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THE RELATION BETWEEN INBREEDING AND INTELLIGENCE

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THE effect of inbreeding upon man and animals is still one of the question marks of biology. In general, the opinion of geneticists seems to be that expressed by Lush (1) who considers that the result depends upon the soundness of the stock upon which inbreeding is practised. It concentrates genes more rapidly than is the case with other types of matings, thus increasing the degree of homozygosis. It does this with genes for desirable characters and with those for undesirable ones. As the latter may undo the good work of the former it is not surprising that inbreeding so often results in disaster. All writers on the subject emphasize that sound stock to begin with, together with rigid culling of animals with undesirable genes as they come to light, are essentials for successful inbreeding. On the other hand, many practical breeders believe that inbreeding has a weakening effect upon the line independent of the gene concentration, a difficult belief to prove when so few genes are actually known.

There is evidence that the animals which have proved outstanding for production in several breeds of cattle have not been produced by the concentration of genes by inbreeding. Thus, McPhee and Wright (2, 3) found that the 20 prize-winning beef Shorthorn sires and the 100 highest milk yielding Shorthorn cows were no more inbred than

the average of the breed, and Asdell (4) has found the same for the 100 highest milk yielding Holsteins and the 100 highest butter-fat yielding Guernseys. In the latter work it was concluded that the best advice still is to breed the best to the best and to rely upon this to produce the most desirable combinations. No definite system of breeding was outstanding in its contribution to the select class of animals examined. In the case of the Holsteins many of them showed a reduction of inbreeding when highly inbred parents were crossed, a result due to the fact that part of the inbreeding in the sire and dam was not to the same ancestor. This is the only exception to the statement made above regarding the lack of breeding systems which produce the outstanding individuals.

Evidence that characters which need for their highest expression the interaction of many factors, health, development of specific parts or organs, ability to eat much, and good digestive ability, are best expressed with a condition of heterosis, or outbreeding, is not lacking, especially in pigs. Winters *et al.* (5) have found better production when inbred lines of pigs have been crossed, so that the degree of inbreeding has been markedly reduced or has disappeared altogether. But the inbred lines used for the cross must be good for the cross to be good. This may mean that homozygosis is not desirable for the best results to be achieved; it does not necessarily mean that inbreeding is harmful apart from its genetic effects. The cattle work quoted above seems to point in the same direction, and in an extensive cattle cross-breeding experiment by Fohrman (6) marked improvement in milk yield has resulted, apparently as a result of the crossing. Much more work could be cited, some pointing in one direction and some in the other. There are too many unknowns in all the data to draw a general conclusion; so much depends upon unknown factors in the genetic make-up of the animals used.

In man there has been a general prejudice against inbreeding of any kind, a prejudice which may have been founded upon observations on the ill effects of inbreeding as practised without culling or selection, and which has found expression in the many ecclesiastical and civil laws restricting consanguineous marriages. Huth (7) has reviewed much of the literature, legal and otherwise, but he points to a general trend of opinion in the opposite direction, a trend toward *laissez faire*. This is aptly summed up in his words:

> ". . . . there is a widely spread uncomfortable feeling that consanguineous marriages are to be avoided if possible; but if Angelina insists on having

> Edwin, and Edwin is fortunate enough to make Angelina persist in her intention, why, let them marry and may they be happy!"

The modern tendency has been to reduce the number of legal restrictions, making more inbreeding possible. Probably the gradual lifting of these restrictions has had little effect upon the quality of humanity in general; the first cousin marriages allowed represent only a mild degree of inbreeding and they are not common in any case, less than 1 per cent, according to the data given by Bell (8), while, according to Haldane (9), they have decreased with increased transportation facilities.

Mental ability is a form of production which is inherited. Numerous papers have appeared to show that this is so and it is unnecessary to review them. The purpose of this inquiry is to obtain data on the mental ability of inbred persons and to determine, if possible, the cause of any deviation from the average in such groups. It requires a variety of other conditions, such as health, and so on, to show its highest expression in activity and so it falls into the class of multiple interacting factors under discussion.

In 1926 Woods (10) wrote a book entitled *Mental and Moral Heredity in Royalty, A Statistical Study in History and Psychology.* In this work he attempted to show that genius and feeble-mindedness appeared in groups. A royal house would have several closely related worthy members at one period of its history. Then the genius would be lost due to unsuitable matings. The same was shown to be true for feeble-minded groupings with recovery if the matings were satisfactory. In making this analysis he classified about 700 persons of royal birth together with a few of the higher aristocracy closely related to the wives of royalty. The ratings were made for intellectual worth or fitness for their duty on the basis of the articles about them in standard biographies and other historical sources. As Woods says, "The adjectives that are used by biographers and historians are the basis of the estimate." He arranged his people, both men and women, in ten classes, the lowest, I 1, containing the imbeciles and feeble-minded, and the highest, I 10, the most intelligent or successful as rulers or leaders. The group, I 1, is small and it contains nine names, among them, Ivan and Feodor of Russia, sons of Alexis, and Charles II of Spain. Group I 10 is also small, containing fourteen names, among them, Frederick the Great of Prussia and his sister, Louise Ulrica, Queen of Sweden, Gustavus Vasa of Sweden, Louis II the

Great Condé, William the Silent of Orange, and Catherine II, the Great, of Anhalt-Russia.

While one can differ in the placing of individuals in these ten classes the general classification seems to have been fairly done and differences of opinion on individual placings would probably cancel one another. For the purpose of the present writer the classification had the great advantage that from his point of view the material used was entirely objective. He had no hand in making the classification.

There are a number of small errors and duplications in Woods' material. When these were eliminated there remained 690 individuals who could be used in this study. Their numerical distribution into classes is given in Table 1.

TABLE 1

Distribution of persons into grades of intellect and their average coefficients of inbreeding

GRADE	WOODS' DISTRIBUTION	BINOMIAL DISTRIBUTION	NUMBER STUDIED	AVERAGE INBREEDING COEFFICIENT
Low 1	9	1.4	9	4.9
2	26	12.1	26	5.4
3	50	48.5	47	4.3
4	96	113.2	87	2.9
5	162	169.8	150	3.1
6	125	169.8	118	2.8
7	111	113.2	99	2.4
8	67	48.5	54	2.1
9	30	12.1	28	1.1
High 10	14	1.4	14	2.7
Total	690		632	

Examination of this data for goodness of fit to a normal distribution curve revealed a fairly good fit except at the ends of the curve and this is understandable since very poor and very successful rulers are more likely to receive notice than those who do an average job. They are therefore present in greater numbers than would be expected in a random distribution. This is especially apparent in the extreme grades, I 1, and I 10. Theoretically, grades I 5 and I 6 should be equal in numbers but I 5 is increased at the expense of I 6, showing that Woods

was unduly severe in his judgment of average specimens of royalty. These differences from random distribution do not impair the value of the data for the use to which it is now put.

Six-generation pedigrees were constructed for all these people. In some cases it was not possible to construct them as genealogical data could not be obtained with the resources at the writer's disposal. These cases have been omitted from further consideration. A criticism which may be made is that the official pedigree may not be accurate in fact; that the morals were such in some courts that parentage is problematical. Most of the cases are drawn from comparatively modern times, in an era of unusually frank memoirs, when the doings of the people considered were subject to close scrutiny. When contemporary gossip has cast doubt upon the parentage of an individual, that case has also been omitted from further consideration. The remaining pedigrees can probably be regarded as reliable. Altogether, 632 persons of known pedigree remain for further treatment. The coefficient of inbreeding of each was calculated, using S. Wright's (11) short formula,

$$F_x = \Sigma\,(\tfrac{1}{2})^{\,n+n^1+1}$$

where F_x is the coefficient of inbreeding; n is the number of steps from the father to the common ancestor, and n^1 the number of steps from the mother. The correction for the coefficient of inbreeding of a common ancestor was not used since it was found not to affect the result. All coefficients were multiplied by 100 and calculated to one decimal place. This method is sufficient to reveal any inbreeding in a 6-generation pedigree except that a single common ancestor in the sixth generation fails to give a significant figure and is thus counted as zero inbreeding. The results were averaged for each intelligence grade and are shown in Fig. 1.

This graph reveals, in general, a progressive decrease in average inbreeding as the intelligence increases. The coefficient for I 1, which is less than that for I 2, may be due to the small sample, or, more likely, to the fact that imbecility may be due to a variety of causes, such as a cretinoid condition, not necessarily due to hereditary mechanisms. Likewise, the increased degree of inbreeding in I 10 as compared with that for I 9 may be due to the smallness of the sample or it may indicate a concentration of genetic factors by inbreeding which causes genius. The writer does not believe that the latter is the cause

in this material since, if it were, one would expect the upper grades, I 8 and I 9 to share in the increase. The concentration of some of the factors should make their influence felt in these grades. Another factor which enters here is the one pointed out by Woods, the concentration of famous names in a family tree. Thus, the grade I 10, contains Frederick the Great of Prussia and his sister, each with 8.3 per cent of inbreeding and Louis II, the Great Condé, with his sister, Anne, Duchess of Longueville, each with 6.6 per cent. These four

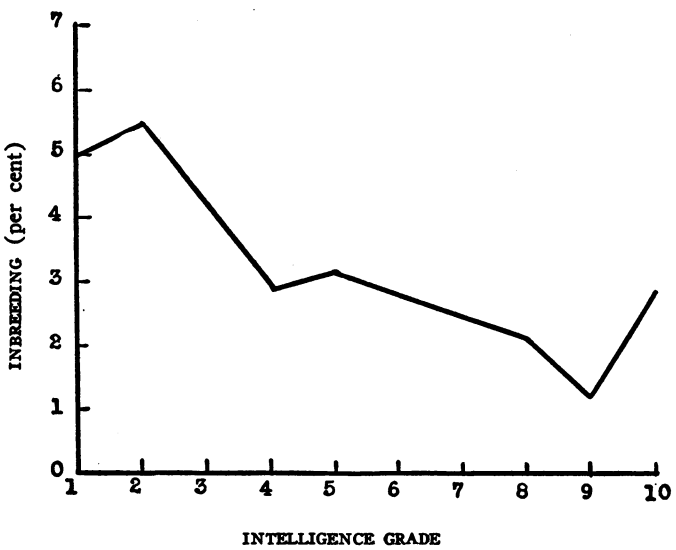

FIG. 1. RELATION OF PERCENTAGE OF INBREEDING TO INTELLIGENCE

account for most of the upswing at I 10. The part of the curve between I 2 and I 9, inclusive, shows a steady decline in the degree of inbreeding as intelligence increases. Even if the curve is corrected by calculating the persons of unknown pedigree as zero inbred (and difficulty in constructing the pedigree nearly always indicates this) its trend is not altered; it is merely dropped two decimal points throughout.

This curve can be, and is, in fact, misleading. It can be interpreted as indicating that inbreeding is the cause of the lessened intelligence. But there is the possibility that inbreeding was practised only by those of lower intelligence in the first place. This possibility has been

tested. Woods showed that the coefficient of correlation (r) between the intelligence ratings of husband and wife was $0.08 \pm .076$, indicating that as far as intelligence of the husband and wife are concerned mating was random and not assortive. Since the main reasons for choice of mate in royal houses are to provide heirs and to satisfy political reasons, the marriage arrangements rest with the house of which the male is a part, so they, alone, therefore, need be considered. It may be argued that the young man has little say in the matter, that his parents, near relatives, and their advisers make the selection, and they should be the subjects of the test. But they do not provide the offspring of the mating, so, biologically, the husband must be the subject. The wife may be neglected as, statistically speaking, she represents the average intelligence of the group under study. So, therefore, a comparison was made of the intelligence of the husbands whose marriages produced no inbreeding with that of an equal number of husbands whose matings produced a maximum of inbreeding. In other words, the children were not considered, but only their fathers. Only legitimate matings were considered since illegitimate children are rarely considered in Woods' data unless they were outstanding, so that matings which produce them, usually with zero inbreeding, cannot be considered as biologically randomized for our purpose. There remained 50 matings with zero inbreeding to be considered. The husbands had an average rating of I 6.2. For the highly inbred matings all of 6.0 per cent inbreeding and above were taken. This lower limit was chosen since it gave a sample of approximately equal size. There were 52 such matings and the average intelligence of the fathers was I 4.9. The fathers of the more highly inbred children averaged, therefore, more than a whole intelligence grade below the fathers of the children that were not inbred. The decline in intelligence rating of the children with increasing inbreeding may therefore be due to the poorer quality of the fathers who practised the inbreeding.

Is this the whole explanation for the decline? May the inbreeding in itself produce some of the effect? A method of testing this possibility is to work with fathers within one intelligence grade and to decide whether the more inbred children are less intelligent than the less inbred ones. In order to test this possibility the material was sorted according to the intelligence grade of the fathers and then divided into approximately two equal halves, the less and the more inbred. The average intelligence of the children was then compared in each group.

No consistent trend was found (Table 2), perhaps because the dividing line made the average coefficient of inbreeding in the more inbred groups very low. The amount of inbreeding might not have been sufficient to show a difference in intelligence. Accordingly, the averages of the 10 or more (the division was made to avoid separating those with the same tenth per cent of inbreeding) most inbred children in each father intelligence group were considered (Table 2). These showed a

TABLE 2

Effect of inbreeding within intelligence grades of fathers

FATHERS' GRADES	LESS INBRED HALF		MORE INBRED HALF		THE "TEN" MOST INBRED	
	N	Average grade of children	N	Average grade of children	Average grade	Average grade of mothers
1	..	..	..	..	..	..
2	14	4.3	12	5.2	..	..
3	35	5.8	35	5.1	4.6	6.0
4	37	5.1	39	5.3	4.5	4.7
5	49	5.2	48	5.6	4.5	?
6	34	5.6	30	5.5	5.0	5.7
7	46	6.0	69	5.9	4.8	5.6
8	27	6.5	25	5.7	5.6	5.3
9	9	4.9	9	5.4	..	..
10	13	6.8	4	6.8	..	..

consistent trend toward less intelligence. But, working with such small groups as 10 individuals, it is not safe to assume that the mothers were average, as had been done in the larger groupings on the basis of the correlation coefficient. The intelligence of all the mothers was not known but the average grades of the known ones did support the theory of a decline due to the inbreeding. The results, however, might equally well be explained by invoking the principle of reversion to the average which must be taken into account in considering material of this nature. Or, the classification may have merely picked out cases in which Woods' grading was awry. The evidence is far too scanty to warrant the conclusion that the inbreeding in itself, without the influence of parental genes, causes a decline in intelligence.

The sample of humanity studied shows a steady decline in intelligence as inbreeding increases but this is in part, if not wholly, due to the poorer quality of the fathers who have practised inbreeding. Evidence that inbreeding has a deleterious effect other than that of concentration of genes which produce undesirable effects is lacking. This result is entirely in line with general belief in regard to the transmission of hereditary traits. It adds strong evidence to support our existing knowledge that mental ability, or the lack of it, is inherited.

In discussions of this work with others the writer has been asked repeatedly about the Ptolemies. Are they not an example of close inbreeding without ill effects? They are popularly believed to have practised brother and sister matings for generations. The writer has used the historical data given by Mahaffy (12) to inquire into this question with the following result: Ptolemy I, Soter, the first of the line, was highly successful and might have received the rating I 9 in Woods' scheme. His heir, Ptolemy II, Philadelphus, was not inbred and he might have had the rating I 7. The next, Ptolemy III, Euergetes, was also the result of an outcross but his intelligence or success seems to have been low, meriting about I 3. He married outside his line but his son, Ptolemy IV, Philopater, was a very poor specimen, rating about I 2. He married his sister, Arsinoe, who was fairly able, rating about I 7. The son, Ptolemy V, Epiphenes, was somewhat better than his father, but not much is known of him. He might rate I 4. He married Cleopatra I of Syria, an able woman, not closely related. One son, Ptolemy VII, Philometor, was average, about I 6, and he married his sister, Cleopatra II, who was an able woman. Their son did not continue the dynasty. The younger son of Ptolemy V, Ptolemy IX, Physkon, was poor, about I 2. He married his niece, Cleopatra III, and the son who carried on the dynasty, Ptolemy XI, was poor, I 3. His son, Ptolemy XIII, Auletes, had for mother a woman whose ancestry is unknown to history, and therefore she was probably unrelated to her husband who was a weak king, I 2. Ptolemy XIII was father of Cleopatra the Great by an unknown woman. She was, therefore, the result of an outcross in two generations and she cannot be quoted in any discussion of inbreeding. The inbreeding occurred during a time when the rulers were weak men and the results of these matings were about what one would expect, considering the stock from which they came. Intellectual capacity had disappeared before the inbreeding. It cannot be used as an argument for the

inheritance of strength because the inbred Ptolemies were weak, and it cannot be quoted as an example for illustrating the evil effects of inbreeding as the stock was already poor.

An interesting sideline on this work is concerned with the question of the number of ancestors a royal person has, compared with the number he might have, for example, in the tenth generation back. For instance, George V of England possessed no more than 285, and Edward VII, 238 separate ancestors in this generation instead of the possible 1,024. This reduction in numbers does not necessarily represent much inbreeding since duplications which produce inbreeding must be common to the father's and to the mother's pedigree, while inbreeding more than 6 generations back produces little effect upon the concentration of genes. George V was 0.9 per cent inbred and Edward VII, 6.8 per cent inbred in six generations, numbers which are out of proportion to the reduction in their ancestors.

CONCLUSIONS

1. Analyses of royal pedigrees show a progressive decline in intelligence as inbreeding increases.

2. The men whose matings produced the inbreeding were of less average intelligence than were those who married into families less related to themselves.

3. The evidence available indicates that the decline of intelligence with inbreeding is probably the result of the poor stock which has practised this form of marriage.

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