic is a function of the population in which it is measured (*7, 8*). There is no reason to assume that behaviors measured in one population will show the same proportion of genetic and environmental variances when measured in a second population whose distributions of genetic or environmental characteristics, or both, differ in any way from those of the first population. Racial and social class groups are, for many purposes, sufficiently different populations to make a generalization from one to another highly questionable (*9–11*).

The sociological literature on social class and racial differences in style of life, nutrition, child-rearing practices, and the like describes *population* differences in distributions of environments. These population differences must affect the development of phenotypic (observed) IQ (*12*) and the relative proportions of genetic and environmental variances in IQ scores.

Distributions of genotypes for the development of behavioral characteristics may also vary from one population to another. Except for single-gene characteristics such as Huntington's chorea, microcephaly, and the like, we know very little about genotypic variability among populations for behavioral development. Because identified single-gene characteristics are known to occur with varying frequencies among populations, it is assumed that genes for polygenic characteristics may also be distributed somewhat differently among groups.

The sources of within-group and between-group variation can be assessed, although they are seldom effectively studied. Thoday (*13*, pp. 4–5) reviewed the problems of cross-population studies and concluded:

> While discontinuous variables such as blood groups present us with little difficulty [in studying differences between populations], continuous variables such as IQ are a different matter, for it is not possible with these to identify specific genotypes and it is therefore not possible to determine gene frequencies. Furthermore, there are always environmental as well as genetic causes of variation. We may measure the relative importance of environmental as well as genetic causes of variation or heritability within a population, and if the heritabilities are very high, that is, variation is almost entirely a consequence of genetic variety, we may know more than if they are low. But even if they are high, as with fingerprint ridge counts, we are already in difficulties with population comparisons, for there is no warrant for equating within-group heritabilities and between-group heritabilities.

In this article, I outline important concepts and methods in the study of individual and group variation and describe a new study of genetic and environmental variances in aptitude scores in black and white, and advantaged and disadvantaged populations.

Two Models of IQ, Social Class, and Race

There are two major, competing hypotheses for predicting the relation among social class, race, and IQ—the environmental disadvantage hypothesis

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and the genotype distribution hypothesis. Both hypotheses make differential predictions about the proportions of genetic and environmental variance in IQ within lower and higher social class groups.

The term "environmental disadvantage" refers to the largely unspecified complex of environmental factors associated with poverty that prevents an organism from achieving its optimum development. The biological environmental disadvantages have been reviewed by Birch and Gussow (*14*), and references to social environmental disadvantages have been reviewed by Deutsch, Katz, and Jensen (*15*).

Race and social class are terms that refer to socially defined subgroups of the human population. Reproduction is more likely to occur between people in the same subgroup than between people in different subgroups. There is no question that races are partially-closed breeding groups with a great deal more endogamy than exogamy (*10*). It is also true that social class groups (groups whose members have attained a certain educational and occupational status) within races practice more endogamy than exogamy (*11*). Social mobility from generation to generation does not upset the notion of social classes as somewhat different breeding groups, in terms of IQ levels, because the distribution of IQ's within each occupational level is reestablished in each generation of adults (*16*). Brighter children in families at all but the top social levels tend to be upwardly mobile, whereas duller siblings at all but the bottom class level tend to be downwardly mobile (*17*). Social class groups may be thought of as endogamous primarily for IQ (as expressed in occupational and educational achievements).

Social class groups may represent both different distributions of parental genotypes for IQ and different rearing environments for children. Although fathers' average IQ scores may vary by 50 points or more from top professional groups to unskilled laborers, their children's average IQ's differ by 25 points or less (*16, 17*).

The mean differences in children's IQ's by social class reflect differences in both parental genotypes and rearing environments, which covary to a large extent in the development of IQ. Crucial evidence on the genetic and environmental components from adopted children is very limited, but Skodak and Skeels (*18*) revealed a 20 point rise in the IQ of adopted children over that of their biological mothers. The distribution of adopted children's IQ's was also shifted beyond the values expected by regression to a mean above the average of the population, presumably by their better social environments.

Social class groups, then, are subdivisions of races and represent different distributions of parental genotypes, as well as different rearing environments. There is no comparable statement that can be made about racial groups: whereas races represent different rearing environments, no statements can be made concerning different distributions of parental genotypes for IQ. Since there is no direct test possible for distributions of genotypic IQ (*13*), it is impossible to assert that such distributions for the two races are "equal" or "different." Races do constitute different rearing environments in two respects. First, proportionately more blacks than whites are socially disadvantaged, thus more black children are reared under lower-class conditions; second, being black in the United States may carry with it a social burden not inflicted on any white.

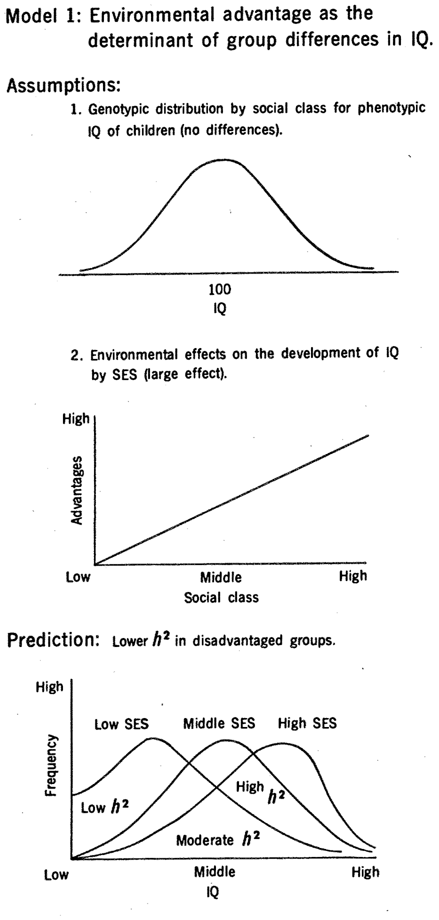


Fig. 1. Environmental disadvantage, model 1 (h^2 is heritability for twins; SES is socioeconomic status).

The environmental disadvantage hypothesis assumes that lower-class whites and most blacks live under suppressive (*19, 20*) conditions for the development of IQ. In brief, the disadvantage hypothesis states: (i) unspecified environmental factors affect the development of IQ, thereby causing the observed differences in mean IQ levels among children of different social classes and races; (ii) blacks are more often biologically and socially disadvantaged than whites; and (iii) if disadvantage were equally distributed across social class and racial groups, the social class and racial correlations with IQ would disappear. The environmental disadvantage hypothesis predicts that IQ scores within advantaged groups will show larger proportions of genetic variance and smaller proportions of environmental variance than IQ scores for disadvantaged groups. Environmental disadvantage is predicated to reduce the genotype-phenotype correlation (*21*) in lower-class groups and in the black group as a whole.

The genetic differences hypothesis, as it applies to social class groups within races, centers on the issues of assortative mating by IQ and selective migration, based on intelligence, within the social structure. Social class differences in mean IQ are assumed to be principally genetic in origin and to result from the high heritability of IQ throughout the population, assortative mating for IQ, and a small covariance term that includes those educational advantages that brighter parents may provide for their brighter children (*3, 10*). Social class differences in phenotypic IQ are assumed to reflect primarily the mean differences in genotype distribution by social class; environmental differences between social class groups (and races) are seen as insignificant in determining total phenotypic variance in IQ. Therefore, the proportion of genetic variance in IQ scores is predicted to be equally high for all social class groups (and for both races). Figures 1 and 2 present models 1 and 2, respectively, as they apply to social class.

In model 1, there are assumed to be equal distributions of genotypes across social classes. In model 2, there are assumed to be unequal distributions of genotypes for IQ, the lower class having proportionally more genotypes for low IQ and the upper social groups having proportionally more genotypes for high IQ. Environmental effects of social class are posited to be strong in model 1 and very weak in model 2.

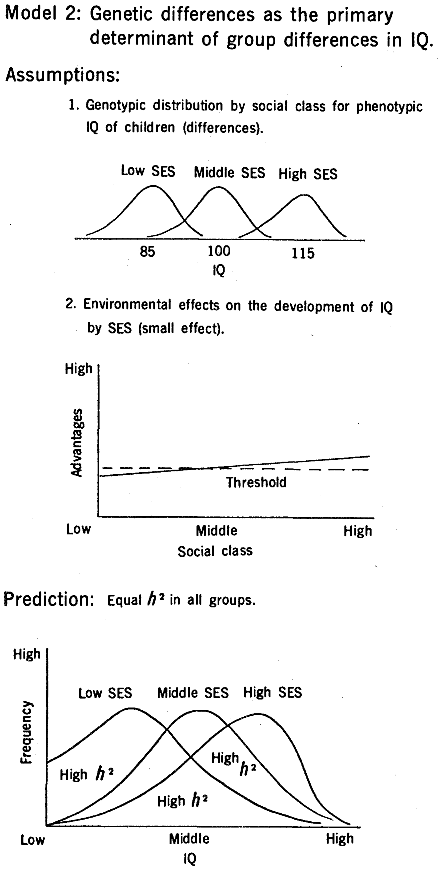
Competing Predictions

Both models account for the observed social class data on IQ, but they make competing predictions about the proportion of genetic variance. In model 1, environmental factors are predicted to reduce the mean and the heritability of IQ in the lower social class groups and raise both in the higher social groups. Model 2 predicts equally high heritabilities for all groups, regardless of rearing environments and regardless of mean scores. Estimated heritabilities by social class and race provide a new way of evaluating the adequacy with which the two hypotheses account for observed differences in mean IQ by social class. Racial differences may also be examined if the following rationale is always considered.

To the extent that the *same* environmental factors are assumed to affect the development of IQ in the same way in both black and white populations, predictions can be made about the sources of racial differences in mean IQ scores. If certain biological deprivations (such as low weight at birth, poor nutrition) are known to be more prevalent in lower class groups of both populations and more prevalent among blacks than whites, then the two models can make differential predictions about the effects of these sources of environmental variance on the proportion of genetic variance in each population. Given a larger proportion of disadvantaged children within the black group, the environmental disadvantage hypothesis must predict smaller proportions of genetic variance to account for differences in phenotypic IQ among blacks than among whites, as whole populations. Since the genotype distribution hypothesis predicts no differences in the proportion of genetic variance for social class groups within the races, it should predict the same proportions of genetic variance in the two races.

To the extent that *different* environmental factors are assumed to affect the development of IQ in black and white populations, or the same environmental factors are assumed not to affect the development of IQ in the same way, or both, no differential predictions about the origin of racial differences can be made by the two models. If all black children are disadvantaged to an unknown degree by being reared as blacks in a white-dominated society, and no white children are so disadvantaged, it is impossible to estimate genetic and environmental variances between the races. Only if black children could be reared as though they were white, and vice versa, could the effects of different rearing environments on the genotype distribution of the two races be estimated.

Some combinations of models 1 and 2 may be found to account best for phenotypic variability within and between groups. The clear opposition of models 1 and 2 as explanations for the same IQ, racial, and social class data was presented to demonstrate the differential predictions that can be generated about proportions of genetic variance in different populations.


Model 2: Genetic differences as the primary determinant of group differences in IQ.

Assumptions:

1. Genotypic distribution by social class for phenotypic IQ of children (differences).

2. Environmental effects on the development of IQ by SES (small effect).

Prediction: Equal h^2 in all groups.

Fig. 2. Genetic differences, model 2 (h^2 is heritability for twins; SES is socioeconomic status).

Twin Sample

An alphabetic roster of all students enrolled in the Philadelphia public schools in April 1968 was examined for children with the same last name, the same birth dates, and the same home address. Children who met the three criteria were identified as twins.

Of the 250,258 children in kindergarten through grade 12, 3042 were identified as twins, including 493 opposite-sex pairs and 1028 same-sex pairs.

The racial distribution of these twins was 36 percent white and 64 percent black. The corresponding figures for the entire public school population were 41 percent white and 59 percent black. The twins' racial distribution was discrepant from the total population by 5 percent, which can be accounted for by the substantially higher rate of fraternal twinning among blacks (*22*).

In a large sample of twins it is tactically difficult to differentiate the monozygotic and dizygotic groups directly. Direct approaches to zygocity could be discarded in favor of the indirect, statistical approach, which is advocated by Burt (*2*), Vandenberg (*23*), Sandon (*24*), and Husen (*25*). The reasoning is as follows: the percentage of opposite-sex pairs is known in any complete population survey. By applying the Weinberg formula, the proportion of monozygotic twins can be easily obtained (*21*). There will always be approximately the same proportion of same-sex pairs as opposite-sex pairs because of the distribution of sexes. It is then a simple matter to estimate the percentage of monozygotic pairs as follows: 100 − 2(percent of opposite-sex pairs) = percent of monozygotic pairs. Percentage estimates for monozygotic and dizygotic groups were done separately for each racial group.

Once the proportion of monozygotic and dizygotic twins is known, the correlations for same-sex and opposite-sex groups can be used to estimate the correlation coefficients for monozygotic and dizygotic twins within the same-sex sample. By converting correlation coefficients to z scores, the same-sex intraclass coefficient can be apportioned according to the percentages of monozygotic pairs in the same-sex group, so that:

$$r_{iss} = \frac{\%\ \mathrm{SS}_{dz}(r_{ios}) + \%\ \mathrm{SS}_{mz}(X)}{\%\ \mathrm{SS}_{mz+dz}}$$

Table 1. Final sample pairs by race and test scores.

Test scores	Black	White
Aptitude only	315	194
Achievement only	129	75
Aptitude and achievement	191	88
Total pairs	635	357

Table 2. Means and standard deviations (σ) of national scores for individuals by race.

Aptitude test	Black ($N = 1006$)		White ($N = 560$)	
	Mean	σ	Mean	σ
Verbal	30.3	18.2	45.9	21.2
Nonverbal	32.7	19.1	47.9	21.8
Total	28.9	18.5	46.1	20.8

On the basis of seven independent studies including more than 1000 pairs of same-sex and 100 pairs of opposite-sex twins, Burt (*2*) found the average correlations for intelligence to be .76 and .57, respectively. From these coefficients, he was able to estimate the correlation for monozygotic and dizygotic groups as .89 and .56, respectively. These estimates match very closely the correlations found for intelligence in samples of monozygotic and dizygotic twins whose zygosity had been determined by blood-grouping procedures.

In the Philadelphia sample, 30 percent of the white pairs and 34 percent of the black pairs were found to be of opposite sexes. Therefore, by the Weinberg formula, 40 percent of the whites and 32 percent of the blacks were estimated to be monozygotic pairs. The higher proportion of monozygotic twins in the white population matched the figures reported (*24*) for a complete age-group of British children taking the 11+ examinations.

The final samples were considerably smaller than the original 1521 pairs found, for several reasons. First, since standardized tests were not administered to the kindergarten or first-grade groups, 282 pairs were lost. Second, one or both members of 124 pairs were found to be enrolled in special classes, to whom the tests used in this study were not given (*26*). Third, the absence of one or both twins on the days that tests were administered eliminated an additional 123 pairs. Combined losses of 529 pairs reduced the final sample to 992 pairs with aptitude or achievement scores, or both, for each twin, as shown in Table 1.

Social Class Measures

Within both the black and white groups, social class variables were used to assign pairs to relatively advantaged and disadvantaged groups. The public school data on parental occupation, income, and education were incomplete and too unreliable for these purposes. Instead, census tract information from the 1960 U.S. Census was used.

Every pair had a census tract designation for which median income and educational data were available. Although census tracts in an urban area are designed to provide maximum homogeneity within tracts, they are still imperfect measures of individual SES (socioeconomic status) characteristics. Relatively advantaged and disadvantaged groups could be designated by neighborhood SES, however, since peer associations and school characteristics would be reflected in the census tract data. To the extent that the social disadvantage hypothesis pertains to the life-style, in addition to within-family environment, the census tract data were appropriate.

Table 3. Mean and standard deviations (σ) of national scores on combined aptitude tests for individuals by race and social class (Q indicates quartile).

Statistics	Black			White		
	Below ($N = 634$)	Middle ($N = 236$)	Above ($N = 134$)	Below ($N = 114$)	Middle ($N = 106$)	Above ($N = 340$)
			Verbal			
Mean	29.0	30.9	35.3	36.4	43.9	49.8
σ	(17.7)	(17.2)	(20.8)	(18.6)	(22.6)	(20.4)
Q	15-28-39	19-31-43	23-32-46	22-38-50	28-42-56	38-41-63
			Nonverbal			
Mean	32.0	32.7	35.9	38.3	44.5	52.2
σ	(19.2)	(18.7)	(19.3)	(18.0)	(22.5)	(21.5)
Q	17-32-44	20-32-46	20-34-50	25-39-50	29-43-59	36-51-68
			Total			
Mean	27.7	29.7	33.0	34.8	43.4	50.9
σ	(18.1)	(18.1)	(20.3)	(16.9)	(21.4)	(20.2)
Q	15-26-39	15-30-41	19-29-47	23-37-47	29-42-56	38-52-65

Social-class assignment was made by establishing a median level of income and educational characteristics for the total number of census tracts from which the twin sample was drawn, regardless of race. Cross-tabulations of above- and below-median levels of income and education provided three groups: one below the census tract medians for both income and education; one above the medians of both; and a third above in one and below in the other. On this basis, the three groups were designated as below median, above median, and middle status.

Aptitude and Achievement Tests

Results from several tests were available in the 1968–69 school year for children in the Philadelphia school district from second through twelfth grade (*27*). All children in grades three through eight who were in regular academic classrooms were given the Iowa Tests of Basic Skills, which test long-term development of intellectual skills (*28*). These are highly reliable group tests (*29*) that are used to measure scholastic achievement in many school districts across the nation. The vocabulary, reading, language total, arithmetic total, and composite scores were obtained. A total of 319 black and 163 white pairs had scores on all subtests for each twin.

Since a different aptitude test was given in every second school grade, it was impossible to obtain a sufficiently large number of pairs for reliable test-by-test results. It was decided, therefore, to combine aptitude test results across tests and age ranges, and to treat them as age-appropriate, equivalent forms of the same test. This radical decision was based primarily on the roughly equivalent structure of the aptitude tests. All have at least two principal subtests, a verbal and a nonverbal (or numerical), as well as a total score. Some tests, such as the Differential Abilities Test, have additional subtests to measure spatial, mechanical, and other abilities not included in more scholastically-oriented tests, such as the School and College Ability Tests. Thus, the total scores based on all subtests are not strictly equivalent; nor are the nonverbal tests, which may be based primarily on arithmetic reasoning or may include abstract reasoning as well. The verbal scores are the most nearly equivalent from test to test, and thus are the most reliable for comparisons across grades.

No a priori assumptions were made about the appropriateness of standardized aptitude tests for different social-class and racial groups. Although there exists a popular notion that standardized tests are less predictive of scholastic achievement in disadvantaged groups, this has generally been unsupported by research (*30*). This hypothesis was tested, however, by examining the correlations between aptitude and achievement scores for each racial and social-class group.

Since the generalizations were never intended to exceed the limits of aptitude test and IQ scores, no extensive discussion of the epistemological issue, "What do IQ tests measure?" will be attempted here. Suffice it to say that variance in IQ and aptitude test scores have been shown to have strong genetic components in other studies of white populations, and that the appropriateness of these measures for other racial and social-class samples will be considered in the results section.

Statistics

Statistics in studies of twins are based on the variances in scores among individuals of different genetic and environmental relatedness. The total phenotypic variance in the populations studied can be apportioned into between-family and within-family variances for both same- and opposite-sex twins. The comparison of between- and within-family mean squares is usually expressed as an F ratio

$$F = \frac{\sigma_b^2}{\sigma_w^2}$$

The intraclass correlation expresses the proportion of variance arising from family influences, both genetic and environmental. It compares the between-family variances minus the within-family variances to the total phenotypic variance in the population from which the related persons are drawn.

$$r_i = \frac{\sigma_b^2 - \sigma_w^2}{\sigma_b^2 + \sigma_w^2} = \frac{F-1}{F+1}$$

where σ_b^2 is the mean squares between pairs, and σ_w^2 is the mean squares within pairs.

The comparison of intraclass correlation coefficients and variance ratios for two or more related sets of individuals leads to the calculation of heritability estimates. The heritability of a trait is an expression of the ratio of

Table 4. Intercorrelations of test scores by race and social class [nonverbal (NV), total (T), vocabulary (Vo), reading (R), language (L), arithmetic (A), composite (C)].

Test	Black							Test	White						
	Aptitude			Achievement					Aptitude			Achievement			
	Verbal	Non-verbal	Total	Vocabulary	Reading	Language	Arithmetic		Verbal	Non-verbal	Total	Vocabulary	Reading	Language	Arithmetic
	Below-median group (N = *351*)								*Below-median group* (N = *60*)						
NV	.57							NV	.44						
T	.84	.87						T	.81	.83					
Vo	.56	.44	.54					Vo	.53	−.04	.31				
R	.56	.47	.59	.64				R	.62	.30	.51	.61			
L	.59	.54	.64	.67	.67			L	.76	.28	.61	.69	.79		
A	.53	.58	.62	.57	.66	.67		A	.67	.37	.59	.58	.77	.79	
C	.64	.57	.67	.82	.84	.86	.83	C	.75	.26	.58	.81	.87	.92	.89
	Middle group (N = *125*)								*Middle group* (N = *43*)						
NV	.71							NV	.57						
T	.90	.89						T	.88	.85					
Vo	.54	.47	.56					Vo	.81	.49	.71				
R	.64	.56	.66	.66				R	.84	.59	.79	.88			
L	.67	54	.65	.66	.75			L	.71	.51	.69	.75	.85		
A	.60	.53	.60	.64	.72	.73		A	.60	.52	.63	.64	.71	.77	
C	.70	.59	.70	.83	.89	.90	.85	C	.78	.61	.77	.86	.93	.94	.85
	Above-median group (N = *51*)								*Above-median group* (N = *147*)						
NV	.53							NV	.66						
T	.82	.86						T	.81	.88					
Vo	.60	.35	.53					Vo	.71	.49	.59				
R	.62	.56	.68	.71				R	.68	.53	.60	.78			
L	.68	.55	.71	.74	.87			L	.69	.61	.66	.73	.74		
A	.55	.65	.68	.61	.81	.77		A	.70	.70	.74	.66	.71	.78	
C	.67	.57	.71	.83	.94	.93	.87	C	.77	.64	.72	.87	.90	.88	.87

total genetic variance to total phenotypic variance.

In the simplest form for studies of twins, the restricted model for broad heritability (h_r^2) was defined by

$$h_r^2 = \frac{2(r_{\mathrm{imz}} - r_{\mathrm{idz}})}{1 - \sigma_E^2}$$

where r_{imz} is the intraclass correlation for monozygotic pairs, r_{idz} is the intraclass correlation for dizygotic pairs, and σ_E^2 is the percentage of variance due to errors in measurement. In this study, σ_E^2 was estimated to be .073, or the minimum unreliability for group aptitude tests.

Another version of the h^2 statistic for broad heritability using twins was offered by Jensen (*31*) to include the available data on assortative mating for IQ in the white population. The assortative-mating model for data on twins takes into account the positive correlation between IQ scores of parents, which are generally found to be around .40. Nonrandom mating patterns produce a genetic correlation between siblings that is somewhat higher than the .50 expected under mating patterns that are random with respect to IQ. The formula for computing the heritability coefficient with assortative mating (h_a^2) is

$$h_a^2 = \frac{c(r_{\mathrm{imz}} - r_{\mathrm{idz}})}{1 - \sigma_E^2}$$

where $c = 1 / 1 - p$, or 2.222, when $p = .55$; and σ_E^2 is the percentage of variance due to errors in measurement.

If the heritability of a trait is known, the total variance can be apportioned into four major components: within-family genetic variance (σ_{wg}^2), within-family environmental variance (σ_{we}^2), between-family genetic variance (σ_{bg}^2), and between-family environmental variance (σ_{be}^2). Regardless of the absolute size of the total variance, the proportions of variance can be estimated (*32*).

Distributions of Scores

An initial look at the distribution of scores within the samples of twins from Philadelphia indicated that the scores were far from normal. The low mean value, especially in the black population, and the skew of the distributions required careful normalization of the scores before any heritability analyses could be attempted. Thus, the results are reported in three sections: first, the distributions of scores and their transformations; second, the analyses of data on twins; and third, the heritability and estimated proportions of variance in the scores by race and social class.

The distributions of aptitude scores, based on national norms were divided first by race and then by race and social class. The means and standard deviations of the scores were markedly different by race; the mean aptitude scores of whites were slightly below the national mean of 50, while the mean aptitude scores of blacks were one standard deviation ($\sigma = 19$) below the national mean. There was almost one standard deviation between the means of the two races. The standard deviations of the whites were slightly higher than those of the blacks, as Jensen (*3, 4*) and others have noted; but the ratios of standard deviations to the means (proportional variance) were higher in the black than in the white groups (see Table 2).

Table 5. Analysis of variance of aptitude scores of twin pairs by race.

Mean squares	Black		White	
	Same sex	Opposite sex	Same sex	Opposite sex
		Verbal		
	($N = 333$)	($N = 169$)	($N = 192$)	($N = 82$)
σ_b^2	129.1	113.7	149.4	133.2
σ_w^2	38.2	44.8	29.6	33.9
F	3.38	2.54	5.05	3.93
r_i	0.543	0.435	0.669	0.594
r_{imz}	0.653		0.719	
		Nonverbal		
	($N = 332$)	($N = 169$)	($N = 192$)	($N = 82$)
σ_b^2	130.5	115.2	149.7	131.7
σ_w^2	39.6	39.4	33.8	26.8
F	3.30	2.92	4.42	4.92
r_i	0.535	0.490	0.631	0.662
r_{imz}	0.594		0.601	
		Total		
	($N = 334$)	($N = 169$)	($N = 193$)	($N = 82$)
σ_b^2	127.4	119.2	168.0	156.9
σ_w^2	35.1	31.2	23.7	28.4
F	3.62	3.82	7.10	5.53
r_i	0.567	0.585	0.753	0.694
r_{imz}	0.544		0.791	

On measures of aptitude, the racial groups had surprisingly large differences, once social class was considered (Table 3). The mean of the below-median (in income and education) white group equalled or surpassed the mean of the above-median black children on verbal, nonverbal, and total aptitude scores. The quartile (q) boundaries showed the distributions of below-median whites and above-median blacks to have similar properties, except that the total variance among advantaged black children was somewhat higher than that among disadvantaged whites.

The social-class divisions among whites separated the aptitude means of the subpopulations by approximately four-fifths of a standard deviation. The comparable divisions among blacks produced a difference of one-quarter of a standard deviation between children below and above the medians for the 280 census tracts in which the twins lived. Social-class groups of children were far more differentiated among whites than among blacks, despite the same criteria for assignment.

Comparisons across racial groups showed that disadvantaged white children scored in a pattern similar to that of black children, while the middle and above-median white groups had much higher means. Variances were not reliably different across races.

Compared to the national distribution, the twins in Philadelphia scored poorly. Instead of mean scores of 50, all black groups and white groups of below-median and middle status had mean performance scores in the 20 to 40 range. Only the above-median whites had mean scores close to the national average. A comparison of the means and variances of the twins' scores with those of all Philadelphia children showed that the twins were indeed representative of their respective racial and social-class groups, and were only slightly handicapped by their twinship.

Since the scores based on national norms were skewed within the Philadelphia samples, the scores for each test were normalized, separately by racial groups, to a mean of 50 and a standard deviation of 10, in order to develop comparable data for blacks and whites. Since the means and variances of the two racial groups were arbitrarily set as equal, there was no longer any differences based on race in the distributions of scores. In every test, there were significant social-class differences and significant class-by-race interaction terms, which reflected the fact that social-class differences in mean scores were much greater among whites than blacks.

Correlational analyses of all test scores by race and social class were done to examine the equivalence of measurement among groups. As Table 4 shows, the patterns of correlation among aptitude and achievement scores were quite similar in all groups, regardless of race or social class. It is difficult to argue that the dimensions of performance measured in the different racial and social-class groups were not comparable. The most parsimonious explanation of similar patterns of correlations is that there are similar underlying dimensions. It is impossible to argue that "nothing" is being measured by these tests in disadvantaged groups, because the prediction from aptitude to achievement scores is approximately as good in the below-median as in the middle black groups, and is certainly as good in the black groups as it is in the white groups.

Analyses of Twins by Race

The four major groups of same-sex and opposite-sex, black and white twins were treated separately for the first set of analyses. Analyses of variance comparing within-pair and between-pair variances were applied to each test score in the four groups. Table 5 gives the twins' results by race for the three aptitude scores. Intraclass correlations for the monozygotic group are estimated by the method described earlier.

Same-sex twins were, in general, more similar than were opposite-sex pairs. In both the black and white groups, the presence of monozygotic pairs in the same-sex group increased their correlation above that of the opposite-sex dizygotic pairs, so that the estimated monozygotic correlation was higher than the dizygotic correlation for four of the six comparisons. The two exceptions are total aptitude score for the blacks and nonverbal aptitude for the whites. Correlations between the two children in each same-sex and opposite-sex black pair were consistently lower than for their white counterparts. Black twins were not found to be as similar to each other as white twins, when compared to randomly paired members of the same groups.

Analyses of Twins by Race and Social Class

It was hypothesized in model 1 that social-class conditions of life would affect twin similarities and resulting estimates of genetic variances. The potentially restricting effects of lower-class life on the development of genetically based individual differences could tend to reduce within-pair correlation co-

Table 6. Analysis of variance of verbal aptitude scores of twin pairs by race and social class.

Mean squares	Black		White	
	Same sex	Opposite sex	Same sex	Opposite sex
	Below-median group			
	($N = 211$)	($N = 107$)	($N = 41$)	($N = 16$)
σ_b^2	120.7	102.9	81.8	105.8
σ_w^2	41.7	42.1	28.7	31.0
F	2.89	2.44	2.85	3.41
r_i	0.486	0.419	0.481	0.546
r_{imz}	0.558		0.430	
	Middle and above-median group			
	($N = 123$)	($N = 62$)	($N = 153$)	($N = 70$)
σ_b^2	136.0	134.0	154.1	119.9
σ_w^2	32.2	49.4	29.8	34.5
F	4.23	2.71	5.17	3.47
r_i	0.618	0.460	0.676	0.553
r_{imz}	0.753		0.749	

Table 7. Analysis of variance of nonverbal aptitude scores of twin pairs by race and social class.

Mean squares	Black		White	
	Same sex	Opposite sex	Same sex	Opposite sex
	Below-median group			
	($N = 211$)	($N = 107$)	($N = 41$)	($N = 16$)
σ_b^2	128.9	120.3	111.1	87.8
σ_w^2	41.4	37.8	34.8	20.7
F	3.11	3.19	3.20	4.25
r_i	0.513	0.523	0.524	0.619
r_{imz}	0.508		0.445	
	Middle and above-median group			
	($N = 123$)	($N = 62$)	($N = 152$)	($N = 68$)
σ_b^2	132.5	107.8	149.9	122.3
σ_w^2	36.3	42.2	33.6	28.1
F	3.65	2.55	4.46	4.34
r_i	0.570	0.437	0.634	0.625
r_{imz}	0.698		0.642	

Table 8. Analysis of variance of total aptitude scores of twin pairs by race and social class.

Mean squares	Black		White	
	Same sex	Opposite sex	Same sex	Opposite sex
	Below-median group			
	($N = 212$)	($N = 107$)	($N = 41$)	($N = 16$)
σ_b^2	122.7	109.7	83.1	109.1
σ_w^2	38.1	27.5	20.5	24.7
F	3.22	3.99	4.05	4.42
r_i	0.526	0.599	0.604	0.631
r_{imz}	0.434		0.585	
	Middle and above-median group			
	($N = 123$)	($N = 62$)	($N = 155$)	($N = 70$)
σ_b^2	130.6	137.4	174.7	139.1
σ_w^2	30.1	37.5	24.5	29.2
F	4.34	3.66	7.13	4.76
r_i	0.625	0.571	0.754	0.653
r_{imz}	0.680		0.813	

Table 9. Estimated heritability ratios by race and social class for aptitude scores.

Aptitude test scores	Black					White				
	r_{ios}	r_{iss}	r_{imz}	h^2_r	h^2_a	r_{ios}	r_{iss}	r_{imz}	h^2_r	h^2_a
				Below-median group						
Verbal	0.419	0.486	0.558	0.309	0.343	0.546	0.481	*	*	*
Nonverbal	0.523	0.513	*	*	*	0.619	0.524	*	*	*
Total	0.599	0.526	*	*	*	0.631	0.604	*	*	*
				Middle and above-median group						
Verbal	0.460	0.618	0.753	0.651	0.723	0.553	0.676	0.749	0.436	0.484
Nonverbal	0.437	0.570	0.698	0.580	0.644	0.625	0.634	0.642	0.038	0.042
Total	0.571	0.625	0.680	0.242	0.269	0.653	0.754	0.813	0.356	0.395
				All						
Verbal	0.435	0.543	0.653	0.470	0.522	0.594	0.669	0.719	0.270	0.299
Nonverbal	0.490	0.535	0.594	0.224	0.249	0.662	0.631	*	*	*
Total	0.585	0.567	*	*	*	0.694	0.753	0.791	0.209	0.232

* Cannot be estimated.

efficients in the lower-class groups, whereas better environmental opportunities could allow a greater range of phenotypic individual differences in the middle-class groups. Model 2 predicted that similar proportions of genetic variance would be found across social-class groups because mean differences in scores were assumed to arise from differences in genotype distributions.

Within-pair similarities were analyzed for those pairs below the median and then for those of middle and above status combined—the small number of black pairs above the median made it advantageous to combine the latter two groups. Tables 6, 7, and 8 give the analysis of variance results of the aptitude tests for the below-median and the combined middle and above-median groups for both races.

In the below-median SES groups of both races, the same-sex correlation exceeded the opposite-sex coefficient only once (black verbal aptitude). The failure of opposite-sex correlations to exceed same-sex cofficients left the estimated monozygotic correlations and heritability statistics indeterminant. It is unlikely that the correlations for monozygotic twins were lower than those for the same-sex dizygotic twins, but it is senseless to assign a value when r_{ios} is greater than r_{iss}. The most likely interpretation of this result is that the greater genetic correlation between monozygotic twins was not sufficient to increase the same-sex correlations above the values obtained for opposite-sex twins. Thus, genetic factors cannot be seen as strong determinants of aptitude scores in the disadvantaged groups of either race.

In the middle- to above-median SES groups, the same-sex correlations exceeded the opposite-sex correlations for all three aptitude scores in both races. The most likely inference from these data is that both genetic and environmental components of variance contributed to the similarity of within-pair scores in the advantaged group. For the disadvantaged group, the failure of same-sex correlations to exceed opposite-sex coefficients makes it doubtful that the proportion of genetic variance in the lower-class group equals that of the advantaged group.

Total variance was generally larger in the advantaged than in the disadvantaged groups of both races. For whites, total variance was larger in all six comparisons of advantaged and disadvantaged groups. For blacks, total variance was larger in four of six comparisons. This finding reflects the greater phenotypic variability of advantaged children, as predicted in model 1. The intraclass correlations were found to be comparable for blacks and whites within classes (see Table 9).

Assuming that the comparison of estimated monozygotic correlations and opposite-sex dizygotic correlations can be used to estimate heritability ratios, the proportion of genetic to total variance was calculated by the restricted and assortative mating formulas. Table 10 gives the intraclass correlations and estimated heritabilities for aptitude scores by race and social class.

As noted earlier, the proportion of genetic variance in disadvantaged groups was low, but indeterminant—except for verbal aptitude among blacks. Aptitude scores in advantaged groups all showed heritability estimates of greater than zero, except in the nonverbal scores of whites. Verbal aptitude scores had the highest heritability for both blacks and whites.

Based on the estimated heritability ratios, genetic and environmental variances can be apportioned. The apportionment between and within families is based on the ratio of between-family to total variance, expressed in the intraclass correlation. Only opposite-sex pairs were used, because their correlations were known to be based on a common inheritance of about 55 percent.

From Tables 11, 12, and 13, one can see that the percentage of total variance attributable to genetic sources was always higher in the advantaged groups of both races. In most cases, genetic variance could not be estimated for the aptitude scores of lower-class children. For both advantaged and disadvantaged children, however, there were approximately equal variances between and within families, the between-family variance being somewhat larger more often. Thus, the major finding of the analysis of variance is that advantaged and disadvantaged children differ primarily in what proportion of variance in aptitude scores can be attributed to environmental sources.

To check on the validity of the findings, the aptitude data were analyzed separately for male-male and female-female pairs who were found to have correlations of similar magnitude. The overall results of the study were not due to the greater similarity of male or female pairs, as seen in Table 14.

Table 10. Percentage of variance in verbal aptitude scores for opposite-sex twins by race and social class.

Source	Disadvantaged			Advantaged		
	Between family	Within family	Total	Between family	Within family	Total
			Black			
Genetic	18.8	15.5	34.3	39.7	32.6	72.3
Environmental	23.1	42.6	65.7	6.3	21.4	27.7
Total	41.9	58.1	100.0	46.0	54.0	100.0
			White			
Genetic	*	*	*	24.0	19.6	43.6
Environmental	54.6	45.4	*	31.3	25.1	56.4
Total	54.6	45.4	*	55.3	44.7	100.0

* Cannot be estimated.

Genotype-Environment Interaction

While neither model 1 nor model 2 predicted statistical interaction, a combination of the two models could predict an interaction between genotypes and environments in producing phenotypic ability. Wiseman (*33*) has suggested that children with lower IQ's are less affected by environmental deprivations than are children with higher IQ's. If lower IQ children are less affected by differential family environments, then the between-family variance and the correlations between siblings with lower IQ's will be smaller than among siblings with higher IQ's, on whom family environment presumably has a greater effect. Burt (*34*) reported a correlation of .61 between siblings both of whose IQ's were above 100, and a correlation of .43 between siblings with IQ's below 100.

The possible explanations for these findings include (i) restriction of total variance in the group with lower IQ's because of a "floor effect" in the tests used; (ii) larger within-pair variances for children with lower IQ's as a function of a poor family environment; and (iii) smaller between-pair variances for children with lower IQ's as a function of less responsiveness to different family environments.

A test for restriction in total variance was made by dividing all opposite-sex pairs into those with both twins above the mean of 50 and those with both twins below. Mixed cases were eliminated from the samples. Neither black nor white twins with aptitude scores below the mean had lower total variances than the above-mean groups. Since total variances were equal in the two groups, a test of the interaction hypothesis could be made.

To test for the effects of lower IQ alone on patterns of sibling correlation in the white group, only those children with social class ratings at the median and above were included. Intraclass correlations for the 22 white, advantaged, opposite-sex pairs with aptitude scores below 50, and the 31 above 50 were found to be consistently different. As Table 14 shows, siblings below the aptitude mean had consistently lower correlations between their scores than siblings above the mean. The lower correlations between siblings with lower IQ's were not a function of social class, but of smaller between-pair variances, primarily. This suggests that white children with lower IQ's are less susceptible to environmental differences between families than are children with higher IQ's, even in an advantaged population. There was no evidence of interaction between IQ and environment in the black population.

Mean Scores and Genetic Variance

The lower mean scores of disadvantaged children of both races can be explained in large part by the lower genetic variance in their scores. A "deprived" or unfavorable environment for the development of phenotypic IQ unfavorably affects mean scores, phenotypic variability, genetic variance in phenotypes, and the expression of individual differences (*21*, pp. 64–65). No study of human family correlations to date has looked at all of these effects of suppressive environments. In a landmark study of mice, however, Henderson (*8*) has demonstrated that suppressive environments reduce the amount of genetic variance in performance, reduce phenotypic variability, and reduce mean performance scores. The percentage of genetic variance in the scores of standard-cage-reared animals was one-fourth that of animals with enriched

Table 11. Percentages of variance in nonverbal aptitude scores for opposite-sex twins by race and social class.

Source	Disadvantaged			Advantaged		
	Between family	Within family	Total	Between family	Within family	Total
			Black			
Genetic	*	*	*	35.4	29.0	64.4
Environmental	52.3	47.7	*	8.3	27.3	35.6
Total	52.3	47.7	*	43.7	56.3	100.0
			White			
Genetic	*	*	*	2.3	1.9	4.2
Environmental	61.9	38.1	*	60.2	35.6	95.8
Total	61.9	38.1	*	62.5	37.5	100.0

* Cannot be estimated.

Table 12. Percentages of variance in total aptitude for opposite-sex twins by race and social class.

Source	Disadvantaged			Advantaged		
	Between family	Within family	Total	Between family	Within family	Total
			Black			
Genetic	*	*	*	14.3	11.7	26.0
Environmental	59.9	40.1	*	42.7	31.3	74.0
Total	59.9	40.1	*	57.0	43.0	100.0
			White			
Genetic	*	*	*	21.5	17.5	39.0
Environmental	63.1	36.9	*	43.5	17.5	61.0
Total	63.1	36.9	*	65.0	35.0	100.0

* Cannot be estimated.

Table 13. Analysis of variance of aptitude scores for same-sex pairs by race.

Mean squares	Black		White	
	Male ($N = 139$)	Female ($N = 194$)	Male ($N = 96$)	Female ($N = 96$)
		Verbal		
σ_b^2	144.3	119.0	162.5	134.8
σ_w^2	43.1	34.7	34.7	24.4
F	3.35	3.43	4.68	5.52
r_i	0.540	0.549	0.648	0.693
		Nonverbal		
σ_b^2	131.6	129.1	156.3	144.6
σ_w^2	47.6	33.7	28.7	39.0
F	2.76	3.83	5.45	3.71
r_i	0.468	0.586	0.690	0.575
		Total		
σ_b^2	127.6	127.3	202.0	135.0
σ_w^2	43.0	29.5	26.1	21.2
F	2.97	4.31	7.75	6.36
r_i	0.496	0.623	0.771	0.728

environments (10 percent versus 40 percent). Not only did genetic variance account for a larger portion of the variance among animals with enriched environments, but their performance on the learning task was vastly superior to that of their relatively deprived littermates.

Although generalizations from genetic studies of the behavior of mice to genetic studies of the behavior of human beings are generally unwarranted (because mechanisms of development vary greatly among species), the role that a better rearing environment played in the development of genetic individual differences among Henderson's mice finds an obvious parallel with the effects of advantaged SES homes in this study.

From studies of middle-class white populations, investigators have reached the conclusion that genetic variability accounts for about 75 percent of the total variance in IQ scores of whites. A closer look at children reared under different conditions shows that the percentage of genetic variance and the mean scores are very much a function of the rearing conditions of the population. A first look at the black population suggests that genetic variability is important in advantaged groups, but much less important in the disadvantaged. Since most blacks are socially disadvantaged, the proportion of genetic variance in the aptitude scores of black children is considerably less than that of the white children, as predicted by model 1.

"Disadvantage" has been used as a term throughout this paper to connote all of the biological and social deficits associated with poverty, regardless of race. As long as these environmental factors were considered to be the same, and to act in the same way on children of both races, then racial differences in scores could be discussed. Unquantified environmental differences between the races—either different factors or the same factors acting in different ways—preclude cross-racial comparisons. Informed speculation is not out of order at this point, however.

Those cultural differences between races that affect the *relevance* of home experience to scholastic aptitudes and achievement may be of primary importance in understanding the remaining racial differences in scores, once environmental deficits have been accounted for. In a series of studies of African children's scholastic performance, Irvine found that many sources of variation that are important for European and American scores are irrelevant for African children (*35*, p. 93).

Table 14. Analysis of variance of white, advantaged, opposite-sex twins, by aptitude level.

Mean squares	Both < 50 ($N = 22$)	Both ≥ 50 ($N = 31$)
	Verbal	
σ_b^2	54.8	65.7
σ_w^2	30.1	20.3
F	1.82	3.24
r_i	0.291	0.528
	Nonverbal	
σ_b^2	44.7	59.4
σ_w^2	18.7	20.9
F	2.39	2.84
r_i	0.41	0.479
	Total	
σ_b^2	34.6	57.5
σ_w^2	17.8	19.8
F	1.94	2.90
r_i	0.320	0.487

> Of environmental varibles studied in population samples, including socio-economic status, family size, family position, and school quality, only school quality showed significant and consistent relation to ability and attainment tests. Other sources of variation were irrelevant to the skills being learned.

For the black child in Philadelphia, the relevance of extrascholastic experience is surely greater than it is for the tribal African. But one may question the equivalence of black and white cultural environments in their support for the development of scholastic aptitudes. As many authors of an environmental persuasion have indicated (*6*, *36*), the black child learns a different, not a deficient, set of language rules, and he may learn a different style of thought. The transfer of training from home to school performance is probably less direct for black children than for white children.

The hypothesis of cultural differences in no way detracts from the predictive validity of aptitude tests for the scholastic achievement of black children. The correlations between aptitude and achievement are equally good in both racial groups. But the cultural differences hypothesis does speak to the issue of genetic and environmental components of variance. If most black children have limited experience with environmental features that contribute to the development of scholastic skills, then genetic variation will not be as prominent a source of individual phenotypic variation; nor will other between-family differences, such as SES level, be as important as they are in a white population. School-related experiences will be proportionately more important for black children than for white children in the development of scholastic aptitudes. The Coleman report (*37*) suggested that scholastic environment does have more influence on the performance of black children than it does on the performance of white children. The generally lower scores of black children can be fit adequately to the model 1 hypothesis, with the additional interpretation of cultural differences to account for the lower scores of black children at each social-class level.

The differences in mean IQ between the races can be affected by giving young black children rearing environments that are more conducive to the development of scholastic aptitudes. Or the differences in performance can simply be accepted as differences, and not as deficits. If there are alternate ways of being successful within the society, then differences can be valued variations on the human theme (*38*), regardless of their environmental or genetic origins. Haldane (*39*) has suggested that, ideally, different human genotypes would be found to respond most favorably to different environmental conditions—that genotype-environment interactions would exist for many human characteristics. From a genetic point of view, varied adaptations are useful to the species and permit the greatest flowering of individual differences. Socially invidious comparisons, however, can destroy the usefulness of such differences.

Group differences in mean scores and phenotypic variability that exist because of environmental deprivation can and should be ameliorated. To the extent that children are not given supportive environments for the full development of their individual genetic differences, changes can be made in their prenatal and postnatal environments to improve both their overall performance and the genetic variance in their scores. If all children had optimal environments for development, then genetic differences would account for most of the variance in behavior. To the extent that better, more supportive environments can be provided for all children, genetic variance and mean scores will increase for all groups. Contrary to the views of many naive environmentalists, equality of opportunity leads to bigger and better genotype-phenotype correlations. It is toward this goal that socially concerned citizens should work.

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27. Aptitude tests used in this study are Primary Mental Abilities (2nd grade): * verbal meaning, perceptual speed, *number facility, spatial relations, and *total; Lorge-Thorndike Intelligence Tests (4th grade): *verbal, *nonverbal, and *total; Academic Promise Tests (6th grade): abstract reasoning, numerical, *nonverbal total, language usage, verbal, *verbal total, and *total; Differenital Abilities Tests (8th grade): *verbal reasoning, *numerical ability, abstract reasoning, space relations, mechanical reasoning, clerical speed and accuracy, language usage, and *total (scholastic aptitude); School and College Ability Tests (10th grade): *verbal, *quantitative, and *total; Test of Academic Progress (12th grade): *verbal, *numerical, and *total. Achievement tests used are Iowa Tests of Basic Skills (3rd through 8th grades): *vocabulary, *reading comprehension, *language total, work-study skills, *arithmetic total, and *composite (average of five scores). Asterisks indicate scores reported.
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Stereochemistry of Hemes and Other Metalloporphyrins

The remarkably varied stereochemistry of the iron porphyrins is utilized in the hemoprotein function.

J. L. Hoard

A high level of interest in the porphyrins and the metalloporphyrins is fully justified by their behavior as complex physicochemical systems, and it is further enhanced by the biological circumstance that iron porphyrins serve as the hemes or prosthetic groups in the several classes of the hemoproteins (*1*). Both the chemistry and the concomitant stereochemistry (*2*) of the iron porphyrins are richly diversified, thus permitting the diversity of biological function that characterizes the distinctive families of the hemoproteins. The specificity of the function, the consequence of a severe delimitation of the reactions open to the prosthetic groups, is, of course, the primary responsibility of the protein; the constraint thus imposed is rationally presumed to be of stereochemical origin (*2*). The importance of stereochemical considerations for elucidating the behavior of the iron porphyrins and, in general terms, that of the oxygen-carrying family of the hemoproteins is the principal theme of this article. Essential to this end are the quantitatively precise descriptions of metalloporphyrin stereochemistries that are the recent products of structure analyses in which the extensive x-ray data afforded by single crystals have been utilized. Background material from earlier studies of the porphyrins and hemoproteins is introduced as needed.

Metalloporphyrins: The Porphinato Core

All porphyrins are derivatives of porphine, an aromatic molecule with the carbon-nitrogen skeleton illustrated in Fig. 1. In the porphine molecule, the

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