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Genetics, Social Structure and Intelligence

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GENETICS, SOCIAL STRUCTURE AND INTELLIGENCE

A. H. Halsey¹

INTRODUCTION

IT IS OUR PURPOSE in this paper to consider the question of social class differences in measured intelligence as an illustration of the more general problem of the relation between social structure and the distribution of genetic characteristics in populations. Though innate intelligence may legitimately be inferred from available evidence, the evidence is also strong that it is determined not by one gene but polygenically. On these assumptions a genetic model may be constructed which, when relevant variations in social structure are taken into account, throws considerable doubt on the possibility that mean differences between classes in measured intelligence are innate. This doubt arises from the fact that the relevant aspects of social structure have not been stable enough for long enough in differentiated societies to allow sufficient time for the kind of polygenic process involved in human intelligence to develop class differences of the order suggested by the known social distribution of measured intelligence. This conclusion is, moreover, strengthened by a consideration of the variance found in measured intelligence among social class groups.

I. THE THEORY OF INTELLIGENCE

On the evidence, especially of correlation coefficients derived from studies of twins, siblings and foster children, it may be concluded that there is a genetic component in the intelligence test performance of individuals² and hence it is reasonable to postulate a genotype of innate intelligence which we shall call I_A .³

The actual manifestation of intelligence, which we shall call I_B , is a social product of adaptive behaviours within the framework laid down by I_A . Largely on the basis of the work of Hebb⁴ and Piaget,⁵ Vernon describes I_B as the set of behavioural characteristics correlative to Hebb's 'phase sequences' or patterns of discharge in the association areas of the brain. Phase sequences, and their counterparts in adaptive behaviour, are dependent for their formation on experience of

appropriate environmental stimuli. Piaget too views intelligence as a developing complex of adaptive behaviours beginning with simple reflexes in the new-born child and ending with intricate conceptualizations and trains of reasoning in the adult. The growth of intelligence is dependent upon stimulation in social interaction, the use of language and the manipulation of objects. To say that I_B is a complex is also to emphasize that intelligence is no one single factor. We do not know what are the factors involved. If we did then the problem of the relation between I_A and I_B could be more successfully tackled.

Our present knowledge of factors in intelligence is derived from intelligence tests. Performance in intelligence tests we shall call I_C . Any one of the many measures of intelligence (I_C) consists of a *sample* from the set of behaviours which constitute I_B . It is a biased sample because of the use of intelligence tests for educational selection and their validation predominately in terms of educational success. The factors derived from analysis of intelligence tests are determined by the content of the tests and this in turn by the requirements of prediction of educational performance.

That the determination of I_B and I_C is partly social is well known though our knowledge of the relevant social processes is unsystematic and incomplete. What, however, is much less fully appreciated is the important role played by social structure in the distribution of genetically determined characters among which the postulated I_A is here considered as an example. A brief consideration of the mechanics of inheritance should make this clear.

Genetic Variation

It is of the greatest importance to bear in mind that the appropriate unit for consideration of genetic variation is not the individual but the *population* of individuals between whom mating is possible. The stock of genes present in an endogamous population is usually called a gene pool. Limits to the variation of a population are set at any one time by the composition of its gene pool and these limits vary from one generation to another according to four factors: (1) genetic drift,⁶ (2) mutation, (3) selection, and (4) migration. For the purposes of the present problem the factors of importance are selection and migration.

Within populations, genetic variation between individuals is ensured by heterozygotes, i.e. cells carrying alternative (allelic) genes. In fact, only a small proportion of the possible gene combinations in any species is ever realized. With n heterozygous genes there may be produced 2^n kinds of sex cells with different gene combinations. For example, an individual with 20 heterozygous genes may produce 1,048,576 kinds of sex cells. Thus, since most people are heterozygous for 30 or more genes, it becomes 'a reasonable guess that no two persons alive (identical twins excepted) carry the same genes'.⁷

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Heterozygotes increase the potential variability of a group over that actually exhibited by its members and this adaptive advantage is greater the faster the breeding rate, i.e. the more rapid the rate of sampling of the possible gene combinations in the gene pool. Phenotypic variation is, in general, an outcome of cumulative interplay between these factors and the accidents of environment.

Social Structure and Genetic Variability

There are sociological aspects of genetic drift, mutation, selection and migration. One important illustration may be taken from the pattern of human social life for the greater part of the history of man. This pattern having been one of small scattered endogamous groups, has tended to maximize genetic drift, because of isolation and small numbers, and to form trial gene pools for mutations. However, in the modern world these conditions for rapid evolution or differentiation have passed away with the formation of vast states and nations and hence large endogamous populations. In essence this is the basis of Keith's group theory of human evolution.⁸

Again, to take a second illustration, some genotypes are more viable, more socially attractive and more fecund than others. The resultant differential fertility is partly determined by social structure. Sexual selection and control of migration (social and geographical mobility) are found in all human mating systems—never panmixia. There are universal rules of exogamy and widespread rules and practices of endogamy. The former lead to increased frequency of heterozygote individuals and the latter to increased frequency of homozygotes. Thus, though deviations from panmixia do not usually result in alterations in the gene frequencies of the total population, the facts of social differentiation produce a tendency towards homozygous genetic clusterings within societies.

These two examples are sufficient to indicate that the course of genetic evolution and of variations within the human species are limited and partially controlled by variations in social structure, especially the size of populations, the degree of endogamy and exogamy in their mating systems and the ease of geographical migration and social mobility between groups within them. The postulated character of innate intelligence (I_A) may now be considered from this point of view.

II. A GENETIC MODEL OF INTELLIGENCE

We begin with an assumption of single gene determination of I_A . This is a gross oversimplification but nonetheless instructive because, in any given social structure, it gives the maximum weight to genetic factors in the selection process which we are about to discuss.

Let it be assumed that I_A is produced by inheritance through a gene A such that the homozygote AA has the value of 120, the heterozygote Aa the value of 100, and the homozygote aa the value of 80.

Case 1. A Caste System

We may begin consideration of the effect of variations in social structure on the social distribution of innate intelligence (I_A) by imagining a society having a population of 1000 divided into two castes—a low caste numbering 900 and a high caste numbering 100. Castes are by definition endogamous and let us further assume that there is random mating within them and equal fertility between them.

Looked at genetically and ignoring mutation and genetic drift⁹ this society consists of two separate gene pools, each in Hardy-Weinberg equilibrium,¹⁰ the Hardy-Weinberg formula [$p^2 + 2p(1-p) + (1-p)^2$] being a mathematical statement of the frequency (p) of a genotype in a random mating population in successive generations. Thus if the frequency of the gene for high intelligence (A) in the low caste is $\cdot 3$ ($p_A^L = \cdot 3$) and in the high caste is $\cdot 7$ ($p_A^H = \cdot 7$) the following equilibrium results:

	Low Caste			High Caste		
Proportions:	$\cdot 49aa$	$\cdot 42Aa$	$\cdot 09AA$	$\cdot 09aa$	$\cdot 42Aa$	$\cdot 49AA$
Numbers:	441aa	378Aa	81AA	9aa	42Aa	49AA
Means:	(Low Caste)			(High Caste)		
	$I_A^L = 92$			$I_A^H = 108$		
	(Total population) $I_A^T = 94$					

In words, the result under these genetic and social conditions is that:

- (1) The high caste has the higher mean (108 compared with 92).
- (2) The high caste has a much higher proportion but a much lower number of individuals with high intelligence (49 compared with 81).
- (3) There is a considerable overlap between the castes in the distribution of I_A , and, genetically, this means that there are many more A genes in the low than in the high caste, most of them in heterozygous condition.

The situation described would remain stable between generations. It should, however, be noticed that the means of I_A are a function of the frequencies (p_A) chosen in the example. We could, for instance, have shown equal p_A 's in the two castes and in that case the mean values of I_A^L , I_A^T and I_A^H would have been equal.

Case 2. A Class System

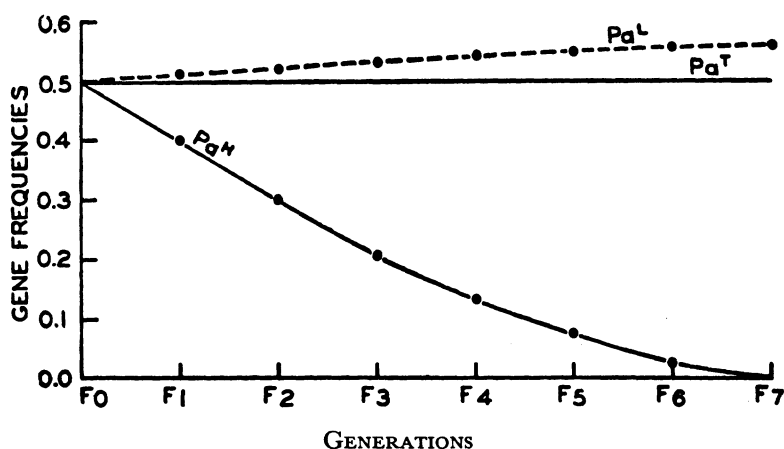
The assumptions made in the caste model could not be found in any actual society and are certainly very far from representing the kind of social structure to be found in modern Britain. We may move closer to the latter by imagining a society in which social position is determined

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by selection according to I_A . In the example which follows we continue to ignore mutation and genetic drift, we retain our assumption that innate intelligence is determined by a single gene but we introduce new migration (or mobility) assumptions. We postulate a low class of 900 and a high class of 100 with, in each generation before marriage, mobility upward of the 10 most intelligent members of the low class and mobility downward of the 10 least intelligent members of the high class. Mating is again assumed to be random within classes and fertility equal between classes.

The process begins at generation F_0 with gene frequencies p_A and p_a equal (i.e. .5) in both classes. Then the proportions of aa, Aa and AA individuals are .25, .50 and .25 respectively in both classes and the corresponding numbers of individuals are 225aa, 450Aa and 225AA in the low class and 25aa, 50Aa and 25AA in the high class. Mobility then takes place to alter the distribution of individuals so that there are 235aa, 450Aa and 215AA in the low class and 15aa, 50Aa and 35AA in the high class. The gene frequencies become, at the same time $p_a^L = .5111$ and $p_a^H = .4000$ so that, after mating, the distribution of individuals in generation F_1 is, for the low class, 235aa, 450Aa and 215AA and, for the high class, 16aa, 48Aa and 36AA. This distribution gives the low class a mean intelligence (I_A^L) of 99.56 and the high class (I_A^H) 104. A summary of the process, continued for subsequent generations is given in Table 1, and frequencies of the gene for low intelligence (p_a) and of the mean innate intelligence scores (I_A) are shown in Figure 1 and Figure 2.

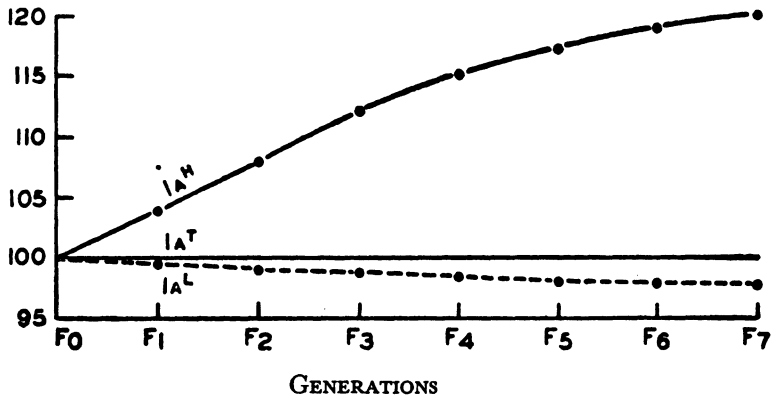
FIG. 1. FREQUENCY OF GENE a (LOW INTELLIGENCE) OVER SEVEN GENERATIONS IN A TWO-CLASS SOCIETY



p_a^L = Frequency of Gene for Low Intelligence in the Low Class

p_a^T = Frequency of Gene for Low Intelligence in the Total Population

p_a^H = Frequency of Gene for Low Intelligence in the High Class

FIG. 2 MEAN INNATE INTELLIGENCE (I_A) OVER SEVEN GENERATIONS IN A TWO-CLASS SOCIETY

I_A^H = Mean Innate Intelligence of High Class

I_A^T = Mean Innate Intelligence of Total Population

I_A^L = Mean Innate Intelligence of Low Class

It may be seen from Table 1, Fig. 1 and Fig. 2 that the trend of the distribution of I_A has the following characteristics:

- (1) The mean I_A^L decreases at a decreasing rate to 98; the mean I_A^H increases at a decreasing rate to 120 and the mean I_H^T is constant at 100.
- (2) The class distributions continue to overlap, the majority of people with high intelligence still remaining in the low class.
- (3) Only over seven generations would low intelligence (a) be bred out of the high class. High intelligence would never be bred out of the low class. At the eighth generation the social distribution of I_A stabilizes with a constant rate of 'circulation' of AA between the classes.
- (4) The number of homozygotes in the total population increases in each generation (from F_1 to F_7), i.e. there are more people of high intelligence *and* more people of low intelligence, i.e. the standard deviations increase in each generation.
- (5) In other words, the heterozygotes form a reservoir of both high and low ability which, in this case, is drained high to high class and low to low class up to the eighth generation.

Thus the general effect of selective migration through intelligence, other things being equal, is to increase the frequency of homozygotes and to decrease heterozygotes, i.e. to increase the incidence of both high and low intelligence and to reduce the incidence of middling intelligence.

These results have been obtained from a very simple model of

TABLE 1

Social Distribution of Intelligence (I_A) in a Class Society with Single Gene Inheritance of Intelligence

Generation	Low Class						High Class						Mean Intelligence of total Population
	Gene Frequency		Number of Persons			Mean Intelligence	Gene Frequency		Number of Persons			Mean Intelligence	
	p_A^L	p_A^H	aa	Aa	AA	I_A^L	p_A^N	p_A^H	aa	Aa	AA	I_A^H	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
F_0	·500	·500	225	450	225	100·0	·500	·500	25	50	25	100·0	100
F_1	·511	·489	235	450	215	99·6	·400	·600	16	48	36	104·0	100
F_2	·522	·478	245	449	206	99·1	·300	·700	9	42	49	108·0	100
F_3	·533	·467	256	448	197	98·7	·205	·795	4	33	63	111·8	100
F_4	·541	·459	263	447	190	98·4	·134	·866	2	23	75	114·6	100
F_5	·547	·453	270	446	186	98·1	·075	·925	1	14	86	117·0	100
F_6	·553	·447	275	445	180	97·9	·022	·978	1	4	96	119·1	100
F_7	·556	·444	278	444	178	97·8	·000	1·000	0	0	100	120·0	100

Note: For purposes of presentation numbers are rounded to whole numbers in columns 3, 4, 5, 9, 10 and 11; to one decimal place in columns 6, and 12 and to three decimal places in columns 1, 2, 7, and 8.

society. If we wish to move still nearer to reality, many more complex assumptions as to both social structure and the genetics of intelligence must be considered. However, these complications do not alter the basic features of the simple model and they can be treated summarily. What we want to know of each complication is its effect on the rate of social class differentiation in I_A . We may therefore divide them according to whether they speed up or slow down the differentiation process.

Among the accelerating factors must be included a higher rate of social mobility and the differentiation of more social classes. It may be noted, parenthetically, that a uniform increase of mean I_A with social class need not be assumed. An interesting case of this kind is suggested by the recent British social mobility inquiry in which the Index of Association (i.e. the degree to which caste conditions are approximated) rises sharply at the highest occupational levels.¹¹ If the high caste in our Case 1 were allowed to remain a caste while selective migration for I_A were allowed to produce a middle class out of the former low caste, then the middle class would inherit a mean I_A higher than that of the high caste, largely by recruitment from the heterozygote pool in the low class.

A more formidable array of decelerating factors comes into play as the model is modified to take account of real conditions. Of these the first is the assumption of polygenic determination of I_A —and the trend in psychology toward the recognition of more factors in measured human abilities implies a more complex genetic structure determining intelligence. In fact it is difficult to conceive of anything as elaborate as human intelligence being determined by as few as (say) 10 genes. Yet if we add only one other gene B in Case 2, with all other assumptions, both genetic and social, remaining the same the result is that the high class does not become 'pure'¹² before the passage of 9 generations.¹³ This process is summarized in Table 2.

Second, on the side of social structure we have to recognize the existence of determinants of social mobility which are wholly unconnected or only partially connected with intelligence—for example, sexual beauty or ugliness, good or evil fortune in business, military prowess or timidity, etc. Though precise estimates are impossible, we can be confident that selection other than for I_A has been of great relative importance especially before the rise of the educational system as an agency of social selection in the last two generations. This type of social mobility or any increase in its incidence would have decelerating effects on the process of differentiation in the I_A composition of the classes. Moreover, any reduction in mobility based on selection for I_A would have a similar effect.

Putting the accelerating and decelerating factors together it seems reasonable to conclude that the net effect would be to slow down the

TABLE 2

Social Distribution of Intelligence (I_A) in a Class Society with Two-Gene Inheritance of Intelligence

Gener- ation	Low Class							High Class						
	Gene Frequency			Number of Persons				Gene Frequency			Number of Persons			
	p_a^L and p_b^L	p_A^L and p_B^L	aabb	aAbb or aaBb	AAbb or aaBB	AABb or aABB	AABB	p_a^H and p_b^H	p_A^H and p_B^H	aabb	aAbb or aaBb	AAbb or aaBB	AABb or aABB	AABB
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
F_0	.500	.500	56	225	338	225	56	.500	.500	6	25	38	25	6
F_1	.510	.490	61	234	337	216	52	.409	.591	3	16	35	34	12
F_2	.519	.481	65	242	337	208	48	.327	.673	1	9	29	40	21
F_3	.528	.472	70	250	335	200	45	.250	.751	0	5	21	42	32
F_4	.535	.465	74	256	334	194	42	.186	.814	0	2	14	40	44
F_5	.541	.459	77	262	333	188	40	.130	.870	0	0	8	34	57
F_6	.547	.454	80	266	332	184	38	.082	.918	0	0	3	25	71
F_7	.550	.450	83	270	331	180	37	.047	.953	0	0	1	16	82
F_8	.553	.447	84	273	330	177	36	.019	.981	0	0	0	7	93
F_9	.556	.444	86	274	329	176	35	.000	1.000	0	0	0	0	100

Note: For purposes of presentation the figures in columns 1, 2, 8 and 9 are rounded to three decimal places and in all other columns to whole numbers.

process of differentiation described under the simple assumptions of Case 2. If this be so, then we are justified in concluding that what little we know of the history of social stratification in Britain would hardly yield an expectation of social class differences in innate intelligence of the order arrived at in Case 2.

Differential Fertility and the Decline of National Intelligence

At this point in the discussion, and before turning to the social distribution of measured intelligence it is convenient to undertake a short digression and consider one further social variable, namely differential fertility. We do so because of the importance of this factor in connection with the long-standing controversy over the trend of national intelligence. In the cases we have considered, the mean innate intelligence of the total population (I_A^T) is constant because random mating and equal fertility between classes (castes) is assumed. If, however, in these cases we substitute the assumption of higher net reproduction rates for the low class (caste) then the mean I_A^T would decline.

A hypothesis that a trend of this kind has obtained in Britain since about 1870 remains tenable. The results of the Scottish Enquiry¹⁴ can be attributed to a temporary action of ameliorative environmental influences which must follow from the correlation of social status inversely with fertility and positively with measured intelligence (I_c).

On the other hand, it is possible to produce a model of 'intellectual equilibrium' with appropriate genetic and social assumptions including that of an inverse relation between social status and fertility. Penrose's model is an example of this.¹⁵ Moreover, what is known about social status, family size and intelligence indicates a complex set of relationships.¹⁶ The inverse relation between status and fertility is neither simple nor universal. It is often reversed at the higher income¹⁷ and occupational¹⁸ levels and does not apply to the high fertility areas of the world.¹⁷ The negative correlation between family size and I_c is well established where family size is defined as size of sibship but, so far, has not been found in studies where parental I_c is correlated with number of offspring.¹⁹

III. MEASURED INTELLIGENCE (I_c)

We may now return to our central problem. The existence of individual differences in a postulated I_A remain as a 'legitimate hypothesis'. But especially if I_A is polygenically determined, and given the history of social structure in Britain, their issue in social class differences is doubtful.

Further evidence in favour of this view may be had from an examination of the social distribution of measured intelligence (I_c). The figures given in Table 3 relating to 1,316 children entering secondary schools

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in South West Hertfordshire in 1952 are typical. For the total group of children they show a mean I_c^T of 100.97 with a standard deviation of 14.15. When the children are classified by paternal occupation the mean I_c rises with occupational status and the variance in each occupational group is less than that of the total population.

TABLE 3
The Social Distribution of Measured Intelligence

Father's occupation	Mean I.Q.	Standard deviation	Variance	Variance as percentage of total variance
	(1)	(2)	(3)	(4)
Professional workers, business owners and managers	112.95	11.62	135.01	67
Clerical workers	109.15	12.59	158.51	79
Foremen, small shopkeepers, etc.	103.70	13.47	181.44	91
Skilled manual workers	100.10	12.79	163.58	82
Unskilled manual workers	97.15	13.24	175.30	88
Total	100.97	14.15	200.22	100

Source: J. E. Floud, A. H. Halsey and F. M. Martin, *Social Class and Educational Opportunity*, 1957, p. 59.

Now the fraction of variation in I_c which is attributable to heredity is a matter of dispute, but the estimates of $3/4$ and $1/2$ may be taken to represent the upper and lower limits.²⁰ If the lower limit is accepted it follows that only where the variance in a sub-group is less than 50 per cent of that of the total population can we be certain that both heredity and environment are at work in the differentiation of the sub-group. Similarly if the variance remains at more than 50 per cent it is possible to entertain the hypothesis that the sub-group is differentiated solely on the basis of environmental circumstances. Thus it is clear from column 4 of Table 3 that, assuming the lower limit, the class differences in I_c may be entirely environmental.

On the other hand, if the upper limit of $3/4$ is taken as the fraction of variation which is heritable the result still holds with the single exception of the professional group, the variance of which is 67 per cent of the variance for the total group.

Of course this analysis, even leaving aside the exceptional case, does not demonstrate that the differences in mean I_c between the classes are caused by environment; it only shows that they could be. An experiment designed to test the hypothesis that these differences

are caused by the environmental components of social class is, in principle, simple. It would be necessary to take a random sample from newly-born babies among (say) the unskilled workers, distribute them at random in the other classes and, during and after upbringing, compare the mean I_C of each of the 'displaced' and 'control' groups. In practice, however, the difficulties of such an experiment are enormous. The available comparisons most approximate to it are to be found in those twin and foster children studies in which an assessment of the social or 'cultural' level of the home is taken explicitly into account. Among the 19 pairs of identical twins reared apart, studied by Newman and his associates,²¹ the average difference between members of a pair was 8.2 I.Q. points. Among six pairs judged to have the greatest discrepancies from the point of view of social advantage in the home, the average difference was 12 points. For the group as a whole, I.Q. differences correlated .51 with judged discrepancies in social environment. In studies of foster children correlations of I.Q. with assessments of the cultural level of the foster home vary from .25 to .52.²²

We can, however, be quite sure that these results underestimate the environmental effects of social class. The types of homes into which the twins in any one pair were placed rarely differed very much and the placement of children in foster homes tends to be selective. In evaluating the studies of foster children, Anastasi and Foley state that 'if the total range of American homes were covered, reaching down to the most deficient then the observed effect of home environment upon intellectual development would probably be greater'.²³

CONCLUSION

Accepting the hypothesis of an innate intelligence (I_A) we have drawn up a simple model of society designed to show the relation between variations in social structure and the distribution of genotypes.

In the extreme case of a caste society each caste has to be seen genetically as a separate gene pool and therefore, provided there is random mating within castes and equal fertility between them, the distribution of I_A is stable.

When a caste society is transformed into a class society the classes, may still be seen as gene pools but with migration between them. The question now becomes one of determining the relation between social mobility and genic migration. In our model of the class society we assumed that the rate of social mobility was such as to replace the 10 per cent of the high class with the least intelligence with an equal number of the most intelligent members of the low class. Under these conditions and assuming innate intelligence to be determined by a single gene it took seven generations to produce a 'pure' high class.

Even so, it is important to notice that, with a high class constituting one-tenth of the total population, the effect of draining off a pure high-intelligence high class from the reservoir of the low class scarcely affected the mean I_A of the latter and still left it with a heavy preponderance of the total number of available genes for high intelligence.

The model may be elaborated in order to approximate more closely to the real conditions of contemporary society. For example its fertility assumptions may be modified in order to throw light on the question of trends in the national intelligence. The central focus of our attention has been on the rate of genetic purification in the high class. From this point of view the refinement of our assumptions has to be considered in terms of acceleration and deceleration of the process of purification: and what we know of the genetics of I_A and the history of social mobility in Britain leads us to doubt the hypothesis of innate class differences in mean intelligence.

From this and from a consideration of the small reduction in the variance of measured intelligence which results from classifying children according to paternal occupation it seems reasonable to conclude that the observed differences between social classes in measured intelligence are more likely to be explained by environmental rather than genetic factors. Accordingly the research problem becomes one of disentangling the environmental components of social class which are relevant for intellectual development.

NOTES

¹ In preparing this paper I have had helpful discussions with E. Caspari, R. Savage, M. E. Beesley and Mrs. J. E. Floud. Mrs. E. Proschan has helped me with the statistical calculations.

² See R. S. Woodworth, *Heredity and Environment: A Critical Survey of Recently Published Material on Twins and Foster Children*, N.Y., 1941, or E. R. Hilgard, *Introduction to Psychology*, 2nd Edition, N.Y., 1957, p. 454 *et seq.*

³ Cf. P. E. Vernon, 'The Assessment of Children' in *Studies in Education*, No. 7. University of London, Institute of Education, 1955. In this lucid discussion, Vernon distinguishes Intelligence A, B and C. A is 'inherited', B is 'largely acquired' and C is test performance.

⁴ D. D. Hebb, *The Organisation of Behaviour*, 1949.

⁵ J. Piaget, *The Psychology of Intelligence*, 1950.

⁶ Suppose a population to consist of equal numbers of MM and Mm individuals. Then the relative frequency of M to m is 3 to 1. Now consider the mating of an MM with an Mm in-

dividual. The offspring could perchance all be Mm, thus reducing the relative frequency of M. Thus owing to chance fluctuation, especially in small populations, gene frequencies may increase or decrease. This phenomenon is called genetic drift.

⁷ T. Dobzhansky, *Evolution, Genetics and Man*, 1955, p. 34.

⁸ See Arthur Keith, *A New Theory of Human Evolution*, 1947.

⁹ Genetic drift could not, of course, be ignored in a complete analysis of such small populations.

¹⁰ See P. A. Moody, *Introduction to Evolution*, New York, 1953, p. 340.

¹¹ D. V. Glass, (ed.), *Social Mobility in Britain*, 1954, p. 199.

¹² It should be noted that we are looking at the rate of genetic purification of the classes and not the translation of those rates into means and standard deviations of scores. The latter would involve us in the complication, mentioned earlier, of increasing standard deviations in each generation.

¹³ However, for the addition of

each further gene there is a smaller increase in the number of generations required to reach purity.

¹⁴ Scottish Council for Research in Education, *The Trend of Scottish Intelligence*, 1949.

¹⁵ L. S. Penrose, 'The Supposed Threat of Declining Intelligence', *Am. J. of Mental Deficiency*, 1948.

¹⁶ An excellent summary of the present state of knowledge is given in A. Anastasi, 'Intelligence and Family Size', *Psychological Bulletin*, May, 1956.

¹⁷ United Nations Department of Social Affairs, Population Division. *The Determinants and Consequences of Population Trends*. ST/SOA/Series A, Popul. Stud. No. 17, N.Y., 1953.

¹⁸ R. M. Dinkel, 'Occupation and Fertility in the United States', *American Sociological Review*, 1952, 17, pp. 178-83.

¹⁹ Cf. A. Anastasi, loc. cit., p. 195.

²⁰ Cf. K. Mather, 'The Effect on the Distribution of Intelligence of Increasing the Heritable Variation' in *The Hazards to Man of Nuclear and Allied Radiations*, Cmd. 9780, H.M.S.O., 1956, p. 100, where these limits are used.

²¹ H. H. Newman, F. N. Freeman and K. J. Holzinger, *Twins: A Study of Heredity and Environment*, Chicago, 1937.

²² Anastasi and Foley, *Differential Psychology* (rev. edn.), 1949, pp. 351, 353, 356.

²³ Ibid., p. 362.

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