CHAPTER XXXVII

TWINS AND HEREDITY

I. THE BIOLOGY OF TWINS

Twins have always been a source of interest and amusement to other people. There is something inherently comic in the existence of two individuals so similar that their identities are likely to be confused. Stories and plays have been written, the chief plot of which involves the mistaken identity of two brothers, two sisters, or a brother and sister. Quite recently I came to know an attractive lady who told me an interesting story of her girlhood—a story from real life that bears out those of drama and fiction. This young woman had a sister so much like herself that her best friends could not tell them apart. It so happened that a young man became attracted to one of the twins and called practically every night to pay his court. This assiduous wooing soon became burdensome, and, to relieve herself, the young lady had her twin sister substitute for her on some of the evenings. In the course of time the young man approached a proposal of marriage, but unfortunately selected an evening for popping the question when the substitute twin was on duty. He told her that, though some claimed to see no difference between her and her sister, he himself thought there was a great difference and all in her favor. He said he could not see why other people thought them so much alike. The substitute was forced to confess the deception; but in spite of this, the young man insisted that she was the one he wanted, and suspected her of merely testing his fidelity. In the resultant confusion the young man made such an ass of himself that neither twin had any further use for him.

This is, however, not to be a romance about twins, but a serious discussion about the scientific value of twins; so let us get on with it.

Various kinds of twins.—Several different kinds of human twins are recognized, among which the most significant are identical (duplicate) twins, "Siamese twins," and fraternal twins. Duplicate twins are, as the name implies, extremely similar in their personal characteristics (Fig. 91). They are always of the same sex in a pair, have the same or very similar temperaments, dispositions, and mental capacities. They are believed to be derived from the division of a single zygote. There is no such reality in nature as that useful and romantic

type of twin in which brother and sister are so much alike that one may take the place of the other. Such twins are purely literary significance and justified only for dramatic and fictional purposes.

Siamese twins are of the same origin as duplicate twins. They are the product of the division of a single individual into two, but in their case the division has been incomplete. Sometimes they are double in the head region and single back of that; sometimes they are double in the lower trunk region and single anterior to that; and

FIG. 90.—A pair of typical fraternal twins, showing differences in eye color, features, body build, etc.

sometimes they are double in the head and leg regions and united only in a small area at the hips or sides. Cases of Siamese twins that survive are exceedingly rare, the number recorded being so small that they could be counted on one's fingers. Yet it has been my privilege to have examined within recent years two of these cases.

Fraternal twins are quite different in origin. They arise from the simultaneous fertilization of two eggs and, except that they develop together in the same uterus, they have no closer kinship than ordinary brothers and sisters. They may be of the same sex or of opposite sexes in just the same way that families of two children may be both boys, both girls, or a boy and a girl. Fraternal twins are therefore,

only about as similar as ordinary brothers or sisters. A typical pair of fraternal twins is shown in Figure 90.

The origin of identical twins.—While there is no doubt in the minds of biologists that human identical twins are derived from the division of a single egg or embryo, it has never been possible to demonstrate this directly. Early stages in the development even of ordinary single human embryos are exceedingly rare, and there are no specimens

FIG. 91.—A pair of typical identical twins, showing no genetic differences.

known that are young enough to show the beginnings of normal twinning. Hence our belief that identical twins come from a single egg is based on a mass of indirect, but none the less conclusive, evidence.

In the first place, it so happens that the entire developmental history has been worked out for another mammal, the nine-banded armadillo, an animal which bears one-egg identical quadruplets at nearly every birth (see Fig. 52). The peculiarities of both egg and uterus are very similar to those of man. The known steps of embryology of the two species accord so closely that it is believed that the

process of twinning in man must be essentially the same as in the armadillo. Now, in the armadillo, every step in the double twinning process has been observed, and we have some rather well-supported theories as to why the egg divides into four individuals instead of developing into but one. There is in the armadillo a well-defined hitch in the process of the attachment of the young embryo to the membranes of the uterus. For a month or more after the embryo descends the egg tube into the uterus it lies free in the uterine cavity, whereas it should normally have attached itself immediately to the maternal tissues so as to receive food and oxygen from the maternal blood. During this period the young embryo is completely stopped down and is unable to develop at all. Its vitality becomes so lowered that, when finally the mechanism of attachment does right itself and the embryo is afforded the chance to feed and respire, the fires of life have burned so low that the embryo cannot maintain its unity, but starts to develop first at two regions and then at four. These four growing points develop into the four separate embryos.

That a lowering of the rate of vital activity during early development is able to induce twinning has been demonstrated experimentally in several species of animals, notably certain fishes and echinoderms. Apparently some embryos cannot maintain their singleness under conditions that lower vitality. On this account right- and left-hand sides cease to co-operate to form a single individual, and each half grows independently into a whole embryo. In armadillo quadruplets, some hundreds of which have been examined, there are frequent cases of mirror-imaging, that is, peculiarities found in the right side of one twin occur on the left side of the other. Again, it has been found that armadillo quadruplets are about 90 per cent identical, on the average, and are always all of the same sex in a litter.

Applying these known facts to the case of human twins, we find the following correspondences. Identical twins in man average about 90 per cent identical; they are always of the same sex in a pair; they show frequent instances of mirror-imaging. Thus, in about one-third of the cases one twin is right-handed, the other left-handed; also in about one-third of the cases the whirl of hair at the crown is clockwise in one twin, counter-clockwise in the other. Minor peculiarities of features—skin, teeth, finger prints, and palm patterns—are commonly on opposite sides of the two individuals. In addition to these evidences for the one-egg origin of human identical twins, it should be said that many prenatal human twins have been observed by obste-

tricians and these show peculiarities in embryonic membranes similar to those of armadillo quadruplets. Thus it will be seen that the human twinning situation rests largely on the armadillo quadruplet situation.

As to the causes of human one-egg twinning, we have no positive knowledge. It seems probable, however, that the cause is somewhat similar to that described for the armadillo. Some early hitch in the normal correlation of embryonic and maternal physiological relations, involving a delay in placentation, is believed to be responsible for twinning in man. Technical studies of tubal pregnancies strongly support this view; but lack of space forbids the introduction of this testimony.

In concluding the discussion of the causes of human twins, it must be admitted that as yet we do not know enough to enable us to control or to permit the production of twins. So we can give no practical advice to those who desire to have twins or to avoid them.

II. THE TWIN METHOD OF STUDYING HEREDITY IN MAN

In recent years there has grown up a new method of studying heredity in man by making use of twins, and especially of identical twins. A number of European workers, notably Siemens and von Verscheur, have written extensively on this method and have contributed many new facts about the heredity of pathological conditions and normal peculiarities in man.

The validity of the method rests on the ability of experienced students of twins to diagnose twins accurately as to whether they are identical (monozygotic) or fraternal (dizygotic). Both Siemens and von Verscheur are confident of their ability to do this, and I fully agree with them, having had no real difficulties in making this diagnosis in considerably more than a hundred cases.

Assuming that the two types of twins can be accurately separated by experts, how can twins be used in determining what characters are hereditary? The working hypothesis is that those characters that are the same in all cases of identical twins, but are usually different in fraternal twins, are hereditary; and that those characters that are different in identical twins, or that occur in one such twin and not in the other, are non-hereditary. Now there is one weakness of this hypothesis, namely, that some undoubtedly hereditary characters actually do express themselves differently in the two individuals of a monozygotic pair. This is not surprising, for often in a single individual a hereditary character may express itself on one side of the body

and not on the other, or else it may express itself much more extensively on one side than on the other. For example, there are certain finger-print and palm-print patterns that may occur on the right hand of an individual and not on the left, or may be present in one form on one hand and in another form on the other hand. Now, if identical twins are derived from the separated right and left halves of an embryo that typically would produce a single individual, such twins may be expected to be only as similar as are the two sides of a single individual. In view of this circumstance, we would be inclined to modify the working hypothesis of Siemens to the extent of saying that characters which are always the same in both individuals of a pair of identical twins are undoubtedly hereditary, but that the failure of certain characters to be the same in both members of a pair does not prove that such characters are non-hereditary. That this point is well taken is demonstrated by a study of armadillo quadruplets, which are unquestionably monozygotic. In these animals it frequently happens that a well-defined peculiarity, such as a local doubling of a band in the armor of the back, a rare anomaly known to be inherited from the mother, does not appear in all four offspring from a single zygote. One of the four may have it on the right side, another on the left side, a third on both sides, and a fourth may fail to show any sign of it. Yet it would be foolish to claim that, because the character failed to appear in one out of the four quadruplets, such a character is non-hereditary.

Using the working hypothesis, however, in its original form, Siemens has been able to show that a large number of pathological conditions are hereditary. He has specialized on birthmarks (naevi) and has shown that various types of naevi constantly appear in both twins, if they appear at all. He has shown that even moles and freckles are hereditary.

Bonnevie, Wilder, and I, working independently, have shown that various peculiarities of finger prints and palm patterns are hereditary. This has been done by the method of determining the coefficients of correlation between right and left sides of the same individual. Comparisons of the extent of correlation in identical twins is made with those in fraternal twins, sibs, and unrelated persons. For example, I have studied statistically the numbers of ridges in the finger patterns of fifty pairs of identical and of fifty pairs of fraternal twins, and the coefficients of correlation obtained are as follows:

COEFFICIENTS OF CORRELATION BETWEEN TOTAL RIDGE COUNTS OF FIVE FINGERS OF EACH HAND

Correlation between right and left hands of same individual	$r=0.93\pm0.01$
Correlation between right plus left hands of identical twins	$r=0.95\pm0.01$
Correlation between right plus left hands of fraternal twins	$r=0.46\pm0.08$
Correlation between right plus left hands of 30 pairs of brothers and sisters (Bonnevie)	$r=0.59\pm0.08$
Correlation between right plus left hands of 30 unrelated individuals (Bonnevie)	$r=0.27\pm0.12$

It will be seen that identical twins are even more alike in total ridge counts of finger patterns than are the two sides of the bodies of single individuals. This is in itself strong proof of the hereditary character of finger patterns. Fraternal twins are no more alike (in this series not as much alike) as are ordinary sibs. The extremely close resemblance between identical twins should be contrasted with the very low correlation in unrelated individuals. The slight positive correlation in unrelated individuals may be taken as a residuum of racial heredity.

In contrast with finger patterns, which everyone knows are fixed at birth and do not change throughout life—a fact that makes them valuable as an aid in personal identification—let us examine the degree of correlation in mental qualities as exhibited by groups of varying grades of relationship. Taking the Intelligence Quotient (I.Q.) as a measure of mental capacity, the following table was worked out by Kohn, a capable German student of twins:

COEFFICIENTS OF CORRELATION BETWEEN INTELLIGENCE QUOTIENTS (I.Q.)

Identical twins	0.90
Fraternal twins	0.59
Sibs	0.50
Sisters	0.47
Brothers	0.46

It is highly significant that mental differences show substantially the same grades of correlation as do the finger patterns, which are generally admitted to be purely hereditary. Various other authors, including our own local investigators, have found essentially the same

situation. Moreover, we have found that, in identical twins, the more alike they are physically, the more alike they are mentally. These studies tend to show one thing most clearly, that there is no distinction as to heredity between physical and mental characters.

A great many reports have come in from clinics all over the world concerning cases of identical twins in which both show rare and peculiar physical anomalies. Only a few examples can be given out of a large number that lie before me:

Bruce and Daugherty report seven cases of identical twins both afflicted with the same form of diabetes mellitus. Kelly Hale reports a pair of twins both afflicted with congenital dislocation of the hips, one with left hip dislocated and right eye crossed, the other with right hip dislocated and left eye crossed. This is a case of pronounced mirror-imaging and shows an unusual association of characters. Meierowski reports a striking case of identical twins, both with unilateral strabismus, one with right eye badly crossed and the other with left eye slightly less crossed. Croon reports a case of a pair of identical twins who began menstruation on the same day, were normal until thirty, then suffered alike from menstrual difficulties. Both had menopause at fifty, and three years later both developed the same type of carcinoma of the uterus. Von Verscheur reports a striking case of inguinal hernia (rupture) in a pair of elderly twin men, in which the rupture appears on the right side of one and the left side of the other. Goldstein and Schenck report an unusual case of dwarfism in twins. The smaller of the twins was smaller in all organs on one half of the body, a case of hemihypertrophy. Ahfeld reports seven cases of twins in which similar bodily malformations were present in both members of a pair. D'Outrepont reports a case of twins of which both had spina bifida and both had six fingers or six toes on each limb. Lehmann reports cases of twins both afflicted with cerebral hernias and hypospadias. Davis reports six cases of hare lip and cleft palate present in both members of the twin pairs. Parker reports two cases of twins both of whom developed dementia praecox, at nearly the same age. Bradley reports several cases of twins both afflicted with similar forms of manic depressive psychoses. Gesell reports twins who both showed extraordinary precosity, who sat up at six months, walked and talked at eleven months, learned French at three years, and were in the seventh grade at the age of nine.

No one has ever taken the trouble to get together all the data reported by observers of twins. If we had all this information together

in available form, it would doubtless constitute a most valuable contribution to the study of human heredity. The twin method is a new one and not yet so well established as the others, but it is growing in favor every year.

III. CRIME AND DESTINY

One of the most remarkable uses of the twin method in the study of heredity has to do with the problem of the heredity of criminal tendencies. Professor Johannes Lange, of Munich, has recently reported the results of many years of work on the criminal records of twins one or both of whom had been in Bavarian prisons or reformatories. This work was a part of the program of research of the Bavarian Institute for Criminal Biology, and is held in high esteem by leaders in the field. Lange's book entitled *Crime and Destiny* reports in some detail the criminal records of thirteen pairs of identical twins and seventeen pairs of fraternal twins, one or both members of a pair being in every case a confirmed and inveterate criminal. But what about the other twin in the two groups? The answer to this question is astonishing. Of the thirteen pairs of identical twins, there were ten cases in which the other twin of the pair was also an equally confirmed criminal. Not merely this, but the twin criminals of each pair exhibited the same types of criminality: both were swindlers, both thieves, both sex-offenders, both drunken ne'er-do-wells, etc., though in no case were the two members of a pair associated in their crimes. Of the three pairs of identical twins in which only one was a criminal, there were two cases in which one member of the pair had suffered a serious head injury at birth or in infancy, which might well have been responsible for his criminal tendencies, while in the remaining case one twin suffered severely from a goiter which might have profoundly affected his conduct. From Lange's description of the last case, however, it seems highly probable to me that this case is incorrectly diagnosed as identical, but Lange leans over backward in his attempt to weight the evidence against the conclusion that criminal tendencies are hereditary.

In contrast with this impressive study of identical twins, is that of the seventeen cases of fraternal twins, of which there were only two cases in which both members of a pair were criminal, and these exhibited relatively mild forms of criminality, such as might not have appeared at all in a more favorable environment.

In one of the cases of identical twins, both of whom were criminal, one twin, after a long criminal record, married a good woman of strong

character, who influenced him to stop drinking and stealing, and helped him to become a fairly useful member of society. This case tends to show that there is an environmental element in crime; but the point of the whole study is that there are certain hereditary types of mind that yield more readily than others to the ordinary social conditions that lead to crime. In this sense, and in this sense only, may it be said that criminality is hereditary.

IV. TWINS AND THE RELATIVE POTENCY OF HEREDITY AND ENVIRONMENT

Two sets of factors are involved in the development of an individual, and doubtless the same two sets of factors are responsible for racial development, or evolution. One category of factors is intrinsic and seems to depend upon the physical organization of the germinal protoplasm or upon the mechanisms that are involved in cell multiplication and differentiation: all such factors are here included under the term "heredity." The other category of factors is extrinsic and seems to involve both environment and training: these factors are usually included together under the term "environment." The controversy as to the relative importance of these two sets of factors is so old as to be time-honored. In the case of man especially, the question as to what characters are due to nature and what to nurture has long been an active issue.

Before the rise and growth of democracy the opinion was very commonly held that man was born noble or base, with high qualities or low, according as he came from good or bad stock. The various well-defined strata of society were believed to have a basis in blood. Blue blood was the criterion of nobility or of high character. With the rise of democracy, however, the view has come to prevail that "all men are created equal" and that inequalities arise only as the result of inequitable distribution of environmental and educational advantages. This has been until recently the prevailing opinion in educational, sociological, and political circles. This view, ignoring hereditary differences and overemphasizing of the potency of environment, has caused the pendulum to swing to the opposite extreme.

The present century has seen such a surprising advance in our knowledge of the laws and the mechanism of heredity that it is no wonder that biologists have come to feel that heredity is far and away the chief factor in human development and that environment and training are only minor modifying factors.

In one sense, the controversy about the relative importance of heredity and environment is rather silly and futile, for both heredity and environment are absolutely essential for development to take place at all. The real controversy hinges on this question: *With respect to any given character, do the actually existing differences in heredity have a greater or a less effect in determining the differences found in the adult than do the actually existing differences in the environment?*

Now some characters, such as eye-color, hair-color, shape and arrangement of teeth, finger and palm patterns, features, body build, and a long list of others, are evidently not much altered by existing differences in the environment and may therefore be called purely hereditary—and by this we do not mean that the environment has nothing to do with their determination. Other characters, such as body weight, muscular development, skills of various kinds, extent of tanning of the skin, certain types of eye defects, effects due to the ravages of disease, and many others, seem to be very largely influenced by existing differences in the environment, and may be called environmental. Large numbers of characters fall in between these extremes, characters that are surely predetermined, within limits, by heredity but are also much modified by actually existing differences in the environment. Among the most significant types of human difference that are both hereditary and environmental, in the sense just discussed, are differences in mental capacity (as determined by intelligence tests) and differences in temperamental and emotional make-up (as determined by psychological tests).

Identical twins have furnished some highly significant data on this point. As a preliminary step it was necessary to determine the average differences in mental capacity and in temperament for fifty pairs of identical twins reared together and for the same number of same-sexed fraternal twins reared together. Since the heredity was the same and also the environment essentially the same for identical twins reared together, the observed differences must be due largely to the workings of the asymmetry mechanism, the same mechanism that makes the two halves of a single individual different. In order to test the effect of differences in environment, therefore, we must compare the differences found in identical twins reared together with those of identical twins reared apart. In both those reared together and those reared apart the asymmetry mechanism works in the same way; therefore, greater differences in separated twins than in those reared together may fairly be attributed to differences in environment.

Now scientists cannot cold-bloodedly separate identical twins in infancy and rear the two under radically different environments, but fortunately this very thing has sometimes been done for them without their knowledge. When by a stroke of good fortune we are able to locate such cases, we have before us a scientific experiment completed and only needing to be studied. During the last few years we have completed the study of five such cases. A brief account of these five cases, (one studied by Muller and five by Newman) may interest the reader:

Muller studied a pair of twin sisters, left orphans and separated at two weeks. They did not meet until they were eighteen years old. They lived under somewhat similar social conditions, in northwestern mining and ranch country, but there were marked differences in their educational and social experiences. Physically, although entirely separated from infancy to adulthood, they were as identical as are identical twins reared together. Their heights, weights, features, teeth and finger nails, eye-color, hair-color, glove size, blood group, etc., were indistinguishably similar. In addition, both were left-handed, both had the same peculiar prominences on the ankles, and both had a droop of the mouth on the left side. Both had had two or three attacks of tuberculosis almost simultaneously. Intelligence tests showed them to be both very bright, and their scores were as similar as those commonly made by the same individual taking the tests twice over. In the temperament and emotional tests, on the other hand, they showed a very wide divergence, as great or greater than those between two individuals taken at random. In this case the environmental differences had left the physical and intellectual characters unmodified, but had produced a profound effect on the emotional nature of the twins.

Newman's first case consisted of a pair of twin sisters separated at eighteen months. One was taken to Ontario, and the other remained in London, England, where they were born. After seventeen years of complete separation, the English twin joined her sister in Canada, where they now live in a pleasant medium-sized town. Their environments were very different during the period of separation, as different as one is ever likely to find in cases of separated identical twins. One was reared in a congested district of London and passed the trying period of the war there; the other lived under good circumstances in a suburban town in Ontario, and did not feel the pressure of war conditions. Their educational careers were equal in amount and kind.

Tests showed, however, that they were very different in mental capacity, the Canadian twin being decidedly the brighter of the two. The difference was three times as great as the average difference of fifty pairs of identical twins reared together, and even somewhat greater than the average differences of fifty pairs of fraternal twins reared together. Physically, the Canadian twin was much superior, weighing 102 pounds, as compared with 92 for the English twin, a great difference for such small persons. They were strikingly similar in height, build, features, hair and eye-color, and finger and palm patterns. Also, they showed great similarity in their will-temperament qualities and in emotional reactions. Thus the differences in environment had caused marked divergence in the physical condition of the body and in mental capacity, but had left the emotional nature unmodified. In every respect this case is the direct opposite of Muller's case.

Newman's second case consisted of two twin sisters, who never heard of each other until they were about twenty-one years of age, but came together through the lucky accident of an acquaintance of one accosting the other by mistake. They were separated at eighteen months, adopted by two different families, reared in much the same stratum of society, but one had only grade-school education, while the other went through secondary and normal schools and taught grade school. These twins were physically almost complete duplicates when examined, as similar as the most similar identical twins reared together. The mental tests showed that the more highly educated twin ranks far above her less educated sister, the difference being more than three times as great as the average difference of fifty pairs of identical twins reared together and even greater than the average difference of fifty pairs of fraternal twins reared together. In contrast with this stands the fact that in all tests of emotional traits and of temperament, the twins give the impression of being remarkably and unusually similar. To summarize, these twins show a profound effect upon mental capacity due to vastly different educational careers, but physically and temperamentally they are nearly identical.

Newman's third case consists of two young men, one of whom lived in fairly large cities and the other in small country towns and villages. They had been separated at two months and had never met until they were about twenty-two years old, when one discovered that he had a twin brother while looking over some old papers. By a little detective work he located him. Their educational experiences were

nearly the same, the city twin having perhaps slightly better training. When examined, they were very similar in all genetic characters, but the city boy was in much better physical condition, weighing over 10 pounds more than his brother, though they were both small persons. In mental capacity the city boy was, on the basis of most of the tests given, definitely superior, though they were nearly equal on the Stanford-Binet test. In will-temperament and emotional tests they were very far apart, as far apart as were Muller's twins in this respect. In summary, this pair shows marked differences physically, mentally, and temperamentally, but more pronounced differences in temperament than in either of the others.

Newman's fourth case concerns itself with a pair of young women, now twenty-nine years of age, separated at five months, and reared in different families in the same part of Ohio. One was reared entirely on a farm, while the other lived mostly an indoor life in a town. The town girl had grade-school and high-school education, the farm girl only country grade-school training. They were almost identical physically until about twelve years ago, but now the farm girl is in far better physical condition, weighing 138 pounds as compared with 110 pounds for the town girl, and being very much stronger and more vigorous. The town girl had a mental rating much higher than her sister, the difference being over three times as great as the average difference of fifty pairs of identical twins reared together and considerably greater than the average differences of fifty pairs of fraternal twins reared together. In will-temperament and emotional reactions they are extremely different, as far apart as were Muller's twins or Newman's third case. In summary, these twins were about equally different in physical, mental, and temperamental characteristics.

A fifth case is being studied just as this revised edition goes to press. It concerns itself with a pair of twin women, now thirty-eight years old, separated at three months. They did not know of each other's existence till they were sixteen years old. A preliminary study of the data shows rather close similarity mentally and temperamentally, but a great difference in physical condition.

It is still too early to attempt to draw general conclusions on the basis of these six cases, but some facts confront us that cannot be dodged. Perhaps the most disconcerting fact revealed by the data is that *fraternal twins reared together are on the average somewhat more similar in mental rating, as judged by intelligence tests, than are identical twins reared apart.* This seems to mean that when heredity is different

and the environment the same, twins tend to become more similar than when the environment is different and the heredity is the same. Extreme environmentalists may see in this situation evidence that environmental differences are more powerful in determining mental capacity than are hereditary differences. I do not believe that this is true, and for several reasons. In the first place, if environment were more powerful than heredity, identical twins reared together should not be twice as similar as fraternal twins reared together; yet this is the case. In the second place, all the tests used to determine mental ability, except possibly the International test, measure largely the effects of training. This tends to mask or cover up hereditary resemblances and differences, increasing the difference in cases where educational experiences are widely divergent and decreasing the differences (in fraternal twins reared together) where educational experiences are alike. Thus the tests used tend to exaggerate the potency of environmental differences and to minimize the potency of hereditary differences.

In spite of these weaknesses in method, however, the data at least warrant the conclusion that both hereditary differences and environmental differences play important rôles in determining mental characteristics. In so far as a person's mental status is measurable in terms of ability to perform well or poorly on intelligence tests, it seems fair to conclude from our data that differences in heredity and differences in environment are about equally responsible for the mental status of an individual. On the other hand, since a large part of what is measured by intelligence tests is merely achievement and not real mental capacity, some will say we are not really measuring mental status at all. There is doubtless some justification in this criticism of intelligence tests, yet I cannot help but believe that one's individual mind, his mental rating, is at any time the product of his hereditary make-up and his training. If this be true, it is only fair to rate him according to this product.

In spite of all this apparent evidence that hereditary differences and environmental differences are of about equal potency in determining mental status, I have a deep-seated conviction, which I am unable completely to justify at this time, that differences in heredity are considerably more influential, perhaps twice as influential, in determining one's mental status, as are differences in environment.