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The Possible Origin of Mutations in Somatic Cells

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THE POSSIBLE ORIGIN OF MUTATIONS IN SOMATIC CELLS

THAT mutations are accompanied by some change in the germ-plasm is, I take it, indisputable. Have we, however, any reason to suppose that the change takes place within the germ cells? I am not sure, as a matter of fact, that genetists in general regard the gametes as the place of origin of mutations. It is true, however, that experiments in the artificial production of mutations in plants[1] have been limited largely to treatments of the ovaries from about the time of the reduction division to about the time of fertilization. This suggests a belief on the part of investigators that mutations are most likely to be induced in the gametes or in the stages of the plant closely associated with gamete formation. MacDougal (*loc. cit.*) considered it most probable that mutations take place just prior to the reduction division.

The very uniqueness of the reduction division has perhaps suggested the likelihood of the occurrence of chance irregularities in it resulting in the production of mutations. Davis[2] has interpreted the occurrence of 21 chromosomes in *semi-gigas* forms of *Œnothera* as possibly brought about by a pushing forward of the premature fission of the chromosomes from the anaphase to the metaphase of a heterotypic mitosis followed by another fission before the metaphase of the following homotypic mitosis, resulting in the production of gametes with 14 chromosomes, which are supposed to unite with normal gametes (with 7 chromosomes). The *gigas* forms of *Œnothera,* with their 28 chromosomes, however, seem more readily explained by the assumption of a double fission of chromosomes in some mitosis after fertilization. Otherwise we must assume that both male and female gametes with 14 chromosomes are produced at about the same time and that two such gametes happen to meet in fertilization—certainly a rare chance.

The heterozygous condition of the new character in some mutations and the frequent appearance of mutations as seed-sports rather than as bud-sports may, at first thought, make it seem reasonable that they might have their origin in the gametes or at least at about the time of gametogenesis. Neither of these occurrences, however, affords any real evidence for placing any such limit upon the time of origin of a mutation. The reason for this statement will become apparent later.

East[3] has called attention to the asexual production of varia-

[1] MacDougal, D. T., *Pop. Sci. Mon.,* 69: 207–225, 1906; Carnegie Pub. 81: 61–64, 1907. Gager, C. S., *Mem. N. Y. Bot. Gard.,* 4: 22, 1908. Humbert, E. P., *Zeit. ind. Abst. Vererb.,* 4: 161–226, 1911.

[2] Davis, B. M., *Annals of Botany,* 25: 959, 1911.

[3] East, E. M., Ann. Rpt. Conn. Agr. Expt. Sta., 1910, p. 139.

tions in the potato that are known to mendelize in sexual reproduction, but has regarded these occurrences as a segregation of characters in somatic cell divisions (of a heterozygous plant?) rather than as a change in genetic factors, which alone can be regarded as a true mutation.

The interpretation that I have given to the results of a study of the inheritance of a recurring somatic variation in maize have some interest in this connection.[4] The results in brief are these: (1) The more red there is in the pericarp of the seeds of variegated-eared maize ("calico" corn), the more likely is the progeny of these seeds to have self-red ears and the correspondingly less likely to have variegated ears. (2) Red ears thus produced behave like F_1 red ears produced by crossing self-red races with variegated races or self-red races with white races, depending upon whether the variegated parent ear was homozygous or heterozygous and upon whether it was selfed or cross-pollinated. (3) Red ears that behave exactly like crosses between pure reds and pure whites occasionally arise from the seeds of white races crossed by pollen from variegated races.

My interpretation of these results postulates the presence of a genetic factor for self-color, S, in occasional gametes instead of the ordinary variegation factor, V. The presence of S in female gametes is apparently due to a change of V to S in somatic cells from which these gametes arise and this change in genetic factors apparently manifests itself in the development of red pigment in such pericarp cells as are directly descended from the original modified cell. The larger the mass of modified cells the more red appears in the pericarp and the more likely are the female gametes to carry the S factor. But since red never develops in the pericarp until the seeds are nearly mature, it happens that the somatic variation does not become visible until weeks after the gametes are formed and until still longer after the change in factors occurs. It is reasonable to suppose that the presence of the S factor in the male gametes is due to the same sort of change in the somatic cells from which they arise as that responsible for the presence of S in the female gametes. This somatic variation, however, never becomes visible because the staminate inflorescence dies very soon after the pollen is shed. It is quite possible indeed that such a somatic change would never become apparent even if the tassel did not die too early, for a color limited principally to the cob and to the pericarp of the seeds could scarcely be expected to appear in the tassel.

It seems possible that the production of self-colored plants

[4] These results were presented at the Cleveland meeting of the American Society of Naturalists, January 2, 1913. The paper will be printed later.

from variegated ones as here outlined[5] bears more than a superficial resemblance to mutation. The comparative frequency of the change in factors from V to S in variegated plants is perhaps the most striking dissimilarity between the two. Mutations must certainly result from the loss or gain or the modification of genetic factors. They must arise potentially whenever a change in genetic factors takes place, whether in the somatic cells or germ cells of the parent or in the early somatic cells of the mutant offspring. It is conceivable that many mutations may arise in a manner similar to the origin of red-eared maize plants from the male gametes of variegated maize—similar in the sense that the change in genetic factors may occur in somatic cells without any visible modification of those cells or of any part of the plant body arising from them.

East has shown (*loc. cit.*) that Mendelian characters of potato tubers sometimes arise as bud-variations. If the same characters should be found to appear as seed-sports, that fact would not, in some cases at least, preclude the possibility of their having had their potential origin in somatic cells of the parent plant. If a change of genetic factors having to do with tuber shape should occur in the growing point of an underground stem, the change would doubtless manifest itself in any tubers that grew from the modified cells of that stem (provided that the new character were a dominant one or that the change affected both of the like genetic factors of the modified cells) and the change would at once be recognized as a bud-sport. But if exactly the same change should occur in the growing point of an aerial stem, the new tuber shape obviously could not manifest itself in the parent plant and would appear, if at all, only among the seedlings of that plant where it would of course be classed as a "seed-sport."

Whether or not mutations do arise as suggested here, the possibility seems great enough to warrant the extension of experiments in their artificial production to include the treatment not merely of plant ovaries but of all growing parts from which gametes may be expected eventually to arise. In animals of course treatment would have to be aimed at the germinal tissue but with the higher plants in general almost any meristematic tissue is potentially germinal tisue.

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[5] Correns has reported results with *Mirabilis* similar to my results with maize (Correns, C., *Ber. Deutsch. Gesel.*, 28: 418–434, 1910). There is little doubt also that de Vries's results with *Antirrhinum*, listed by him as ever-sporting variation, are to be interpreted in the same way (Vries, H. de, "Species and Varieties," pp. 315–322, 1905).