LETTERS TO THE EDITOR.

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Average Number of Kinsfolk in each Degree.

WHAT is the average number of brothers, sisters, uncles, nephews, nieces, first cousins, &c., that each person possesses? I had occasion to compute this for a particular collection of persons; the results were so far unexpected as to show that the question deserved a consideration which it has not yet received, so far as I am aware. The problem proved easy enough in the end, but not at first, for there are other ways of attacking it, in which I blundered and lost time.

The simplest conditions that will serve for a general theory are those of a supposed population (1) the numbers of which are statistically constant in successive generations; (2) the generations of which do not overlap; and (3) which are "completed" by having wholly passed into history; and again (4) where every person is taken into account, at whatever age he or she may have died. It will be a further great simplification if it be allowed (5) to suppose the males and females to be equal in number, and in all respects to admit of similar statistical treatment. This need be only a provisional way of looking at the problem, for it will be seen that corrections can easily be introduced if desired.

It will much facilitate matters to begin by dealing exclusively with either the male or the female half of the population, leaving the other half to follow suit. We will begin with the females.

Let d be the average number of female children born of each woman who is a mother, so if there be n mothers in the population the total number of females in the next generation will be nd. How many of these latter will prove fertile of female children? On the supposition of statistical constancy, the number of mothers in the two generations will be the same, therefore d out of the nd will be fertile of female children; conversely, the probability that any one of these female children will herself bear one or more female children $=1/d$. As a test of this, the average number of fertile daughters to each mother will be $d\times 1/d=1$, as it should be.

Next, as regards sisterhoods. Each mother bears on the average d female and d male children, or $2d$ individuals in all. Each of these will have $2d-1$ brothers and sisters, and half that number of sisters, namely, $d-\frac{1}{2}$.

The syllable *si* will be used to express "sisters" without regard to age or fertility, and *si'* to express "sisters who are fertile of female children"; similarly *da* and *da'* for daughters.

The number therefore of *si* is $d-\frac{1}{2}$, of *si'* it is $(d-\frac{1}{2})/d$, of *da* it is d, of *da'* it is 1. The number of *me'*, or of mothers to a child, is, of course, 1, and there is no occasion for using *me*, as a mother must be fertile.

A few examples of results are given in the following table; it could have been extended indefinitely, but these are quite sufficient for drawing conclusions:—

Specific kinships.		Average number in each	
ANCESTRY—			
me'	(mother)	1	1
me' me'	(mother's mother)	1×1	1
me' me' me'		$1\times 1\times 1$	1
COLLATERALS—			
si	(sisters)	$(d-\frac{1}{2})$	$d-\frac{1}{2}$
me' si	(mother's sisters)	$1\times(d-\frac{1}{2})$	$d-\frac{1}{2}$
me' me' si		$1\times 1\times(d-\frac{1}{2})$	$d-\frac{1}{2}$
si' da	(sister's daughters)	$(d-\frac{1}{2})/d\times d$	$d-\frac{1}{2}$
me' si' da		$1\times(d-\frac{1}{2})/d\times d$	$d-\frac{1}{2}$
si' da' da		$(d-\frac{1}{2})/d\times 1\times 1/d$	$d-\frac{1}{2}$
DESCENDANTS—			
da	(daughters)	d	d
da' da	(daughter's daughters)	$1\times d$	d
da' da' da		$1\times 1\times d$	d

The foregoing remarks and table are equally applicable to males if *bro* (brother) is substituted for *si*, *son* for *da*, *fa* (father) for *me*.

It will, then, be understood that each mother, father, or fertile couple has, on the average, d sons and d daughters, or $2d$ children altogether, of whom 1 is a fertile son, 1 a fertile daughter, and that the others die without issue. In the collection mentioned above, the value of d was about $2\frac{1}{2}$, that is to say, an average family consisted of about 5 children, which is a usual estimate.

It is unnecessary to prolong these remarks by considering the minor corrections to be supplied on account of the hypotheses not being strictly accordant with observation. The two most important of these relate to populations that are not stationary, and to the allowance to be made for inequality in number of the sexes. There are others hardly worth even the trouble of describing, being utterly insensible in rough work.

The general results are that kinships fall into three distinct groups:—(1) direct ancestry, (2) collaterals of all kinds, (3) direct descendants, and that the number of individuals in each *specific* kinship in these classes is respectively 1, $d-\frac{1}{2}$, and d. Also that $d=2\frac{1}{2}$ may be accepted as a reasonable and not infrequent value. To determine the number of individuals in each *general* kinship, the appropriate tabular number must be multiplied by the number of *species* that the *genus* contains; thus there are two species of aunts, *me si* and *fa si* (mother's sisters and father's sisters), each of which has the tabular number of $d-\frac{1}{2}$; therefore the average number of aunts is twice that amount, or $2d-1$, which, in the above case of $d=5$, is equal to 4.

FRANCIS GALTON.

The Mendelian Quarter.

A FEW weeks ago we heard in Section D at the Cambridge meeting of the British Association a paper by Mr. A. D. Darbishire on the bearing of his experiments in crossing Japanese waltzing and albino mice on Mendelian theory. He told us that on that theory we should expect a quarter of the offspring of the hybrids to be albinos—and we found them albinos—and a quarter of the offspring of the hybrids to waltz—and they did waltz. Somebody protested *sotto voce*, and Mr. Darbishire added "a rough quarter." Since that meeting I have been looking up the matter, for the point seems to me of great interest, and this is what I find in a recent paper by Mr. Darbishire in the *Manchester Memoirs*, "On the Bearing of Mendelian Principles of Heredity on Current Theories of the Origin of Species," vol. xlviii. p. 13:—"Let us consider the offspring of hybrids . . . . Secondly with regard to their progression, we should expect to find 25 per cent. waltzing mice: this is very roughly what happens; . . . Now let us look at the offspring of hybrids from *both* points of view at the same time: one mouse in every four is an albino; one in every four is a waltzer, so we should expect one in every sixteen to be an *albino waltzer*. Now these albino waltzers are new things . . .," and then Mr. Darbishire tells us that he has been unable to get offspring from them.

Here, from a quarter, we have got to a quarter "very roughly," but still "one mouse in every four is a waltzer." I must confess that Mr. Darbishire's "rough quarter" excited me to look further, and these are the words I find describing some actual experiments on these mice:—"*Waltzing* occurs in only 97 out of the 555 individuals resulting from the union of hybrids. When we compare this with the number of pink eyed individuals (131–134) or of albinos (137) we see that the proportion of waltzing individuals *cannot be regarded as a possible quarter*. The probable error of the expectation that a quarter of the individuals will waltz is, on the Mendelian hypothesis, $0{\cdot}6745\sqrt{\frac{1}{4}\times\frac{3}{4}\times 555}=6{\cdot}88$ only, and the observed deviation is $138{\cdot}75-97=41{\cdot}75$, the odds against so great a deviation being rather more than 50,000 to 1. As the result here obtained differs from Mendelian expectation in the same direction as that already obtained by von Guaita and to an extent consistent with the agreement of both, *the evidence that the waltzing character does not segregate in Mendelian proportions is very strong*."

The sentences in italics are not in italics in the original,