Division of characteristics from a hereditary viewpoint.

Strictly speaking, all characteristics in living organisms are determined by hereditary tendencies, genes, and also, at the same time, by environment. The genes in a fertilized egg must have a certain nature for the egg to be able to develop for a longer or shorter period. The constitution of the genes can, however, vary within certain limits. If the constitution of the genes deviates too much from the average of the species, the fertilized egg cannot develop, or will only do so for a short time. The environment, too, can only vary within certain limits if there is to be development. If the environment diverges too much from what is normal for the species, there can be no development. Genes and environment, then, can vary within the limits set by death. The characteristics of an individual are therefore always determined both by genes and environment. Naturally, the state of an individual at a given moment is also dependent on his age. A certain characteristic is therefore, strictly speaking, always determined by 1. hereditary factors, 2. environmental factors, and 3. an age factor.

When assessing an individual's characteristics, we often try to eliminate the age factor by comparing individuals of the same age. In a number of presentations of the problem, this factor is left out of account. Particularly in problems of heredity and environment is the age factor often tacitly disregarded, a proceeding naturally justified if this factor is of no importance for the special characteristic or characteristics in question, or if the argument postulates a comparison between individuals of a certain definite age. Generally the constitution of the individuals in adulthood, before increasing age has become noticeable, is discussed. It is not possible to say exactly how long this period is. We assume, however, that the limits are drawn to be on the safe side. During this period we have certainly right to consider the importance of the age factor to be little or nothing in most of the cases. Yet this is by no means always the case, in particular with regard to disease. When in the following chapters the age factor is in general passed over in the theoretical argument, this implies a conscious simplification. When solving a specific practical problem this must be kept in mind.

In a given case particular investigation must, if necessary, determine the part played by this factor.

We must assume, then, that a certain characteristic in an individual
is always determined by both environmental and hereditary factors. Which group of factors is to be assigned the greatest importance depends on their respective frequencies. Assume that a characteristic is determined by a hereditary factor and an environmental factor. If both the hereditary and the environmental factor is present in all individuals, the characteristics will always be there. This, then, is of no interest from the point of view of genetics. Characteristics present in all individuals are considered of interest only in discussions of differences between human beings and closely allied animal species, but they are, of course, of no importance when the problems bear on differences between human beings. If the environmental factor is always present and the hereditary factor present in a part of the population, but not in all individuals, this means that those individuals without that hereditary factor have another such factor. The population falls into two groups, between which there is a difference determined by heredity. If, on the other hand, the hereditary factor is found in all individuals but the environmental factor only in a group of the population, there is a difference determined by environment between the two population groups. If a population shows two hereditary factors and two environmental factors, which have a different distribution, the appearance of the characteristics must be determined by a coincidence of hereditary and environmental factors. There is a difference between two groups, conditioned by the fact that in one group a hereditary and an environmental factor have coincided, whereas in the other group only the hereditary factor is present, or only the environmental factor, or neither. In the latter case, the characteristics are absent. (It is of course possible that there are differences of characteristics between the three last-mentioned groups, also.) On these theoretical starting-points, we thus arrive at the following classification.

The first group consists of hereditarily determined characteristics in the proper sense. These characteristics are but little affected by environment. They depend upon a certain combination of genes for their existence. If this combination is there, the characteristic is always present in the individual, no matter how the environment varies. If the environment diverges unduly from the normal, both characteristic and individual cease to exist. In other words, the characteristic has little or no variability conditioned by the environment; or, expressed otherwise, the necessary environmental factors are always present. Now as, in practice, one as a rule never knows how individuals with this combination
of genes react to all conceivable environmental factors, it is clear that the statement that a characteristic in the actual sense is hereditarily conditioned can only claim a certain limited validity. It is conceivable that some rare and untested environmental factor might change the way in which the combination of genes manifests itself. When we pronounce a characteristic in the proper sense to be hereditary, we refer, then, only to the more usual environmental factors, "normal" for the species.

The second group consists of characteristics whose existence is in the first place determined by one or more not unduly common environmental factors. The genes necessary for the environmental factors in question to produce the characteristics exist in practically speaking all individuals in the species or population investigated. The environmental factors in question affect only some of the individuals in the population. Under such conditions it will be the environmental factors that play the deciding part. An example of this is typhus. Practically speaking, everyone has the hereditary constitution that disposes them to fall ill if infected with typhus germs. We say, therefore, that the disease is determined by the occurrence of the infection; strictly speaking, however, a certain hereditary constitution is necessary here, too. Dogs, for example, are immune to typhus. If a dog is infected by typhus germs, he does not contract the disease; his hereditary make-up is different from that of man. Thus certain genes are necessary for the existence of these environmentally determined characteristics, too, but when the genes are commonly present, they do not play the deciding part in any one case.

The third group comprises characteristics determined by a coincidence of environmental and hereditary factors, which are neither of them always present in the individuals in the population. The hereditary factors occasion a certain disposition, a leaning to react in a certain way to definite environmental factors. Individuals lacking this disposition do not react at all, or very little, to the special environmental factors; whether these exist or not is of very little consequence to them. Individuals with the disposition determined by special genes react to the special environmental factors in a different way, on the other hand. Such characters may be termed constellationally determined.

In all groups the question may be one of characteristics which can be found in healthy individuals, and which do not make for any limitation of fitness for life, and such as make for a more or less reduced
adaptation to the demands of life. If the reduced adaptability is very moderate, so small that the individual is inconvenienced by the characteristic more by way of exception, we speak of anomalies. If, on the other hand, the reduction is greater, we speak of disease. In any case, it is clear that in all the groups the characteristics may be of either more incidental or more permanent nature. A hereditary characteristic is, of course, fairly independent of environment, and if it is of a more incidental nature, this merely means that it is present for a short time at a certain age. Particularly striking is the accidental nature of hereditary diseases, which rapidly lead to death. There are many examples of accidental characteristics among those determined by environment; among these may be reckoned a number of infectious diseases, such as typhus, measles, etc. More permanent characteristics determined by environment include a number of diseases, e.g. syphilis, and the immunity consequent on certain accidental, environmentally determined diseases, e.g. measles. The group of constellational characteristics shows a special need for a division in respect of the accidental or permanent nature of the characteristic. The accidental constellational characteristics include a large number of infectious diseases, susceptibility to which hardly seems to be general in human populations, e.g. encephalitis lethargica and poliomyelitis. A constellational characteristic of a more permanent nature is, for example, a disease like tuberculosis, which postulates a certain disposition, certain genes, and an environmental factor, tuberculosis infection, and which results in a characteristic which in many cases has a fairly permanent nature. As the last example shows, the limit between our different groups is by no means sharp. It is to a certain extent a matter of taste whether a characteristic be regarded accidental or permanent, as also whether a certain combination of genes is so usual that its reaction to more infrequent environmental factors shall be thought to make for characteristics possible to denote as determined by environment. It is also clear that when genes of this kind react to some more usual environmental factor in one way, and to another more unusual factor in another, it is also to a certain extent a matter of taste whether the one or the other characteristic is to be considered abnormal or normal respectively.

As regards environmental factors, we can also discuss whether such a factor is common enough to enable us to put the main stress on the hereditary factor. If we assume that general paralysis is, at bottom,
due to a special way of reacting, determined by heredity, we can also say that the disease is conditioned by environment in so far as only those infected with syphilis are affected with paralysis. In a population where syphilis is very widespread, so that nearly everyone becomes infected, we would, however, have reason to consider the disease determined by heredity.

Summing up, it may be suggested that, in classifying characteristics, the frequency of the hereditary and environmental factors which play a part thus comes to be of great importance for the designation of the characteristic. If the hereditary and the environmental factor alike are of importance for the genesis of the characteristic, and both kinds of factors occur with moderate frequency, the characteristic is termed constellational. If the environmental factor is very usual and is present in almost the entire population, the characteristic is termed hereditary in the proper sense of the word. If, on the other hand, the hereditary genes have a very high frequency and the environmental factors a low one, the characteristic is taken to be determined by environment. If both hereditary and environmental factors occur in the whole of the population, then all individuals possess the characteristic and there are no hereditary differences in the population; if the hereditary and environmental factors disappear, then the characteristic disappears from the population.

The system proposed and the limits we have set are therefore to a certain extent arbitrary. The classification used here of characteristics from the point of view of heredity and environment has only recently been presented by the author (Dahlberg, 1939 a), and is therefore not universally accepted. Whether the system and the terminology based on this system is practicable remains to be seen. For the present, however, the system should suffice to clarify the rôle of heredity and the importance of the environment, and to give a more differentiated grasp of these problems.