TABLE II.—Stars approaching the Sun.

Star.	Compared with	Apparent motion.	Earth's motion.	Motion towards sun.
Arcturus	Mg	50	+ 5	55
Vega	H	40 to 50	+ 3·9	44 to 54
α Cygni	H	30	+ 9	39
Pollux	Mg	32	+17	49
α Ursæ majoris	Mg	35 to 50	+11	46 to 60
γ Leonis	Mg			
ε Boötis	Mg			
γ Cygni	H			
α Pegasi	H			
γ Pegasi ?	H			
α Andromedæ	H			

II. "On Blood-relationship." By FRANCIS GALTON, F.R.S.

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I propose in this memoir to deduce, by fair reasoning from acknowledged facts, a more definite notion than now exists of the meaning of the word "kinship." It is my aim to analyze and describe the complicated connexion that binds an individual, hereditarily, to his parents and to his brothers and sisters, and, therefore, by an extension of similar links, to his more distant kinsfolk. I hope by these means to set forth the doctrines of heredity in a more orderly and explicit manner than is otherwise practicable.

From the well-known circumstance that an individual may transmit to his descendants ancestral qualities which he does not himself possess, we are assured that they could not have been altogether destroyed in him, but must have maintained their existence in a latent form. Therefore each individual may properly be conceived as consisting of two parts, one of which is latent and only known to us by its effects on his posterity, while the other is patent, and constitutes the person manifest to our senses.

The adjacent and, in a broad sense, separate lines of growth in which the patent and latent elements are situated, diverge from a common group and converge to a common contribution, because they were both evolved out of elements contained in a structureless ovum, and they, jointly, contribute the elements which form the structureless ova of their offspring.

The annexed diagram illustrates my meaning, and serves to show clearly that the span of each of the links in the general chain of heredity extends from one structureless stage to another, and not from person to person:—

Structureless elements in Father	........Adult Father ....Latent in Father........	Structureless elements in offspring.

I will now proceed to consider the quality of the several relationships by which the above terms are connected together.

The observed facts of Reversion enable us to prove that the latent elements must be greatly more varied than those that are personal or patent. The arguments are as follows:—(1) there must be *room* for very great variety, because a single strain of impure blood will reassert itself after more than eight generations; (2) an individual has 256 progenitors in the eighth degree, if there have been no ancestral intermarriages, while under the ordinary conditions of social and neighbourly life he will certainly have had a considerable, though a smaller number of them; (3) the gradual waning of the tendency to reversion as the generations increase conforms to what would occur if each fresh marriage contributed a competing element for the same place, thus diluting the impure strain until its relative importance was reduced to an insignificant amount. It follows from these arguments that for each place among the personal elements there may exist, and probably often does exist, a great variety of latent elements that formerly competed to fill it.

I have spoken of the primary elements as they exist in the newly impregnated ovum, where they are structureless but contain the materials out of which structure is evolved; the embryonic elements are segregated from among them. On what principle are they segregated? Since for each place there have been many unsuccessful but qualified competitors, it must have been on some principle whose effects may be described as those of "*Class Representation*," using that phrase in a perfectly general sense as indicating a mere fact, and avoiding any hypothesis or affirmation on points of detail, about most, if not all, of which we are profoundly ignorant. I give as broad a meaning to the expression as a politician would give to the kindred one, a "representative assembly." By this he means to say that the assembly consists of representatives from various constituencies, which is a distinct piece of information so far as it goes, and is a useful one, although it deals with no matter of detail; it says nothing about the number of electors, their qualifications, or the motives by which they are influenced; it gives no information as to the number of seats; it does not tell us how many candidates there are usually for each seat, nor whether the same person is eligible for, or may represent at the same time, more than one place, nor whether the result of the elections at one place may or may not influence those at another (on the principle of correlation). After these explanations there can, I trust, be no difficulty in accepting my definition of the general character of the relation between the embryonic and the structureless elements, that the former are the result of election from the latter on some method of Class Representation.

The embryonic elements are *developed* into the adult person. "Development" is a word whose meaning is quite as distinct in respect to form, and as vague in respect to detail, as the phrase we have just been considering; it embraces the combined effects of growth and multiplication, as well as those of modification in quality and proportion, under both internal and external influences. If we were able to obtain an approximate knowledge of the original elements, statistical experiences would no doubt enable us to predict the average value of the form into which they would become developed, just as a knowledge of the seeds that were sown would enable us to predict in a general way the appearance of the garden when the plants had grown up; but the individual variation of each case would of course be great, owing to the large number of variable influences concerned in the process of development.

The latent elements in the embryonic stage must be developed by a parallel, I do not say by an identical process, into those of the adult stage. Therefore, to avoid all chance of being misapprehended when I collate them, I will call, in the diagram I am about to give (see fig. 1, p. 398), the one process "Development *a*" and the other "Development *b*."

It is not intended to affirm, in making these subdivisions, that the embryonic and adult stages are distinctly separated; they are continuous, and it is impossible but that they should overlap, some elements remaining embryonic while others are completely formed. Nevertheless the two, speaking broadly, may fairly be looked upon as consecutive.

Again, the two processes are not wholly distinct; on the contrary, the embryo, and even the adult in some degree, must receive supplementary contributions derived from their contemporary latent elements, because ancestral qualities indicated in early life frequently disappear and yield place to others. The reverse process is doubtful; it may exist in the embryonic stage, but it certainly does not exist in a sensible degree in the adult stage, else the later children of a union would resemble their parents more nearly than the earlier ones.

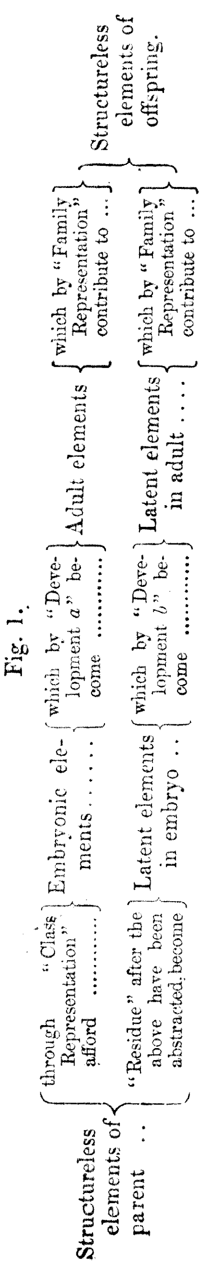
Lastly, I must guard myself against the objection that though structure is largely correlated, I have treated it too much as consisting of separate elements. To this I answer, first, that in describing how the embryonic are derived from the structureless elements, I expressly left room for a small degree of correlation; secondly, that in the development of the adult elements from the embryonic there is a perfectly open field for natural selection, which is the agency by which correlation is mainly established; and, thirdly, that correlation affects groups of elements rather than the complete person, as is proved by the frequent occurrence of small groups of persistent peculiarities, which do not affect the rest of the organism, so far as we know, in any way whatever.

The ground we have already gained may be described as follows:—

Out of the structureless ovum the embryonic elements are taken by *Class Representation*, and these are *developed* (*a*) into the visible adult individual; on the other hand, returning to our starting-point at the structureless ovum, we find, after the embryonic elements have been segregated, the large ***Residue*** is ***developed*** (*b*) into the latent elements contained in the adult individual. All this is summarily expressed in the first two columns of the diagram (fig. 1). I might have inserted vertical arrows to show the minor connexions between the corresponding stages in the two parallel processes, but it would have complicated the figure.

In what way do the patent and latent adult elements respectively contribute representatives towards the structureless stage of the next generation? We know that every quality they possess *may* be transmitted to it, but it does not follow that they *are* invariably transmitted. The contributions from the patent elements cannot be by "Class," because their own original elements have been themselves specialized, and therefore can contain no more than one or a few members of each class (which, it is true, must have been somewhat developed, both in numbers and variety, into what we may call "families"). Their contributions may therefore be justly described as being effected on some principle that has resulted in a "*Family representation*," though whether in the representation of every family I do not profess to say.

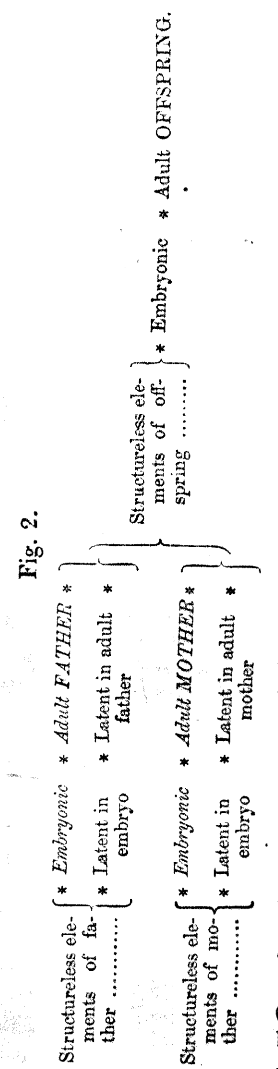
As regards the large variety of adult latent elements, they cannot all be transmitted, for the following obvious reason—the corresponding qualities of no two parents can be considered exactly alike; therefore the accumulation of subvarieties, if they were all preserved as the generations rolled onwards, would exceed in multitude the wildest flights of rational theory. The heritage of peculiarities through the contributions of 1000 consecutive generations, even supposing a great deal of ancestral intermarriage, must far exceed what could be packed into a single ovum. The contributions from the latent adult elements are therefore no more than *Representative*; but they have to furnish all the various members of each Class whence its representatives have afterwards to be drawn. Therefore, bearing in mind what has been just argued, that it is impossible for the elements of every individual quality to be contributed, we are driven to suppose, as in the previous case, a "*Family representation*," the similar elements contributed by the two parents ranking, of course, as of the same family. It is most important to bear in mind that this phrase states a fact and not an hypothesis; it does not mean that each and every Family has just one representative, for it is absolutely reticent on all such matters of detail as those I enumerated when speaking of Class Representation. To show the importance which I attach to this disclaimer, I may be permitted to mention what appears to me the most probable *modus operandi*, namely, that it is in reality a large selection made out of larger and not out of smaller constituencies than those I have called "classes," similar to that which would be obtained by an indiscriminate conscription: thus, if a large army be drawn from the provinces of a country by a general conscription, its constitution, according to the laws of chance, will reflect with surprising precision the qualities of the population whence it was taken; each village will be found to furnish a contingent, and the composition of the army will be sensibly the same as if it had been due to a system of immediate representation from the several villages.



The diagram (fig. 1) expresses the whole of the foregoing results; it begins with the structureless elements whence the parent individual was formed, and ends with his contributions to the structureless elements whence his offspring is formed.

I will now inquire what are, roughly speaking, the relative proportions of the contributions to the elements of the offspring made respectively by the patent and latent elements of the adult parent. It is better not to complicate the inquiry by speaking, at first, of these elements in their entirety, but rather of some special characteristic: thus, to fix the ideas, suppose we are speaking about a peculiar skin-mark in an animal; the peculiarity in question may be conceived (1) as purely personal, without the concurrence of any latent equivalents, (2) as personal but conjoined with latent equivalents, and (3) as existent wholly in a latent form. It can be shown that, in the first case, the power of hereditary transmission is exceedingly feeble; for, notwithstanding some exceptions (as in the lost power of flight in domestic birds), the effects of the use and disuse of limbs, and those of habit, are transmitted to posterity in only a very slight degree. Again, it can be fairly argued that many instances which seem at first sight to fall under case (1), that is, to be purely personal, and to prove a larger hereditary influence than what I assign to it, do really belong to case (2): thus, when individuals born with a peculiar mark are reputed to be the first of their race in whom it had ever appeared, it would be hazardous in the extreme to argue that the latent elements of that mark were wholly deficient in them. It is very remarkable (I was indebted for a knowledge of this fact to Mr. Tegetmeier) how nearly every bar or spot found in any species of an animal in its wild state may be bred into existence in the domesticated variety of that species, showing that the elements of all these bars and spots are universally present in all varieties of the species, though their manifestation may be overborne and suppressed. We therefore see that the hereditary influences of an

animal with respect to any particular spot are, I will not say in every case, but certainly on the *average of many cases*, much more numerous than if that spot had been purely a personal characteristic, without the concurrence of any latent elements. Bearing this argument in mind, we shall more justly estimate the import of the statistical evidence to be obtained from breeders of animals. I should judge, from the impression left by many scattered statistics, that it is perfectly safe to affirm that breeders, when they mate two animals, each having the same unusual characteristic, not through known hereditary transmission, but by supposed variation, would consider themselves fortunate if one quarter of the progeny inherited that quality. Now these successful cases are, as I have shown, on the average, the produce of parents having the peculiarity not only in a personal but also, to some degree, in a latent form. We may therefore reasonably conclude that, had the latter portion been non-existent, the ratio of successful cases would have been materially diminished.



I should demur, on precisely the same grounds, to objections based on the fact of the transmission of qualities to grandchildren being more frequent through children who possess those qualities than through children who do not; for I maintain that the personal manifestation is, on the average, though it need not be so in every case, a certain proof of the existence of some latent elements.

Having proved how small is the power of hereditary transmission of the personal elements, we can easily show how large is the transmission of the purely latent elements, in the case (3), by appealing to the well-known facts of Reversion; but into these it is hardly necessary for me to enter at length. The general and safe conclusion is, that the contribution from the patent elements is very much less than from the latent ones.

If we now combine our results into a diagram (fig. 2), showing the fainter streams of heredity by *italic lines*, and indicating those processes by asterisks (*) which were described at length in the previous figure, we shall easily recognize the complexity of hereditary problems. We see that parents are very indirectly and only partially related to their own children, and that there are two lines of connexion between them, the one of large and the other of small relative importance. The former is a collateral kinship and very distant, the parent being descended through two stages (two asterisks) from a structureless source, and the child (so far as that parent is concerned) through five totally distinct stages from the same source; the other, but unimportant line of connexion, is direct and connects the child with the parent through two stages. We shall therefore wonder that, notwithstanding the fact of an average resemblance between parent and child, the amount of individual variation should not be much greater than it is, until we have realized how complete must be the harmony between every variety and its environments in order that the variety should be permanent.

We also infer from the diagram how much nearer, and yet how subject to variation, is the kinship between the children of the same parents; for only two stages are required to trace back their descent to a common origin, which, however, proceeds from four separate streams of heredity, namely the adult patent and latent elements of each of the two parents.

An approximate notion of the nearest conceivable relationship between a parent and his child may be gained by supposing an urn containing a great number of balls, marked in various ways, and a handful to be drawn out of them at random as a sample: this sample would represent the person of a parent. Let us next suppose the sample to be examined, and a few handfuls of new balls to be marked according to the patterns of those found in the sample, and to be thrown along with them back into the urn. Now let the contents of another urn, representing the influences of the other parent, be mixed with those of the first. Lastly, suppose a second sample to be drawn out of the combined contents of the two urns, to represent the offspring. There can be no nearer connexion justly conceived to subsist between the parent and child than between the two samples; on the contrary, my diagram shows the relationship to be in reality much more remote, and consisting of many consecutive stages, and therefore hardly to be expressed by such simple chances. Whenever the balls in the urns are much of the same pattern, the samples will be alike, but not otherwise. The offspring of a mongrel stock necessarily deviate in appearance from each other and from their parents.

We cannot now fail to be impressed with the fallacy of reckoning inheritance in the usual way, from parents to offspring, using those words in their popular sense of visible personalities. The span of the true hereditary link connects, as I have already insisted upon, not the parent with the offspring, but the primary elements of the two, such as they existed in the newly impregnated ova, whence they were respectively developed. No valid excuse can be offered for not attending to this fact, on the ground of our ignorance of the variety and proportionate values of the primary elements: we do not mend matters in the least, but we gratuitously add confusion to our ignorance, by dealing with hereditary facts on the plan of ordinary pedigrees—namely, from the *persons* of the parents to those of their offspring.

It will be observed that, owing to the clearer idea we have now obtained of the meaning of kinship and of the consecutive phases of the chain of life, the various causes of individual variation can be easily and surely sorted into their proper places. I will mention a few of them, merely as examples.

Previous to the segregation of the embryonic elements, if the structureless ones be diverse without any strongly preponderating element, it is impossible to foresee the character of the embryo, just as it is impossible to foresee the character of a handful chosen from an urn containing a mixed assemblage of variously coloured balls; but if they be not diverse, then the embryonic elements will be a true sample of the structureless ones, the conditions of purity of blood are fulfilled, and the offspring will resemble its parents.

We also see, in the process by which the embryonic elements are obtained, how the curious phenomenon may occur of inheritance occasionally skipping alternate generations. The more that has been removed from the structureless group for the supply of the embryonic (which, as we have seen, is a nearly sterile destination) the less remains for the "residue," too little, it may be, to assert itself by that, the only prolific, line of transmission. In the supposed case it would recuperate itself during the succeeding generation, where the elements in question will have remained wholly latent, owing to their insignificance in the structureless stage of that generation, which would be sufficient to secure any portion of it from selection for the embryonic form.

Again, it is in the process of selection of elements, both latent and patent, from the adult parents for the structureless stage of the next generation, where I suppose the curious and unknown conditions usually to occur through which a change in the habits of life, after the adult age has been reached, is apt to produce sterility. I may be permitted to remark, hypothetically, that this view appears to be corroborated by the fact that many grains of pollen or many spermatozoa are required to fertilize each ovum, because, as it would seem, each separate one does not contain a sufficiently complete representation of the primary elements to supply the needs of an individual life, and that it is only by the accumulation of several separate consignments (so to speak) of the representative elements that the necessary variety is ensured. I argue from this that there is a tendency to a large individual variation in the constituents of each grain of pollen, or spermatozoon, and, by analogy, that there is a similar though smaller tendency in each ovum; also that changes in the habits of life may increase this variation to a degree that involves sterility.

Lastly, it is often remarked (1) that the immediate offspring of different races or even varieties resemble their parents equally, but (2) that great diversities appear in the next and in succeeding generations. In which stage does the variability occur? It cannot be in the first (class representation) nor in the second (development), else (1) could not have been true; therefore it must be in the third stage. A white parent necessarily contributes white elements to the structureless stage of his offspring, and a black, black; but it does not in the least follow that the contributions from a true mulatto must be truly mulatto.

One result of this investigation is to show very clearly that large variation in individuals from their parents is not incompatible with the strict doctrine of heredity, but is a consequence of it wherever the breed is impure. I am desirous of applying these considerations to the intellectual and moral gifts of the human race, which is more mongrelized than that of any other domesticated animal. It has been thought by some that the fact of children frequently showing marked individual variation in ability from that of their parents is a proof that intellectual and moral gifts are not strictly transmitted by inheritance. My arguments lead to exactly the opposite result. I show that their great individual variation is a necessity under present conditions; and I maintain that results derived from large averages are all that can be required, and all we could expect to obtain, to prove that intellectual and moral gifts are as strictly matters of inheritance as any purely physical qualities.

III. "Further Experiments on the Effect of Alcohol and Exercise on the Elimination of Nitrogen and on the Pulse and Temperature of the Body." By E. A. Parkes, M.D., F.R.S. Received April 25, 1872.

In the 'Proceedings of the Royal Society' (xviii. p. 362, xix. p. 73) are some observations by the late Count Wollowicz and myself on the effect of alcohol, brandy, and claret on the elimination of nitrogen. As the experiments were on one man, I have taken an opportunity of repeating them on another person; and as the late observations of Dr. Austin Flint (junior) on a man who walked 317 miles in five days have appeared to some persons to run counter to the now generally accepted view that exercise produces either no change or only insignificant changes in the urea, I have combined experiments on exercise with those on alcohol. With respect, however, to Dr. Austin Flint's experiments, it would appear that while the egress of nitrogen was determined with the greatest accuracy, the amount taken in was for the most part merely estimated by reference to Payen's Tables, and therefore there is no certainty that the ingress was what it is assumed to have been. The food also was very

varied, so that the difficulty of properly estimating the nitrogen was still more increased.

The following experiments were made on a soldier, W. D., aged 30. He is a powerfully built man, 5 feet 6 inches in height, and measuring 40 inches round the chest. As a young man, he had been employed in a distillery near Glasgow, and at that time drank largely of whisky, sometimes taking half a pint before breakfast. For the last ten years, since he has been in the army, he has been very temperate, taking chiefly beer in moderate quantities, and only occasionally spirits. He bears the character of a very steady soldier, and has always had perfect health, with the exception of an attack of "spotted typhus" six years ago. He has never served abroad.

As he is a Scotchman and had been brought up on oatmeal and milk, I placed him on a diet entirely composed of these two substances; and after a preliminary trial to see how much he required, he received every day 28 ounces of Scotch oatmeal and two pints of milk, the whole of which he took at regular hours. The oatmeal was all purchased at the same time and was well mixed, so that he received daily precisely the same amount of nitrogen. It would be impossible to keep the ingress of nitrogen more uniform than was done in this case. The milk was very good in quality; but to ensure, as far as possible, that it should be of equal nutritive value every day, water was added until its specific gravity, which was usually 1·032, was reduced to 1·028. He drank only water except on the days when brandy was added, and, with the exception of salt, took no other solid food for sixteen days except the oatmeal and milk. The daily amount of water (including that in the milk) was 135 fluid ounces; but some was lost in cooking the oatmeal. He was perfectly well and vigorous on this food, and his weight remained unchanged.

The oatmeal, burnt with soda-lime, was found to contain 2·023 per cent. of nitrogen; and the milk contained from ·35 to ·37 per cent. of nitrogen, and is taken at a mean of ·36. In the milk and the oatmeal together he received daily 20 grammes, or 308·6 grains, of nitrogen. The brandy contained 45 volumes per cent. of alcohol.

The course of experiment was as follows:—

For six days he remained quiet, taking only slow walking exercise to keep him in health; for three days he then worked hard at digging ground from eight to nine hours daily. It was intended that he should march thirty miles daily in heavy marching order; but after marching for eight miles he became footsore, and I was obliged to change his work to digging. He worked as hard as he could and felt fatigued in all his muscles, but it was impossible to calculate the exact amount of work: as far as could be done, he made it as uniform as he could from day to day.

After three days' exercise he was kept at rest for three days, and then resumed exercise of the same kind for three days, taking, however, during