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THE GERM CELL AND THE RESULTS OF MENDEL.

Discussion before the Academy of Medicine of Cincinnati, April 13, 1903.

DR. MICHAEL F. GUYER: Mendel and other investigators have found that when two pure forms are crossed, a given character of one parent as a rule predominates in the hybrid offspring, and masks the corresponding character of the other parent. For example, if in plants the seed of one parent is round and that of the other long, then the seed of the hybrid will be all round or all long, depending upon which parental character predominates. Furthermore, in respect to a given character, as, for example, the shape of the seed, if the hybrids are fertilized among themselves, one-fourth of the resulting offspring will show again the particular ancestral character which was masked ("recessive"), one-fourth the ascendent character ("dominant"), which obscured its fellow, and the remaining half, though apparently of this same ascendent type, will really continue to be hybrid or mixed. Both the particular isolated dominant character in question and its complementary recessive persist and remain pure in succeeding generations, provided the respective forms which bear them are not again cross-bred, but the mixed type will break up each time into three groups similar in proportion and kind to those derived from the original hybrids.

To account for the behavior of the two sets of parental characters it was supposed that any particular quality from one line of ancestry does not occur in the same germ-cell with a corresponding quality from the other line of ancestry. In such an event, since there are two parents and consequently two sets of qualities or characters, half of the germ cells will contain a given quality from one line of ancestry and the other half will contain the corresponding character from the opposite line.

If we designate these parallel qualities as A and B respectively, then half the germ cells of both the male and the female hybrid will contain the A character and half the B character. Consequently, when two germ-cells unite in fertilization, according to the laws of chance, the qualities may be brought together as AA, AB, BA or BB. AB and BA are of the mixed type, and will occur in one-half of the offspring; AA will be represented exclusively in one-fourth and BB in the remaining fourth. That is, with respect to this quality, one-fourth have reverted to one grandparent, one-fourth to the other, and half continue hybrid.

The above conclusions were derived from the study of the characters of hybrids, and not from a study of the germ cells. The question naturally arises as to whether there is any evidence from the study of the germ cells themselves to bear out this theory of the separation and isolation of the corresponding qualities of each parent. In studying the germ cells of hybrid pigeons some years ago (1897-1900),¹ the writer observed certain phenomena which led him to much the same opinion regarding the separation of qualities in germ cells as that expressed by Mendel, although at the time the results of Mendel were wholly unknown to him. In the light of the Mendelian law, the facts discovered at that time become doubly significant, and seem to point precisely to such a state of affairs in the germ cells as the law would necessitate, although the general conclusions originally drawn from the facts by the present writer will have to be qualified

¹ Guyer, M. F. "Spermatogenesis of Normal and of Hybrid Pigeons." Dissertation, University of Chicago, 1900; also, Bulletin 22, University of Cincinnati.

somewhat to bring them within the pale of this law, if it proves to be universal. The important fact is that in the germ cells of hybrid pigeons an actual separation of paternal and maternal germ plasma apparently occurs. When germ cells are to be matured, before the real reduction, there is in most forms a so-called false reduction, in which the chromosomes fuse in pairs so that there appears to be only half the normal number present, though in reality each is double (bivalent) and equivalent to two of the simple (univalent) type. The doubling of chromosomes which normally occurs at such times is frequently incomplete, or lacking, in hybrids. This is especially true if the hybrids are from widely separated species. Instead of a normal spindle bearing the usual number of bivalent chromosomes, multipolar spindles, or two separate spindles may appear, thus apparently permitting the two kinds of parental chromatin to remain apart. In the most extreme cases a complete separation may occur subsequently, the entire chromatin of one parent occupying one cell, that of the other a different cell. Such visible separations, however, only occur extensively in sterile hybrids from markedly different parent species. Fertile hybrids from closely related forms, for the most part, display spindles normal in appearance. We may suppose, however, that there is the same tendency for the respective parental characters to separate, though the incompatibilities of the plasmas are not sufficient to prevent the formation of bivalent chromosomes and normal spindles. It does not necessarily follow that in the ensuing division all of the characters of one parent will be set apart in a separate cell, as was the case in the abnormal mitoses. If such a separation were actually to occur, then the offspring which returns to a grandparent type must revert

in not only one given character, but in all characters; that is, the reversion would be complete. The Mendelian law, however, confines itself to a given character, and if any other character is chosen, although it will follow the same law, it does so without any reference to the first character, so that offspring may be pure with respect to a particular character, yet also possess other characters of a mixed nature, or even pure characters of the other parent. In the case of these milder fertile crosses, then, where reversions follow the Mendelian law, the germinal incompatibilities must be narrowed down to the qualities themselves rather than confined to the respective germ plasmas as a whole. These qualities must separate and each take up its abode in a different germ cell irrespective of whether the other qualities of that particular germ cell are of a different parentage or not. The cases in which the entire plasmas are segregated are then probably but magnified images of what occurs among the specific qualities of the milder crosses. The interesting possibility arises that if fertile hybrids can be secured from widely different species the plasmas of which must be more incompatible than those of nearly related forms, such hybrids will give rise to offspring in which there is reversion, not only of one character, but of many or all characters in the same individual, due to a more thorough segregation of the parental germ plasma as a whole. In other words, the farther apart the parent species are, the more complete will be the return in any given offspring which shows reversion. To the mind of the writer, the nearness or the remoteness of the relationship between the two ancestral plasmas will be found to be an important factor in determining the amount (number of characters) of reversion in any given offspring.

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