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HEREDITY AND ENVIRONMENT

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KNOWLEDGE of heredity has changed fundamentally in the past few years; in consequence the relations of environment to heredity have come into a new light. What has gotten into the popular consciousness as Mendelism—still presented in the conventional biological gospels—has become grotesquely inadequate and misleading; its seeming implications as to the trivial rôle of the environment have become null and void.

What happens in any object—a piece of steel, a piece of ice, a machine, an organism—depends on the one hand upon the material of which it is composed; on the other hand upon the conditions in which it is found. Under the same conditions objects of different material behave diversely; under diverse conditions objects of the same material behave diversely. Anything whatever that happens in any object has to be accounted for by taking into consideration both these things. Neither the material constitution alone, nor the conditions alone, will account for any event whatever; it is always the combination that has to be considered.

Organisms are like other objects in this respect; what they do or become depends both on what they are made of, and on the conditions surrounding them. The dependence on what they are originally made of we call heredity. But no single thing that the organism does depends alone on heredity or alone on environment; always both have to be taken into account.

What an organism is first composed of comes directly from its parents; this is the reason why dependence on that composition has been called heredity. But this habit of speech has led to conceiving heredity as something in itself, an entity, a ''force,'' something that itself does things—an error that has induced clouds of misconception. Possibly we should be better off with no such concept as heredity: then analysis would be correctly directed toward understanding, in organisms as in other things, in what ways there is dependence on the stuff they are made of: in what ways on the conditions in which that stuff is found.

As to the dependence on the stuff that they are made of, research has shown that the substances passed from parent to offspring, giving rise to the phenomena of inheritance, are a great number of discrete packets of diverse chemicals, imbedded in a less diversified mass of material. The masses formed by the grouping of these packets are visible under the microscope as the chromosomes. The number of different kinds of packets that go into the beginning of any individual is very great, running into the hundreds or thousands. They are not massed in a haphazard way, but are arranged in a definite manner; so that the young organism is like a well-organized chemical laboratory with many reagents so arranged in containers as to react with each other in an orderly way, producing a definite and harmonious result.

Development we know consists in this orderly interaction of these substances—with each other, with the rest of the cell body, or cytoplasm; and with the oxygen, food and other chemicals brought into the cell from outside; all under the influence of the physical agents of the environment. The final result—what the individual becomes—is dependent upon all these things; a change in any of them may change the result.

The disposition of the chemical packets, or genes, is known to be at the beginning that of a double serial arrangement, like a pair of strings of beads; each chemical has its precise and practically invariable place in the series. For each packet in one of the two strings there is a corresponding packet in the other, so that the whole forms a set of pairs of packets. The two corresponding packets of one pair may both contain the same chemical. More commonly, perhaps, they contain chemicals somewhat diverse, though of related character; every individual has a great number of such pairs with diverse chemicals in the two packets.

When the organism becomes a parent, these sets of packets are distributed to the offspring according to a simple plan. The laws of heredity are in the main simply the rules of distribution of the packets. One parent gives to any particular offspring one packet only of each of its pairs. The other parent supplies the corresponding second packet of the pair, so that the offspring has again the full complement of pairs. The first of the rules of distribution discovered was the so-called Mendelian Law; it is the rule according to which the two packets belonging to the same pair are distributed. But when we take into consideration the interrelations of packets belonging to different pairs, a whole set of rules is discovered, covering the distribution of all the packets. These have been worked out in recent years: they are of equal importance with Mendel's Law. In essence all these laws are simple; any set of beads or buttons can readily be put through the same simple operations, and then they yield the same rules that we call the laws of heredity. But for genes located in different parts of the system, the rules of inheritance are somewhat diverse; and some of the genes are not paired, so that they yield a set of rules very different from those followed by the others. The only way to grasp the laws of inheritance is to arrange a set of objects in the way the genes are arranged and to put them through the simple movements followed by the genes; attempts to understand them in any other way are futile. The laws of inheritance are not immediate consequences of some fundamental physiological principle, but of the arrangement of the packets of chemicals and their method of distribution. Where the arrangement is different, there are other laws. For many kinds of reproduction, on this account, nothing resembling Mendelian inheritance occurs. But as the rules work out in most cases of biparental inheritance, every germ cell gets a different combination of these packets of chemicals from that obtained by any other, so that in consequence every individual starts out as a different combination of chemicals from every other; this makes prediction of results more hazardous in this field than is sometimes represented.

Any correct notion of the relation of environment to heredity depends on proper knowledge of how these packets of chemicals operate in producing the developed organism. This knowledge is obtained in two ways. One is by direct study under the microscope of the changes that occur during development, with experiments on the developing embryo. The other is by interchanging the different packets of chemicals and noting the consequences. In certain organisms it has become possible by proper mating and breeding to control the distribution of the packets almost as if they could be picked out and moved about by hand; this is essentially what is done by Morgan and his associates in their work on Drosophila.

Substituting one or more packets for others is found to change the characteristics of the organism produced; different sets give when they develop, even under similar environments, different physical, mental and moral peculiarities. The first precise discovery made was, essentially, that when a single one of the packets is exchanged for another, some definite later character is changed. So, changing one packet alters the color of the hair from black to red; or changes the eye color from blue to brown; or makes the organism short instead of tall; or even changes a person from a normal individual to a feeble-minded one; or the reverse. Characters changed by altering a single packet were the so-called "unit characters'' of Mendelism. These facts—the relation of single packets to particular later characteristics—gave rise to a general doctrine, a philosophy, of heredity and development—a doctrine which has had and still has a very great influence on general views of life. It is to this doctrine that the prevailing ideas as to the relation of heredity and environment, as to the relative powerlessness of environment, are due. But it has turned out to be a completely mistaken one. This fact has not come to general consciousness: the doctrine continues to be a source of mystification and error. Its complete disappearance would mean a very great advance in the understanding of life.

From the fact that the ''unit characters'' changed when a single gene changed, it was concluded that in some ill-defined way, each characteristic was ''represented'' or in some way condensed and contained, in one particular gene. There was one gene for eye color, another for stature, another for feeble-mindedness, another for normal-mindedness, and so on. Every individual therefore came into the world with his characters fixed and determined. His whole outfit of characteristics was provided for him at the start; what he should be was preordained; predestination, in the present world, was an actual fact. Environment might prevent or permit the hereditary characters to develop; it could do nothing more. Heredity was everything, environment almost nothing. This doctrine of the all-might of inheritance is still proclaimed by the popularizers of biological science.

But this theory of representative particles is gone, clean gone. Advance in the knowledge of genetics has demonstrated its falsity. Its prevalence was an illustration of the adage that a little knowledge is a dangerous thing. The doctrine is dead—though as yet, like the decapitated turtle, it is not sensible of it. It is not true that particular characteristics are in any sense represented or condensed or contained in particular unit genes. Neither eye color nor tallness nor feeble-mindedness, nor any other characteristic, is a unit character in any such sense. There is indeed no such thing as a ''unit character,'' and it would be a step in advance if that expression should disappear.

What recent investigation has shown is this: the chemicals that were in the original packages derived from the parents—the genes—interact, in complex ways, for long periods; and every later characteristic is a long-deferred and indirect product of this interaction. Into the production of any characteristic has gone the activity of hundreds of the genes, if not of all of them; and many intermediate products occur before the final one is reached. In the fruit fly at least 50 genes are known to work together to produce so simple a feature as the red color of the eye; hundreds are required to produce normal straight wing, and so of all other characteristics. And each of the cooperating packets is necessary; if any one of the fifty is altered, the red color of the eye is not produced.

And this is what gave rise to the idea of unit characters represented by particular genes. For suppose that one parent has all the fifty packets necessary to produce the red eye, while the other has but forty-nine of them, the fiftieth containing some substance that will not work in producing red. Then this parent will not have a red eye, but perhaps a white one, although it differs from the other in but one gene. When these parents produce descendants, the red and white eyes follow in heredity the distribution of that single pair of genes of which one is altered: wherever the altered gene alone goes appears a white eye; wherever the unaltered one of the pair, a red eye. So the red color and the white color, inherited according to the Mendelian law, were called unit characters; each was supposed due to a single gene.

But actually, fifty or more genes are required to produce either, as is discovered when some other one of the fifty is changed off for an altered one. Then, although the first pair of genes is now unaltered, still the red eye does not appear. Now the eye color follows the distribution of another pair of genes.

By successively altering genes of different pairs, or by altering genes of two or more pairs in the same parents, certain general relations of the greatest significance are discovered—relations which are commonly ignored. A certain characteristic, such as the red color, may, with a given pair of parents, follow a given gene, being inherited according to a particular rule—say the "typical Mendelian" rule. In other parents it follows a different gene, and is inherited in a different way—perhaps as a "sex-linked" character. There are fifty or more separate and independent ways by which the red character can be altered, and each yields a somewhat different rule of inheritance. Or in the same individual two or more of the genes affecting color may be altered; then the color is no longer inherited as a "unit character;" its inheritance is now of the "multiple factor" type. In some cases it will follow the rules for two-factor cases; in others for three, and so on indefinitely, until the inheritance may not be distinguished from the "blending" type. Such cases are typical. The fact that in an observed instance a characteristic is inherited as a "unit character" does not show that in other cases it will be so inherited. If a characteristic is observed in a given case to be inherited as a sex-linked character, we can not be certain that it will be sex-linked in other cases. If it is recessive in some stocks, it may be dominant in others. Feeble-mindedness appears to be inherited at times as a "unit character"; although nothing can be more certain than that hundreds of genes are required to make a mind—even a feeble mind. It is not surprising that absence or alteration of some one necessary chemical should leave the mind imperfect; this is all that is shown by "unit character" inheritance. Doubtless feebleness of mind is produced in hundreds of different ways—some sorts heritable according to one set of rules, others according to other sets of rules. Color blindness in man appears in some cases to behave as a sex-linked character: this does not make it certain that in other cases it will do so. It is a general truth that, even though we have worked out the precise method of inheritance of a characteristic in a given stock, we can not be certain that this same characteristic will be inherited in that way in another stock. It all depends on which particular one or more of the hundreds of genes on which the character depends is diverse in the two parents. Heredity is not the simple, hard-and-fast thing that old-fashioned Mendelism represented it.

Further, more attentive observation has revealed that any single one of the genes affects, not one characteristic only, but many, probably the entire body. The idea of representative hereditary units, each standing for a single later characteristic, is exploded: it should be cleared completely out of the mind.

The genes then are simply chemicals that enter into a great number of complex reactions, the final upshot of which is to produce the completed body. The characters of the adult are no more present in the germ cells than is an automobile in the metallic ores out of which it is ultimately manufactured. To get the complete, normally acting organism, the proper materials are essential; but equally essential is it that they should interact properly with each other and with other things. *And the way they interact and what they produce depends on the conditions.*

This is shown to be true both through observation of the processes of interaction, in development; and through experimentation with diverse conditions. Under the microscope the set of genes—the chromosomes of the egg—are seen to go promptly to work. They suck up a quantity of material from the surrounding cytoplasm, becoming balloon-like. They transform this chemically, then give it off again into the cell body, visibly changed into something new. Diverse new substances thus formed move into different regions of the egg. By cell division some of the newly manufactured substances are passed into one cell, others into another. Thus the cells become diverse; the different structures of the body are being made. This is repeated in each cell generation, the chromosomes by interaction with the cytoplasm changing the substance of the cells, until finally nerve, muscle, bone, gland and other tissues result. But in all this interaction of the chromosomes to produce new cytoplasmic materials, the chromosomal materials—the genes

—are not themselves used up. Always a reserve portion of each chromosomal substance is saved, so that none of them are lost and their number does not decrease. And at each cell division every reserve packet is divided, half of it going to each of the two cells, where it grows to full size. So every cell of the body continues to contain the entire set of the parental chemicals, just as the egg did. The differences between the diverse cells of the body are therefore not in these substances—not in the genes they contain—but in the remaining part of the cells, the cytoplasm; these differentiations have been produced by the interaction of the genes with the cytoplasm. It is in this way that the complex adult body, with its typical pattern of structures, is produced.

In producing these structures, the genes interact, not only with each other, with the cytoplasm, with the oxygen from the surrounding medium, and with the food substances in the cytoplasm: but also, what is most striking and important, with products from the chemical processes in neighboring cells. Necessarily, then, this complicated interaction depends upon many conditions, a dependence that becomes manifest as methods of experimentation become precise. The process of development shows itself not to be stereotyped, as at first appears to be the case; it varies with changes in conditions. What any given cell shall produce, what any part of the body shall become, what the body as a whole shall become—depends not alone on what it contains—its "heredity"—but also on its relation to many other conditions; on its environment.

This is well shown in the development of our close relatives, the amphibia. The frog or salamander begins as a single cell, which divides into two. Usually one of these two produces the right half of the body, the other the left half. But this depends on the relation of the two cells to one another; separate them, and each produces an entire animal instead of half a one. Somewhat later in development the young salamander has become a sphere of many small cells, differing in different regions. Under usual conditions it is possible to predict what later structure each cell, each region of the sphere, will produce. The cells that will produce brain, eye, ear, spinal cord, skin, can be pointed out. The predicted process occurs with such regularity as to appear stereotyped.

But study shows that this is because the effective environment is usually the same for any given cell. What any cell shall become depends in fact on the conditions surrounding it: on its relation to the other cells. Development, it turns out, is a continual process of adjustment to environment. The recent brilliant work of Spemann shows that at a certain point in the developing mass of small cells (just in front of the blastopore) there begins a differentiating influence, whose further nature we do not know. This creeps from cell to cell, forwards and sideways, determining the type of chemical processes that shall occur in each cell, in such a way as to fit and conform the structures produced by that cell to those produced by the cell differentiated just before it. In this way the whole mass of cells diversifies into the pattern of the later structures. Here the cells differentiate into spinal cord, next into medulla, next into midbrain, here at the side into eye, here into ear; still farther on into skin. But if before this has happened the disk of cells is cut off and turned sideways, or completely around, the differentiating and adjusting influence creeps through it from the same point as before, but now in a different or reversed direction, so far as the cells are concerned. The cells that were to have formed skin produce spinal cord; those that would have produced eyes may form midbrain, or skin or ear, depending on just how they are placed with reference to the spreading differentiating influence; and so of the others. Or, transplant a small piece of prospective skin to the center of the eye-producing region; it now transforms into eye instead of into skin; transplant a prospective ear to another region, and it becomes skin or spinal cord, as its place in the pattern requires. It is proved that any particular cell may become part of any one of these structures, depending on its relation to the other cells, its relation to the "pattern." There comes a time after the wave of differentiation has gone over them, when they can no longer be altered; their fate has been accomplished. But until then development is adjustment to the conditions. What part of the body a cell shall produce is not determined alone by its genes, by what it contains, but equally by the conditions surrounding it.

In later stages we know something of the nature of the cell products which help determine what other parts of the body shall become. There are a vast number of such intermediate products, necessarily produced before the adult structures can be made; some of them are the internal secretions, hormones or endocrine products which are now the reigning sensation in biology. Their production, their distribution, their action and the consequent method of development of the organism are subject in high degree to change by the surrounding conditions.

Not only what the cell within the body shall become, but what the organism as a whole shall become, is determined not alone by the hereditary materials it contains, but also by the conditions under which those materials operate. Under diverse conditions the same set of genes will produce very diverse results. It is not true that a given set of genes must produce just one set of characters and no other. It is not true that because an individual inherits the basis for a set of characteristics that he must have those characteristics. In other words, it is not necessary to have a certain characteristic merely because one inherits it. It is not true that what an organism shall become is determined, foreordained, when he gets his supply of chemicals or genes in the germ cells, as the popular writers on eugenics would have us believe. The same set of genes may produce many different results, depending on the conditions under which it operates. True it is that there are limits to this; that from one set of genes under a given environment may come a result that no environment can produce from another set. But this is a matter of limitation, not of fixed and final determination; it leaves open many alternative paths. Every individual has many sets of ''innate'' or ''hereditary'' characters; the conditions under which he develops determine which set he shall bring forth. So in man, the characteristics of an educated, cultured person are as much his inherited characteristics as are any that he has.

These sweeping statements are substantiated by precisely known facts in many organisms. In that animal whose heredity is better known than is that of any other organism, the fruit fly, individuals occur with hereditary abnormalities. The abdomen is irregular, deformed; the joints between the segments are imperfect. This is sharply inherited as a sex-linked character, so that it is known to be due to a peculiarity of one of the genes in the x-chromosome. If the father has this abnormality, all his daughters inherit it, but none of his sons do so. The daughters hand it on to half their sons and half their daughters, and so on.

But the fruit flies in the laboratory usually live in moist air; this inheritance appears under those conditions. If they are hatched and live under dry conditions the abnormality doesn't appear—even in those daughters which indubitably inherit it. Clearly, it is not necessary to have a characteristic merely because one inherits it. Or more properly, characteristics are not inherited at all; what one inherits is certain material that under certain conditions will produce a particular characteristic; if those conditions are not supplied, some other characteristic is produced.

Similarly, some of the fruit flies inherit, in the usual Mendelian manner, an inconvenient tendency to produce supernumerary legs. But if those inheriting this are kept properly warmed, they do not produce these undesirable appendages. In the cold, only those individuals acquire the extra legs that have inherited the gene to which such are due; but even they need not do so, if conditions are right. In the same animal, some individuals have fewer facets in the compound eye than do others. The number of facets is found to be hereditary, in the sense that under the same conditions parents with few facets produce offspring with few facets, in the Mendelian manner. But the number also depends on the environment; individuals with the same inheritance show different numbers of facets, depending on the temperature at which they develop. If the individual A has a certain number of facets, while B and C have a different number, the same in both, it may be found that the difference between A and B is due to inheritance, while the same difference between A and C is due to environment. Such facts are typical; differences due in one case to heredity may be due in another to environment. There is no characteristic distinction between hereditary diversities and environmental diversities; whether a given instance belongs in one or the other category can be determined only by experimental analysis.

Other known cases illustrate the effect of the environment in altering the totality of the organism; its entire personality, as it were. Many years ago there was discovered in Mexico a salamander that lives throughout its life in water; has a heavy, broad body, a tail flattened for swimming and external gills. In this condition it becomes mature, lays its eggs in the water; produces young that inherit its characteristics and finally dies. This continues for generation after generation. A number of these axolotls were kept for years in the zoological garden at Paris; they showed the inherited characteristics above set forth. Breeding experiments on these animals would show these characteristics to be inherited in the usual Mendelian manner.

But after years in which these were the only inherited characteristics that they were known to possess, certain different environmental conditions were brought into action, and thereupon, to the astonishment of the observers, the axolotls developed a new set of inherited characteristics, a new and diverse personality. The external gills disappeared, the body became smaller, slender and of a very different shape, the animals came out on the land and remained there, breathing air. They now became mature in this amblystoma condition, laid eggs, and produced offspring—which again, under these conditions, developed into land animals of the same sort; and this too may continue for generation after generation. The inherited characteristics are now these land characters; these are, in detail, inherited in the typical Mendelian manner.

Here we have two extremely different sets of inherited characters; which one shall appear is determined by the environment under which the organism develops. Both sets are hereditary characters; both sets are environmental characters. Any character requires for its production both an adequate stock of hereditary chemicals and an environment adequate for its production through proper interaction of these chemicals with each other and with other things.

Beyond all other organisms, man is characterized by the possession of many sets of inherited characteristics; the decision as to which shall be produced depending on the environment. The axolotl may be compared to an uneducated man, the amblystoma to an educated one. The educated man has characteristics very diverse from those he would possess if uneducated. We say, when we think of this fact, that these are acquired characters, environmental characters, due to education. This is correct; but there is a tendency to go farther and say that these are not inherited characters, which is a mistake. The characteristics of the educated man are his native, inherited characters, just as truly as are any that he has. For all his characteristics depend on the conditions under which he develops, and would be diverse under different conditions, just as is true of the characteristics that develop under education. And the characters developed under education depend upon the hereditary materials derived from his parents, changing as these materials are altered, just as do all others. "Hereditary" has no consistent meaning other than this.[1]

Why it seems paradoxical to call the characteristics developed under education inherited, while we make no difficulty in thus designating the color of the eyes and the stature, lies in certain practical difficulties, not in any difference of principle. In the group of organisms to which man belongs there is an early period in which it is practically difficult to change effectively the conditions under which the organism develops, because it is enclosed within the mother's body, or within a resistant egg shell. So we have gotten accustomed to calling inherited those characteristics which are determined before it leaves its mother's body or the egg, while those determined later are called acquired characters. But this is an artificial distinction, based on practical considerations. In many organisms there is no such distinction into two periods; in them it is possible to alter the conditions at any period, even the earliest. And when this is done it is found that *all* the characters depend on the conditions; that such fundamental characters as the number of eyes an animal has or the position of the eyes in the body may be altered. In fish, for example, two eyes, one at each side of the middle line, form as distinctly an inherited characteristic as in man, yet fish can be subjected so early to changed conditions (as Stockard and others show) that the animal has a single median eye instead of two lateral ones; and many other equally

[1] Did not painful experience demonstrate the contrary, it would appear obviously unnecessary to emphasize that nothing in this paper has any bearing on the traditional doctrine of the "inheritance of acquired characters." This doctrine asserts, in effect, that the production of a characteristic under the influence of some specific peculiarity of the environment so changes the genes that in a later generation they produce this characteristic even in an environment that lacks the peculiarity which was originally necessary; a most doubtful thesis.

striking changes are producible by changes in the chemical environment. If the fish lived continuously in these conditions they would regularly inherit a single median eye; the two lateral eyes would be looked upon as a rare abnormality, produced by special conditions and not inherited. In truth, all characters are as certainly due to the conditions of development as to the materials of the germ cells.

If there were not practical difficulties in the way, similar fundamental changes of structure could be made in man or any of the higher animals. In these higher creatures, a time comes, before development stops, in which it *is* possible to change the conditions; that is, after what we call birth. And then it is found that changing the conditions does change the characteristics that later develop —exactly as the characteristics of the fish are changed by changing the conditions. We call this process education; if we could give the same education for many generations to a number of different human families, we should find that the characteristics resulting from education are inherited, just as are color of the eyes and form of the head; that they follow Mendelian rules, as do physical characters. Every creature has many inheritances; which one shall be realized depending on the conditions under which it develops; but man is the creature that has the greatest number of possible heritages. Or, more accurately, men and other organisms do not inherit their characteristics at all. What their parents leave them are certain packets of chemicals which under one set of conditions produce one set of characters, under other conditions produce other sets. In man, the number of diverse sets that may thus be produced is very great; although it is of course not unlimited. But what the limitations are can not be stated from general biological principles or from what we know of any other organisms; they can be discovered only by concrete studies of man himself.

Adequate recognition of these facts and principles, which appear fully established by the advance of genetics, would greatly alter some of the current discussions and attitudes on the relation of biological science to human affairs. The biologist is pained to find that the medical man resists the introduction of the concept of heredity into the domain of disease. This is because of the current fallacy that what is hereditary is certain, fixed, unchangeable. Very properly the medical man rejects that, in its application to disease. But with the recognition that to assert that a thing is hereditary signifies merely that the organism has received such a constitution as to produce it under given conditions, all such ground of objection vanishes. This does not deprive of significance recognition of the part played by heredity in medicine. The individual who may produce an inherited defect under certain conditions need not produce it under others. Some individuals receive a constitution which resists disease under conditions in which others succumb to it. Some respond in one way to particular therapeutic agents, others in another way, depending on their hereditary genes. It is only against what Davenport has characterized as purely impersonal medicine that the implications of genetic science lie.

The same fallacy reappears in discussion of immigration problems. The recent immigrants show certain proportions of defective and diseased persons; and we are informed that "these deficiencies are unchangeable and heredity will pass them on to future generations." There is no warrant in the science of genetics for such a statement; under new conditions they may not appear. It is particularly in connection with racial questions in man that there has been a great throwing about of false biology. Heredity is stressed as all powerful; environment as almost powerless: a vicious fallacy, not supported by the results of investigation. We are warned not to admit to America certain peoples now differing from ourselves, on the basis of the resounding assertion that biology informs us that the environment can bring out nothing whatever but the hereditary characters. Such an assertion is perfectly empty and idle; if true it is merely by definition: anything that the environment brings out *is* hereditary, if the word hereditary has any meaning. But from this we learn nothing whatever as to what a new environment will bring out. It may bring out characteristics that have never before appeared in that race. What the race will show under the new environment can not be deduced from general biological principles. Only study of the race itself and its manner of reaction to diverse environments can give us light on this matter.

All characteristics, then, are hereditary, and all are environmental. Does not this deprive the study of the distinctive parts played by the two of all sense and value? It does not. It is of the greatest importance to know in what different ways diverse stocks respond to effectively the same environment; and how these diversities are perpetuated; what limitations the original constitution puts on what the environment can bring out; this is the study of heredity. It is equally important to know what differences appear among stock of the same original constitution under diverse environments; how great the possibilities of environmental action are with a given stock. In man, where practically every individual represents a different stock and a different environment, the matter is not one for sweeping generalizations based on general biological principles. The concepts of the hereditary and the environmental can not be employed in the absolute way now practiced; but they can be used with entire precision if they are applied, not to characteristics-in-themselves, but to the diversities between different particular concrete cases. Though stature is always dependent on both heredity and environment, the difference in stature between Mr. Jones and Mr. Smith may be purely a matter of heredity; the difference between the same Mr. Jones and Mr. Brown may be purely a matter of environment. If there is clarity as to what comparison is made, there need be no ambiguity as to what is due to heredity, what to environment.

By statistical extension, such comparison may be made for large classes. But it is essential here as elsewhere to keep in mind that we are dealing with comparisons between concrete cases, not with propositions of absolute validity. Are the differences between men due more to heredity or to environment? If we compare ourselves with our ancestors of 10,000 years ago, they are due mainly to environment— if it is correct, as generally admitted, that the fundamental constitution of the stock has not appreciably changed since that time. If the comparison is of ourselves with the Bushmen of South Africa, possibly the differences are mainly due to heredity. If the comparison is between the diverse races of Europe, or between the individual citizens of the United States, the answer is to be obtained only from a much greater amount of precise study, with critical statistical treatment, than has yet been made; and there is reason to think that it would signify little when reached, since it would be merely an average of a very great number of individual comparisons, many falling to one alternative, many to the other. Certainly the answer is not to be deduced from any alleged biological principle that the characteristics of organisms are due to heredity and not to environment.