VARIATION AND HEREDITY

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EDITOR'S NOTE

The subject of this volume is fundamental for every branch of human biology, and indeed for biology generally. Some understanding of the parts played by 'nature' and 'nurture' in the development of the human organism is essential before valid conclusions can be reached on a great variety of problems: examples range from the significance of 'racial' differences to the policy for dealing with 'problem families'.

As Dr. Kalmus makes clear, the subject has been bedevilled by a confused controversy between 'environmentalists' and others, miscalled 'geneticists': the first group claim that nurture is all-important, while the second seem to regard the fate of each individual as determined by his genes—a modern version of the Greek *Erinyes*. Biologically, neither environment nor heredity is the more important for development as a whole. *Particular* differences, such as that between an albino and a normal person, may be attributable to genetical differences alone; others, such as infection with measles, may be considered purely environmental. But a whole individual, at any given moment, is a product of a complex development in which, at every stage, genetical and environmental influences interact. This interaction is especially entangled in man, since the human central nervous system is uniquely adaptable: from birth or before, it is under continuous alteration as a result of the individual's experience; it is this plasticity which makes possible our powers of learning and our variable and rapidly evolving social organization.

It follows that differences of environment have a far greater influence on human behaviour than on that of other species. This is true despite the genetical variation which influences our abilities and other concomitants of behaviour.

The fact that our nervous systems are constructed in this way obliges us to pay special attention to the effects of environmental agencies on intellectual and emotional development.

But, for certain purposes, there is additional justification for emphasis on nurture. These purposes (presented by Dr. Leff in his volume, *Social Medicine*), are those of social *action*. We know a great deal about the effects of social change, while, as Dr. Kalmus shows, there is little certain knowledge to guide us in attempts to alter the genetical structure of human populations.

One of the most important features of this book is that it does not burke an account of the formidable complexities of human genetics. Certain passages, especially some in chapters 6, 7 and 9, will therefore present difficulties to readers without biological training. An adequate assessment of 'eugenic' ideas and programmes must depend, however, on a full understanding of the difficulties implicit in them. The same applies to the attempt to grasp what is involved in the question of effects of irradiation from fissile material. The aim of this book is to help a wide public to acquire this understanding.

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TYPES OF VARIATION

It is often said that all men are equal, but obviously this is not true. What is usually meant is that all people ought to have equal rights and opportunities. This opinion has been given form in a statement on race by UNESCO [155]. However, this book is concerned not with political differences, but primarily with measurable biological differences between men, and with their causes. These scientific matters have a direct bearing on social policy; this will in most places be found by implication, but sometimes it will be necessary to discuss the relationship between the two more fully.

Before plunging into a detailed survey of the biological diversity of man, and the intricate interactions between his uniquely complex environment and his hereditary endowment, it is useful to consider the formal methods by which human variation can best be described [57, 147]. We begin with a few commonly used words and concepts bearing on the distribution of characters. When describing a population, as distinct from an individual, two kinds of characteristics are principally used: first, descriptions or measurements of some sort of representative mean or average; and, second, descriptions or measurements of the spread of these measurements among the individuals of the population, such as the variance, the range or the standard error. The consideration of the spread is not as familiar as the use of the average, but it is of similar importance. If we wish to know something about the height of the boys in a particular school we can first calculate the average height of all the boys and then indicate the range of all the heights by giving the height of the shortest as well as that of the tallest boy; alternatively we might want to know which height class, measured in inches, is the most frequent among the boys, or the height dividing the taller half from the shorter half. The choice of some of these criteria, as well as their advantages and limitations, will be considered later. Here only a few descriptive words and usages will be discussed.

'NORMAL' AND 'AVERAGE'

The word normal is used in everyday language, and has a great variety of meanings. It is perhaps most widely used in the medical sense, when it means 'not ill'. Doctors have for centuries tried to define normality more positively, but it still remains a rather negative concept. Together with other factors this makes the recently advocated policy of positive health a difficult undertaking, as Leff shows in his volume on social medicine in this series [106]. In law too, a concept of normality is used which may be equated to some extent with sanity or responsibility for one's actions. Another aspect of normality is the statistical one, and much of this book deals with this aspect. A normal or average person defined statistically will fall in certain of his measurable characters between arbitrary limits on both sides of the most frequent value, that is, within the 'normal range'. (This 'normality' of individuals has nothing to do with the name 'normal', applied nowadays to a particular (the Gaussian) distribution.) Ever since Quetelet [133] introduced the term 'L'homme moyen', the 'average man' has haunted public life and social science.

The average man, although not a particular person but rather an idea, has certain specific and to most people unexpected characteristics. To begin discussing him one must ask some trivial questions. For instance, is he a man or a woman? It would be absurd to maintain that he should be an hermaphrodite, since this class of person is very rare. One might also ask whether the average man is a Chinese or a Negro, what language he speaks or whether he is a peasant or a town dweller. To meet these commonplace but very real difficulties the average man has begotten many children, such as the average British housewife, the average wage earner and many more, who appear daily in the press and in the results of public and private inquiries. A brother of the average man, the representative man, lives disguised in the textbooks and curricula of our universities, for example, in the young medical student's atlas of anatomy. Only later, in the pursuit of pathology and surgery, does the medical man grasp the diversity in body build and other characters to be found in any population. Properties of the representative man will be discussed later.

QUALITATIVE DIFFERENCES

If it is found impossible or unnecessary to *measure* particular noticeable differences between people, we call such differences qualitative; and if members of a population fall into two or more distinct classes we can apply what is called a natural classification. For instance one can divide humanity into dead and living, into hearing people and deaf mutes, or into male and female. The females one can subdivide according to age into those in the embryonic, pre-menstrual, menstrual and post-climacteric stage. A familiar example of natural classes are those distinguished by different blood groups.

Some artificiality of classification is found in most examples, and frequently it is not at all obvious what classes one should choose and where to set their limits. For instance, although there is no doubt that there exist red-haired people, it is difficult to define the class of redheads; it is by no means easy to decide on a point where one would call reddish hair blond or another point where one would call reddish hair brown. In addition very few people remain red-haired after forty, and many people with non-red scalps have red beards and body hairs. In such situations we can use various classificatory devices. We can for example subjectively call some hair red and other hair near-red. A better method is to match a given hair sample with one of a standard series of variously coloured hair samples such as were used by Martin [112] and other anthropologists. But even this method has obvious drawbacks: two observers may classify some individuals differently, and in addition the rare and sometimes most interesting variants are either misclassified or lumped together into one group as non-classifiable. A more objective method for the classification of hair colours is provided by spectrophotometry; in recording the spectral reflectancy of a hair sample a graph (reflectogram) is produced, which can be characterized numerically in various ways and thus an objective if still arbitrary classification of shade and colour of human hair can be attempted [68]. The method does away not only with subjective differences between observers but also with the vagaries of changing illumination. Its setbacks are that one must cut off a sample of hair and thus cannot test many people quickly—and also that machines for making reflectograms are very expensive and few in number.

It is of course possible to deal with hair colour in many other ways, for instance, by inspecting microscopical sections or extracted pigments. The spectrophotometric method has been chosen only as an example of how one might attempt to transform a subjective and qualitative classification into quantitative measurements which can be used either as such or as a basis for an improved classification.

The distribution of individuals of a population according to classes, whether these appear 'natural' or 'artificial', can be presented in the form of a histogram, or of a frequency polygon. The upper figure opposite is a histogram indicating the distribution of a population according to stature. The lower figure is a frequency polygon showing the same distribution. The results of classification can also be given in the form of a table.

Graded characters, such as length or weight, can be measured only with a certain limited accuracy: it is for instance not very useful to measure body length more accurately than to about 0·5 cm., because people are longer in the morning than in the evening by more than this amount, and repeated measurements even at the same hour of the day often vary by as much. For most purposes 1-cm. intervals or even coarser groupings are quite sufficient. Too fine a classification is not only laborious but may even be misleading, especially if the sample population is not large. In general one should have not fewer than twelve members in the most frequent class and a minimum of one or two in the most rare. The number of classes also is important. Sometimes it is sufficient to subdivide the population into two groups, but sometimes one needs very many classes. In many investigations six or seven classes are quite sufficient for a demonstration of the main features of a distribution.

Numerical differences in respect of anatomical entities which

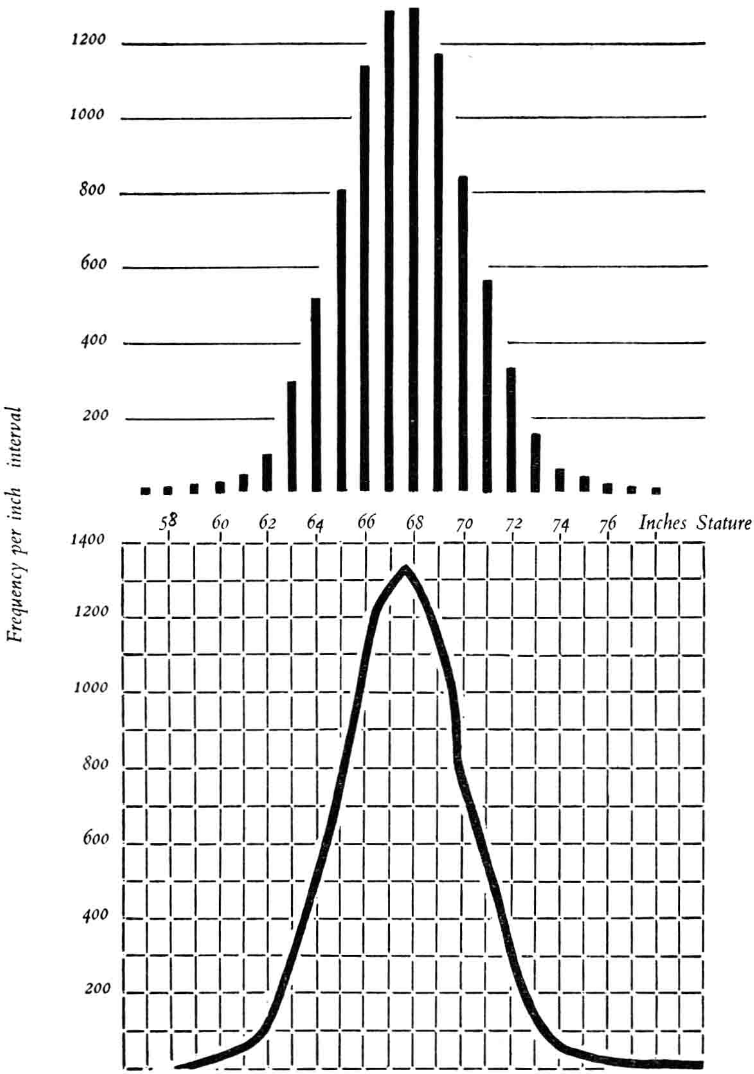

Fig. 1. *Stature among 8,585 adult males in Britain in 1883.* Above: histogram. Below: frequency polygon. Figures from a report of the Anthropometric Commission of the British Association.

are present in integral numbers form a special type of differences. The numbers of fingers, toes, phalanges, vertebrae, ribs are of this kind. A polydactylous individual is one who has more than five fingers at least on one hand, and so on. The classes of such a distribution are simply given by the number of elements present.

Distributions of this kind are not very usefully represented by the mean. It is not very informative to say that 'man' has a mean (average) of 5·001 fingers on one hand; but one can accurately say that most people have five fingers and very occasionally one has six.

If two characters are considered, two extreme situations can be found. The two characters may be independently distributed, or their distribution may be completely correlated. Usually a situation between the two extremes is found, and the problem then is to measure the degree of correlation in the distribution of characters. In Central European populations, for instance, only very low correlations between eye colour and body length are found, but there is generally a high one (if not an absolute parallelism) between eye and hair pigmentation [28]. A similar correlation between skin and hair pigmentation occurs in many other European populations.

The study of correlated variation has applications in many fields. It is of the greatest interest for the clothing industry to know what combinations of body length, width of hip, sitting height and so on are commonly found together, and how often these various 'sizes' occur among their customers. Shoe manufacturers also must know the correlation between the length and width of feet. Inference from one group of measurements to others is sometimes used by forensic experts or palaeontologists; either may be asked whether a bone or a tooth derives from a man or a woman, a human being or an ape; and their answers may be based on tables of correlated measurements.

PROBLEMS OF MEASUREMENT

Some human characteristics such as body temperature, weight or stature can be measured with comparative ease, whereas others—and among them the vastly more interesting intellectual and emotional traits—are much more difficult to assess. Here an interesting discrepancy appears between the assessment of laymen and of scientists, who in all probability will give quite contradictory answers to questions like the following: 'Were the musical abilities of a Bach or Beethoven very much greater than those of most people?' or 'Is the mathematical ability of Einstein of a different order from the mathematical ability of any student in mathematics?' And conversely: 'Is the intelligence of an imbecile or idiot very much less than the average normal intelligence?' As will be shown later, the answers to such questions depend largely on the choice of yardstick [148, 150].

The layman will probably consider such differences as 'very large' and everybody will admit that they certainly make 'all the difference' to the individuals concerned and to society. However, 'very large' and 'all the difference' are not scientific notions and the scientists who have tried to measure human abilities will have to answer that compared with the ranges found in the measurement of natural objects, such as the size of stars or the fertility of animals, the vast majority of normal human traits so far measured vary only between rather narrow limits [41], say between 1: 1·03 (body temperature) and 1: 2·85 ('simple learning'); among, let us say, 1,000 people, the body temperature of the second coldest and the second warmest may vary by not more than three per cent, and learning ability by not more than threefold. (Table I.)

The reader may ask why the full range of measurements is not considered. Usually there will not be much difference between the smallest and the second smallest (or the largest and second largest) measurement in a sample of 1,000, but occasionally there is. For instance, if we measure stature, a pathological dwarf or giant may turn up in the sample; hence the slightly more cautious definition of 'range' used in this discussion.

Table I gives some idea of the range of variation of some human traits. As this table shows, the ranges of listed normal human traits are surprisingly small. How then is it that differences between people appear so big and important? To this only a brief and incomplete answer can be attempted here. Small differences in a particular ability may still make a big difference in effect. Ability or inability to scale a short climb may decide the survival of a mountaineer and his whole party. A child