

**Biosocial Aspects of Life in Britain**

**SOCIAL MOBILITY AND THE GENETIC  
STRUCTURE OF POPULATIONS**

JOHN B. GIBSON

*Department of Genetics, University of Cambridge*

**Summary.** In addition to geographical heterogeneity for major genetic markers in the population there is also vertical differentiation in behavioural and physical characters with significant heritabilities. This vertical differentiation arises from social stratification of the population based on occupational status.

IQ has a significant heritability, is positively correlated with social class and is related to social mobility.

Laboratory experiments have confirmed the hypothesis that social mobility dependent to some extent on a variable with a significant heritability will lead to genetic differences between groups.

It is argued that both genetic and environmental factors must be considered in any explanation of social class phenomena.

The reported associations between some major genetic markers and various quantitative characters suggest that both discontinuous and continuous genetic variation should be taken into account in future investigations concerned with genetic aspects of social stratification.

**Spatial heterogeneity**

Discussion of the genetic aspects of the population structure of the British Isles usually focuses attention solely on geographic variation in the frequencies of genes concerned with discontinuous variation. Indeed there is ample evidence for spatial heterogeneity in the frequencies of the genes determining blood groups (Kopeć, 1970) and for some other major genetic markers.

Three possible sources of variation need to be considered to explain this geographic genetic variation. First, the accumulation of sampling fluctuations that have occurred generation after generation give rise to random genetic drift such that part of a population may differ markedly from another part in the frequencies of genetic factors. Second, differences in the environment between parts of the population will bring about different forms of selection in different geographical areas and,

third, historical events, for example both peaceful and aggressive migration, can produce genetic heterogeneity of populations.

The effects of migration are usually invoked to explain a substantial part of the geographic variation in ABO blood group frequencies in the British Isles. The invading Saxons, Danes and Vikings did not just fight and run away, but some introduced samples of their genes into the local populations. It is likely that both random genetic drift and selection were also factors but evidence for these is difficult to obtain.

There is little doubt that the present population is not in an equilibrium state. The complex patterns of both long- and short-range migration together with changes in the environment, for example the spread of urban life styles, will have effects on the genetic structure of the population.

### Vertical differentiation

In addition to the horizontal spatial heterogeneity in the population there is a vertical differentiation arising from social stratification. The adult working population can be sub-divided into a number of occupational or socio-economic classes. As a classification of occupations is related to qualifications and skills, and hence to level of education, it is not surprising that positive correlations between school attainment, ability, creativity, IQ and class have often been reported for adults. In the case of IQ the reported correlations range from 0.4 to 0.7 (Table 1). In addition to these psychological characters it is also found that the incidence of certain diseases differs between the social classes and the indexes of death rates for men are considerably lower in Class I than in Class V.

**Table 1.** Mean IQs of parent and child according to socio-economic class of parents (from Burt, 1961)

Socio-economic class	Parent	Child
<b>Non-manual</b>		
I Higher professional	139.7	120.8
II Lower professional	130.6	114.7
III Clerical	115.9	107.8
<b>Manual</b>		
III Skilled	108.2	104.6
IV Semi-skilled	97.8	98.9
V Unskilled	84.9	92.6

The socio-economic classes clearly reflect many environmental influences. Family incomes, for example, are positively correlated with socio-economic class

and will have some effect on the home environment. Recently Davie, Butler & Goldstein (1972) have described the abilities, behaviour, physical development, health, home environment and birth history of a large representative sample of 7-year-old children in England, Scotland and Wales. Their very extensive data clearly demonstrate social class differences in both behavioural and physical characters amongst these children. A few examples taken from their results will serve to illustrate the extent of this social stratification. Children in Social Classes I and II were, on average, 3.3 cm taller than those from Social Class V. Teachers' ratings of the children's creativity, oral and reading abilities were more often below average or markedly poor for children in manual than in non-manual social classes. Both maternal and paternal interest in the child's educational progress, again as assessed by the teachers, declined from Social Class I to V. An indication of some of the more subtle environmental differences between the social classes is provided by the observation that the percentage of children who were deprived of the protection afforded by immunization against polio increased from 1% in Class I to 10% in Class V. A similar pattern was found when immunization against diphtheria was considered.

### **Social mobility**

Thus there is ample evidence for differences in behavioural and physical characters amongst both parents and their children in the different socio-economic groups. Some of the variance in some of these quantitative characters is known to have a genetic component. IQ, on which most research has been done, is an example of such incompletely inherited characters (Erlenmeyer-Kimling & Jarvik, 1963) and thus there will be differences between the IQs of children and their parents. It follows that if the relationship between IQ and socio-economic class is maintained over generations, and there is evidence that it is, then a proportion of children in each generation must move from the social class in which they were born into a different occupational group to reconstitute the adult distribution.

Burt (1961) tested this hypothesis in a general population sample by comparing the IQs of fathers and sons and relating the differences to both upward and downward inter-generational social mobility. He found that a large proportion of social mobility was indeed related to IQ. Three pilot inquiries carried out in Cambridge have produced consonant results. The experimental design has varied, as in each case there was an interest in some other questions besides social mobility, but all of the three surveys involved interviews and the use of the same intelligence tests with both fathers and sons; the results are summarized in Table 2. The results show that the movement between classes has more than restored the correlation between IQ and class that there was in the fathers' generation—this perhaps being due to the changes in educational opportunities. All three surveys also showed that if the distance of movement was measured on a 6-point class scale, and related to the

**Table 2.** Correlation coefficients between IQ and socio-economic class in two generations

	Father's IQ/ class	Father's IQ/ son's IQ	Son's IQ/class	
			Before mobility	After mobility
Survey 1	0.46	0.79	0.40	0.70
Survey 2	0.46	0.69	0.37	0.57
Survey 3	0.45	0.64	0.33	0.66

extent of the differences between the IQs of fathers and sons, the greater the difference in IQ the greater the distance of movement. In families in which the IQs of the father and two male sibs were known it was also found that the upwardly mobile sibs tended to have higher IQs than the non-mobile or downwardly mobile sibs (Gibson, 1970). Both verbal and performance components of the IQ were related to this social mobility (Gibson & Mascie-Taylor, 1973).

#### Genetic differences between social classes

As IQ has a significant heritability the observation that it is correlated with social mobility suggests on theoretical grounds that social mobility will give rise to a non-random transfer of IQ genes from class to class on the assumption that the relationship between IQ phenotypes and social mobility implies some significant relationship between IQ genotype and social mobility. Thus the classes will be expected to become genetically differentiated to some extent. In addition the classes will also differ for immediate environmental reasons due to differences in educational opportunities, nutrition and home backgrounds, etc.

Thoday & Gibson (1970) have pointed out that 'the problem is to decide whether and to what quantitative extent environmental factors directly affecting contemporary individuals cause the class differences, and to what extent the differences are caused by genetic differences that have arisen because differing genotypes have in the past moved into different classes. Measurements of the relative contributions of these two causes can be made only if measurements of the between class heritability can be obtained.' The crux of the problem is that although we know that IQ has a significant heritability within groups we cannot extrapolate from these values to obtain estimates of the between group heritabilities. If the variation were of the discontinuous kind it would be possible to classify all individuals into genotypes and then compare the estimates of gene frequencies obtained in the different classes. At the present time there is no way in which we can deal with this problem of continuous characters in human populations and thus we are unable to decide what proportion of the differences in the average values of characters in different social classes is genetic and what proportion is environmental (Thoday, 1969).

### Model experiments

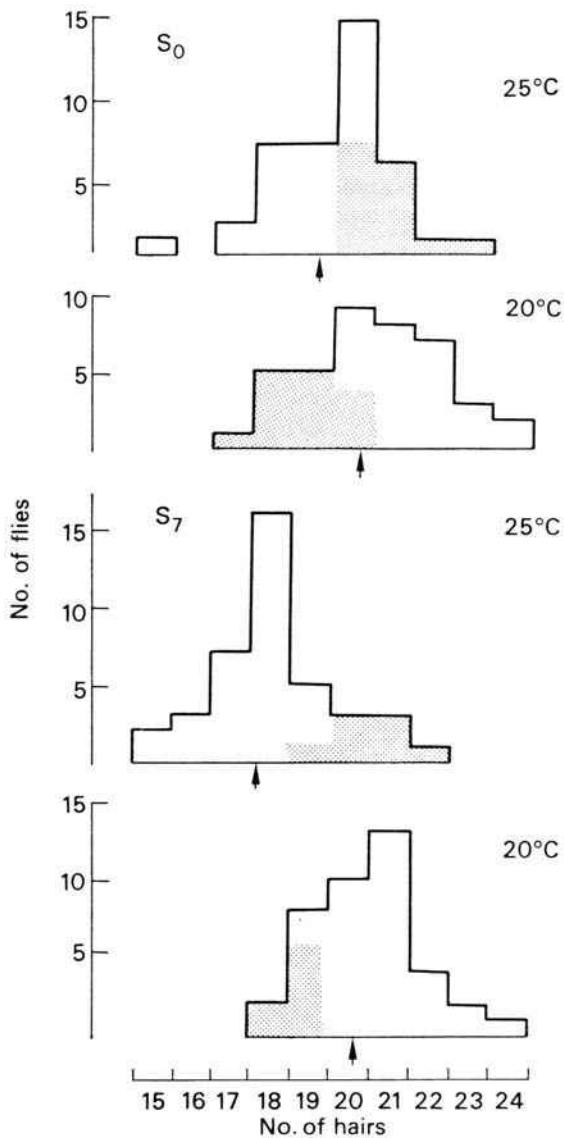
With experimentally more amenable organisms than man, between group heritabilities can be derived from the results of transplant experiments. Thoday & Gibson (1970) tested the theoretical argument discussed above by means of the transplant technique in a model experiment using the fruit fly *Drosophila melanogaster*.

In their experiments the character used, number of hairs on a certain part of the fly, was chosen as an example of an incompletely inherited quantitative character. Of the many identified environmental factors influencing the number of hairs, temperature is the most easily controlled and flies which develop at 20°C have on average more hairs than flies which complete development at 25°C. The experimental design was simple: random samples of flies from the same stock were set up in culture bottles at these two temperatures and from amongst the progeny of each bottle the hairs were counted on each of ten virgin females and ten males. Of the twenty flies assayed, the ten with the highest number of hairs were used as parents of the 20°C culture and the ten with the lowest hair numbers were used as the parents of the 25°C culture. This process was repeated each generation. Overall there was no selection, for all the flies assayed were used as parents for the next generation. 'Social mobility' was represented by the percentage of flies that, because of their hair numbers, changed culture conditions in each generation. In the first generation that the flies were cultured at the two temperatures the difference in mean hair number was 0.9 per fly which represents solely environmental differences between the two cultures. Results for subsequent generations (Table 3 and Text-fig. 1) showed that the 20°C culture always had a higher mean than the 25°C culture

**Table 3.** Mean numbers of hairs of two groups of flies, and inter-group mobility

Generation	Group		Difference	Mobility (%)
	20°C	25°C		
0	19.8	18.9	0.9	
7	19.9	17.7	2.2	20
8	19.9	17.4	2.5	30
9	19.8	17.4	2.4	20

but the mean difference between the two cultures increased over the generations from the original 0.9 to 2.5 hairs per fly. The 'social mobility' was always less than the 50% expected if the two cultures were not different in mean hair number. The important question, to what extent did the 20°C and 25°C cultures differ for genetic or 'cultural' reasons, was answered by transplant experiments. Samples of the high hair number flies were grown at 25°C and samples of the low hair number flies were grown at 20°C.



**Text-fig. 1.** Distributions of hair numbers in quadruplicate assays of female flies grown at 25°C and 20°C. The upper two distributions are taken from the base population and the lower two distributions from Generation 7. Shaded portions represent flies that, because of their hair numbers, would change culture conditions in the next generation. The mean hair number at each temperature and generation is indicated.

The difference in mean hair number between the two groups when they were grown in their own cultural conditions was 2.5 hairs per fly but the difference was reduced to an average of 1.15 hairs per fly when the groups were grown at the same temperature (Table 4). These data gave an estimate of the between group heritability of  $1.15/2.5 = 0.46$  (in the original paper this sum was miscalculated and a value of 0.42 was reported).

**Table 4.** Transplant experiment: mean number of hairs of flies of Generation 8 raised in two environments

Environment	Progeny of flies with high number of hairs	Progeny of flies with low number of hairs
20°C	19.9	18.5
25°C	18.3	17.4

**Table 5.** Components of variance (exclusive of the between-sexes variance) as percentage variance

Source of variance	Phenotypic variance	Heritability	Genetic component	Environmental component
Between groups	60.4	0.46	27.8	32.6
Within groups	39.6	0.13	5.1	34.5

In separate tests the within group heritabilities averaged 0.13. The partition of variance is summarized in Table 5 and it is clear that the proportion of the difference between the groups that was genetic was larger than the proportion of the within group variance that was genetic.

This experiment, together with similar ones carried out using other environmental conditions, has confirmed the hypothesis that social mobility dependent to some extent on a variable with a significant heritability does lead to genetic differences between groups. The 'social mobility' in these experiments sorted out the genetic variance so that it became largely between group rather than within group variance.

### Discussion

Clearly the human situation is much more complex in many respects than this laboratory experiment. But the results of this experiment serve to emphasize that both genetic and environmental factors, including cultural effects, must be con-

sidered in any explanations of social class phenomena. The social class stratification in both behavioural and physical characters referred to above is likely to reflect, to some extent, genetic differentiation of the population.

In view of this suggestion of vertical genetic differentiation of the population it is surprising that there is little published information on the social class distribution of major genetic markers, some of which have been found to be associated with quantitative characters. For example, there is evidence that susceptibility to certain diseases, such as stomach cancer, duodenal and gastric ulcers, is differentially associated with the ABO blood groups (Clarke, 1964). Cattell, Bourtourline Young & Hundleby (1964) have claimed that the personality factor 'tender-minded versus tough-minded' also shows some association with the ABO system although the conclusions they drew from their data have been criticized on statistical grounds (Weiner, 1965; Norton, 1971). Parker, Theilie & Spielberger (1961) found that O type blood occurs more frequently in manic-depressive patients than in either psychoneurotic depressive patients or in the general white population in the USA.

Some diseases and personality factors could be significant in affecting intra-generational occupational mobility and might lead to non-random transfer of the relevant genetic factors from one social class to another.

Moran (1965) has suggested that the social class distribution of schizophrenia might well be an example of this phenomenon. There is ample evidence that genetic factors play a substantial part in the aetiology of schizophrenia although there is no agreement on the exact mode of inheritance (Kallmann, 1953; Slater, 1958; Gottesman & Shields, 1967). However, the frequency of the trait is much higher in manual than in non-manual occupational groups (Hare, 1962). It seems likely that this distribution arises partly from the fact that the nature of the illness and its treatment, often requiring periods in hospital, fosters downward social mobility. Thus in the manual occupational groups there is a higher frequency of the genes involved in the aetiology of schizophrenia and probably also the relevant genotypes are more often manifest in the adverse environment.

The recent discovery of widespread polymorphisms for genetically determined electrophoretic enzyme variants has greatly increased the number of readily screened genetic markers available in human populations. This must encourage those who feel that more precise information about the genes affecting quantitative characters in human populations can theoretically be obtained by modification of the location techniques developed in more experimentally amenable organisms (see Thoday, 1967a,b). Only if and when the genes of such incompletely inherited characters as IQ can be identified will it be possible precisely to answer questions about the proportion of the differences between social classes that is genetically determined. For this reason it is hoped that future investigations of quantitative characters in human populations will be combined with investigations of the segregating genetic markers.



## References

- BURT, C. (1961) Intelligence and social mobility. *Br. J. statist. Psychol.* **14**, 1.
- CATTELL, R.B., BOURTOURLINE YOUNG, H. & HUNDLEBY, J.D. (1964) Blood groups and personality traits. *Am. J. hum. Genet.* **16**, 397.
- CLARKE, C.A. (1964) *Genetics for the Clinician*, 2nd edn. Blackwell Scientific Publications, Oxford.
- DAVIE, R., BUTLER, M. & GOLDSTEIN, R. (1972) *From Birth to Seven*. Longman, London.
- ERLENMEYER-KIMLING, L. & JARVIK, L.S. (1963) Genetics and intelligence: a review. *Science, N. Y.* **142**, 1477.
- GIBSON, J.B. (1970) Biological aspects of a high socio-economic group. I. IQ, education and social mobility. *J. biosoc. Sci.* **2**, 1.
- GIBSON, J.B. & MASCIE-TAYLOR, C.G.N. (1973) Biological aspects of a high socio-economic group. II. IQ components and social mobility. *J. biosoc. Sci.* **5**, 17.
- GOTTESMAN, I.I. & SHIELDS, J. (1967) A polygenic theory of schizophrenia. *Proc. natn. Acad. Sci. U.S.A.* **58**, 199.
- HARE, E.H. (1962) The distribution of mental illness in the community. In: *Aspects of Psychiatric Research*. Edited by D. Richter, J.M. Tanner, Lord Taylor & O.L. Zangwill. Oxford University Press, London.
- KALLMANN, F.J. (1953) *Heredity in Health and Mental Disorder*. W.W. Norton, New York.
- KOPEĆ, A.C. (1970) *The Distribution of the Blood Groups in the United Kingdom*. Oxford University Press, London.
- MORAN, P.A.P. (1965) Class migration and the schizophrenic polymorphism. *Ann. hum. Genet.* **28**, 261.
- NORTON, H.W. (1971) Blood groups and personality traits. *Am. J. hum. Genet.* **23**, 225.
- PARKER, J.B., THEILIE, A. & SPIELBERGER, C.D. (1961) Frequencies of blood types in a homogeneous group of manic-depressive patients. *J. ment. Sci.* **107**, 936.
- SLATER, E. (1958) The monogenic theory of schizophrenia. *Acta genet. Statist. med.* **8**, 50.
- THODAY, J.M. (1967a) Selection and genetic heterogeneity. In: *Genetic Diversity and Human Behavior*. Edited by J.N. Spuhler. Aldine Publishing Co., Chicago.
- THODAY, J.M. (1967b) New insights into continuous variation. In: *Proc. Third Internat. Congr. Hum. Genet.* Edited by J.F. Crow & J.V. Neel. Johns Hopkins Press, Baltimore.
- THODAY, J.M. (1969) Limitations to genetic comparison of populations. *J. biosoc. Sci. Suppl.* **1**, 3.
- THODAY, J.M. & GIBSON, J.B. (1970) Environmental and genetical contributions to class difference: a model experiment. *Science, N. Y.* **167**, 990.
- WEINER, A.S. (1965) Blood groups and personality traits. *Am. J. hum. Genet.* **17**, 369.