CHAPTER II.

PROCESSES IN HEREDITY.

Natural and Acquired Peculiarities.—Transmutation of Female into Male Measures.—Particulate Inheritance.—Family Likeness and Individual Variation.—Latent Characteristics.—Heritages that Blend and those that are Mutually Exclusive.—Inheritance of Acquired Faculties.—Variety of Petty Influences.

A CONCISE account of the chief processes in heredity will be given in this chapter, partly to serve as a reminder to those to whom the works of Darwin especially, and of other writers on the subject, are not familiar, but principally for the sake of presenting them under an aspect that best justifies the methods of investigation about to be employed.

Natural and Acquired Peculiarities.—The peculiarities of men may be roughly sorted into those that are natural and those that are acquired. It is of the former that I am about to speak in this book. They are noticeable in every direction, but are nowhere so remarkable as in those twins[1] who have been dissimilar

[1] See *Human Faculty*, 237.

in features and disposition from their earliest years, though brought into the world under the same conditions and subsequently nurtured in an almost identical manner. It may be that some natural peculiarity does not appear till late in life, and yet may justly deserve to be considered natural, for if it is decidedly exceptional in its character its origin could hardly be ascribed to the effects of nurture. If it was also possessed by some ancestor, it must be considered to be hereditary as well. But "Natural" is an unfortunate word for our purpose; it implies that the moment of birth is the earliest date from which the effects of surrounding conditions are to be reckoned, although nurture begins much earlier than that. I therefore must ask that the word "Natural" should not be construed too literally, any more than the analogous phrases of inborn, congenital, and innate. This convenient laxity of expression for the sake of avoiding a pedantic periphrase need not be accompanied by any laxity of idea.

Transmutation of Female into Male Measures.—We shall have to deal with the hereditary influence of parents over their offspring, although the characteristics of the two sexes are so different that it may seem impossible to speak of both in the same terms. The phrase of "Average Stature" may be applied to two men without fear of mistake in its interpretation; neither can there be any mistake when it is applied to two women, but what meaning can we attach to the word "Average" when it is applied to the stature of two such different

beings as the Father and the Mother? How can we appraise the hereditary contributions of different ancestors whether in this or in any other quality, unless we take into account the sex of each ancestor, in addition to his or her characteristics? Again, the same group of progenitors transmits qualities in different measure to the sons and to the daughters; the sons being on the whole, by virtue of their sex, stronger, taller, hardier, less emotional, and so forth, than the daughters. A serious complexity due to sexual differences seems to await us at every step when investigating the problems of heredity. Fortunately we are able to evade it altogether by using an artifice at the outset, else, looking back as I now can, from the stage which the reader will reach when he finishes this book, I hardly know how we should have succeeded in making a fair start. The artifice is never to deal with female measures as they are observed, but always to employ their male equivalents in the place of them. I transmute all the observations of females before taking them in hand, and thenceforward am able to deal with them on equal terms with the observed male values. For example: the statures of women bear to those of men the proportion of about twelve to thirteen. Consequently by adding to each observed female stature at the rate of one inch for every foot, we are enabled to compare their statures so increased and transmuted, with the observed statures of males, on equal terms. If the observed stature of a woman is 5 feet, it will count by this rule as 5 feet + 5 inches; if it be

6 feet, as 6 feet + 6 inches; if $5\frac{1}{2}$ feet, as $5\frac{1}{2}$ feet + $5\frac{1}{2}$ inches; that is to say, as 5 feet + $11\frac{1}{2}$ inches.[1]

Similarly as regards sons and daughters; whatever may be observed or concluded concerning daughters will, if transmuted, be held true as regarding sons, and whatever is said concerning sons, will if re-transmuted, be held true for daughters. We shall see further on that it is easy to apply this principle to all measurable qualities.

Particulate Inheritance.—All living beings are individuals in one aspect and composite in another. They are stable fabrics of an inconceivably large number of cells, each of which has in some sense a separate life of its own, and which have been combined under influences that are the subjects of much speculation, but are as yet little understood. We seem to inherit bit by bit, this element from one progenitor that from another, under conditions that will be more clearly expressed as we proceed, while the several bits are themselves liable to some small change during the process of transmission. Inheritance may therefore be described as largely if not wholly "particulate," and as such it will be treated in these pages. Though this word is good English and accurately expresses its own meaning, the application

[1] The proportion I use is as 100 to 108; that is, I multiply every female measure by 108, which is a very easy operation to those who possess that most useful book to statisticians, *Crelle's Tables* (G. Reimer, Berlin, 1875). It gives the products of all numbers under 1000, each into each; so by referring to the column headed 108, the transmuted values of the female statures can be read off at once.

now made of it will be better understood through an illustration. Thus, many of the modern buildings in Italy are historically known to have been built out of the pillaged structures of older days. Here we may observe a column or a lintel serving the same purpose for a second time, and perhaps bearing an inscription that testifies to its origin, while as to the other stones, though the mason may have chipped them here and there, and altered their shapes a little, few, if any, came direct from the quarry. This simile gives a rude though true idea of the exact meaning of Particulate Inheritance, namely, that each piece of the new structure is derived from a corresponding piece of some older one, as a lintel was derived from a lintel, a column from a column, a piece of wall from a piece of wall.

I will pursue this rough simile just one step further, which is as much as it will bear. Suppose we were building a house with second-hand materials carted from a dealer's yard, we should often find considerable portions of the same old houses to be still grouped together. Materials derived from various structures might have been moved and much shuffled together in the yard, yet pieces from the same source would frequently remain in juxtaposition and it may be entangled. They would lie side by side ready to be carted away at the same time and to be re-erected together anew. So in the process of transmission by inheritance, elements derived from the same ancestor are apt to appear in large groups, just as if they had clung together in the pre-embryonic stage, as perhaps

they did. They form what is well expressed by the word "traits," traits of feature and character—that is to say, continuous features and not isolated points.

We appear, then, to be severally built up out of a host of minute particles of whose nature we know nothing, any one of which may be derived from any one progenitor, but which are usually transmitted in aggregates, considerable groups being derived from the same progenitor. It would seem that while the embryo is developing itself, the particles more or less qualified for each new post wait as it were in competition, to obtain it. Also that the particle that succeeds, must owe its success partly to accident of position and partly to being better qualified than any equally well placed competitor to gain a lodgment. Thus the step by step development of the embryo cannot fail to be influenced by an incalculable number of small and mostly unknown circumstances.

Family Likeness and Individual Variation.—Natural peculiarities are apparently due to two broadly different causes, the one is Family Likeness and the other is Individual Variation. They seem to be fundamentally opposed, and to require independent discussion, but this is not the case altogether, nor indeed in the greater part. It will soon be understood how the conditions that produce a general resemblance between the offspring and their parents, must at the same time give rise to a considerable amount of individual differences. Therefore I need not discuss Family Likeness and Individual Varia-

tion under separate heads, but as different effects of the same underlying causes.

The origin of these and other prominent processes in heredity is best explained by illustrations. That which will be used was suggested by those miniature gardens, self-made and self-sown, that may be seen in crevices or other receptacles for drifted earth, on the otherwise bare faces of quarries and cliffs. I have frequently studied them through an opera glass, and have occasionally clambered up to compare more closely their respective vegetations. Let us then suppose the aspect of the vegetation, not of one of these detached little gardens, but of a particular island of substantial size, to represent the features, bodily and mental, of some particular parent. Imagine two such islands floated far away to a desolate sea, and anchored near together, to represent the two parents. Next imagine a number of islets, each constructed of earth that was wholly destitute of seeds, to be reared near to them. Seeds from both of the islands will gradually make their way to the islets through the agency of winds, currents, and birds. Vegetation will spring up, and when the islets are covered with it, their several aspects will represent the features of the several children. It is almost impossible that the seeds could ever be distributed equally among the islets, and there must be slight differences between them in exposure and other conditions, corresponding to differences in pre-natal circumstances. All of these would have some influence upon the vegetation; hence there would be a corre-

sponding variety in the results. In some islets one plant would prevail, in others another; nevertheless there would be many traits of family likeness in the vegetation of all of them, and no plant would be found that had not existed in one or other of the islands.

Though family likeness and individual variations are largely due to a common cause, some variations are so large and otherwise remarkable, that they seem to belong to a different class. They are known among breeders as "sports"; I will speak of these later on.

Latent Characteristics.—Another fact in heredity may also be illustrated by the islands and islets; namely, that the child often resembles an ancestor in some feature or character that neither of his parents personally possessed. We are told that buried seeds may lie dormant for many years, so that when a plot of ground that was formerly cultivated is again deeply dug into and upturned, plants that had not been known to grow on the spot within the memory of man, will frequently make their appearance. It is easy to imagine that some of these dormant seeds should find their way to an islet, through currents that undermined the island cliffs and drifted away their *débris*, after the cliffs had tumbled into the sea. Again, many plants on the islands may maintain an obscure existence, being hidden and half smothered by successful rivals; but whenever their seeds happened to find their way to any one of the islets, while those of their rivals did not, they would sprout freely and assert themselves. This

illustration partly covers the analogous fact of diseases and other inheritances skipping a generation, which by the way I find to be by no means so usual an occurrence as seems popularly to be imagined.

Heritages that Blend and those that are Mutually Exclusive.—As regards heritages that blend in the offspring, let us take the case of human skin colour. The children of the white and the negro are of a blended tint; they are neither wholly white nor wholly black, neither are they piebald, but of a fairly uniform mulatto brown. The quadroon child of the mulatto and the white has a quarter tint; some of the children may be altogether darker or lighter than the rest, but they are not piebald. Skin-colour is therefore a good example of what I call blended inheritance. It need be none the less "particulate" in its origin, but the result may be regarded as a fine mosaic too minute for its elements to be distinguished in a general view.

Next as regards heritages that come altogether from one progenitor to the exclusion of the rest. Eye-colour is a fairly good illustration of this, the children of a light-eyed and of a dark-eyed parent being much more apt to take their eye-colours after the one or the other than to have intermediate and blended tints.

There are probably no heritages that perfectly blend or that absolutely exclude one another, but all heritages have a tendency in one or the other direction, and the tendency is often a very strong one. This is paralleled

by what we may see in plots of wild vegetation, where two varieties of a plant mix freely, and the general aspect of the vegetation becomes a blend of the two, or where individuals of one variety congregate and take exclusive possession of one place, and those of another variety congregate in another.

A peculiar interest attaches itself to mutually exclusive heritages, owing to the aid they must afford to the establishment of incipient races. A solitary peculiarity that blended freely with the characteristics of the parent stock, would disappear in hereditary transmission, as quickly as the white tint imported by a solitary European would disappear in a black population. If the European mated at all, his spouse must be black, and therefore in the very first generation the offspring would be mulattoes, and half of his whiteness would be lost to them. If these mulattoes did not interbreed, the whiteness would be reduced in the second generation to one quarter; in a very few more generations all recognizable trace of it would have gone. But if the whiteness refused to blend with the blackness, some of the offspring of the white man would be wholly white and the rest wholly black. The same event would occur in the grandchildren, mostly but not exclusively in the children of the white offspring, and so on in subsequent generations. Therefore, unless the white stock became wholly extinct, some undiluted specimens of it would make their appearance during an indefinite time, giving it repeated

chances of holding its own in the struggle for existence, and of establishing itself if its qualities were superior to those of the black stock under any one of many different conditions.

Inheritance of Acquired Faculties.—I am unprepared to say more than a few words on the obscure, unsettled, and much discussed subject of the possibility of transmitting acquired faculties. The main evidence in its favour is the gradual change of the instincts of races at large, in conformity with changed habits, and through their increased adaptation to their surroundings, otherwise apparently than through the influence of Natural Selection. There is very little direct evidence of its influence in the course of a single generation, if the phrase of Acquired Faculties is used in perfect strictness and all inheritance is excluded that could be referred to some form of Natural Selection, or of Infection before birth, or of peculiarities of Nurture and Rearing. Moreover, a large deduction from the collection of rare cases must be made on the ground of their being accidental coincidences. When this is done, the remaining instances of acquired disease or faculty, or of any mutilation being transmitted from parent to child, are very few. Some apparent evidence of a positive kind, that was formerly relied upon, has been since found capable of being interpreted in another way, and is no longer adduced. On the other hand there exists such a vast mass of distinctly negative evidence, that every instance offered to prove the transmission

of acquired faculties requires to be closely criticized. For example, a woman who was sober becomes a drunkard. Her children born during the period of her sobriety are said to be quite healthy; her subsequent children are said to be neurotic. The objections to accepting this as a valid instance in point are many. The woman's tissues must have been drenched with alcohol, and the unborn infant alcoholised during all its existence in that state. The quality of the mother's milk would be bad. The surroundings of a home under the charge of a drunken woman would be prejudicial to the health of a growing child. No wonder that it became neurotic. Again, a large number of diseases are conveyed by germs capable of passing from the tissues of the mother into those of the unborn child otherwise than through the blood. Moreover it must be recollected that the connection between the unborn child and the mother is hardly more intimate than that between some parasites and the animals on which they live. Not a single nerve has been traced between them, not a drop of blood [1] has been found to pass from the mother to the child. The unborn child together with the growth to which it is attached, and which is afterwards thrown off, have their own vascular system to themselves, entirely independent of that of the mother. If in an anatomical preparation the veins of the mother are injected with a coloured fluid, none of it enters the veins of the child; conversely, if the veins of the child

[1] See *Lectures* by William O. Priestley, M.D. (Churchill, London, 1860), pp. 50, 52, 55, 59, and 64.

are injected, none of the fluid enters those of the mother. Again, not only is the unborn child a separate animal from its mother, that obtains its air and nourishment from her purely through soakage, but its constituent elements are of very much less recent growth than is popularly supposed. The ovary of the mother is as old as the mother herself; it was well developed in her own embryonic state. The ova it contains in her adult life were actually or potentially present before she was born, and they grew as she grew. There is more reason to look on them as collateral with the mother, than as parts of the mother. The same may be said with little reservation concerning the male elements. It is therefore extremely difficult to see how acquired faculties can be inherited by the children. It would be less difficult to conceive of their inheritance by the grandchildren. Well devised experiment into the limits of the power of inheriting acquired faculties and mutilations, whether in plants or animals, is one of the present desiderata in hereditary science. Fortunately for us, our ignorance of the subject will not introduce any special difficulty in the inquiry on which we are now engaged.

Variety of Petty Influences.—The incalculable number of petty accidents that concur to produce variability among brothers, make it impossible to predict the exact qualities of any individual from hereditary data. But we may predict average results with great certainty, as will be seen further on, and we can also

obtain precise information concerning the penumbra of uncertainty that attaches itself to single predictions. It would be premature to speak further of this at present; what has been said is enough to give a clue to the chief motive of this chapter. Its intention has been to show the large part that is always played by chance in the course of hereditary transmission, and to establish the importance of an intelligent use of the laws of chance and of the statistical methods that are based upon them, in expressing the conditions under which heredity acts.

I may here point out that, as the processes of statistics are themselves processes of intimate blendings, their results are the same, whether the materials had been partially blended or not, before they were statistically taken in hand.