

the bad name to inbreeding in the past, the less vigorous offspring frequently resulting from inbreeding, although healthy, were also considered to be valueless for further propagation and were quickly disposed of.

This is still the belief and practise of live-stock breeders. Those who do not know the principles involved think that inbreeding has permanently injured the families with such weakened individuals. Equipped with the results of two decades of genetic investigation, we can say, "No! this is not so. *Nothing has been lost*. These less vigorous inbred individuals of no apparent worth have potentially great value." A widespread reception of this idea has possibilities of great practical outcome. Not to see clearly the important distinction which there is here between the present and former views is not to appreciate the real progress which the combined genetic research of twenty years has made along this line.

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AN APPARENT CASE OF SOMATIC SEGREGATION INVOLVING TWO LINKED FACTORS¹

SOMATIC segregation as an ordinary occurrence, and especially as a source of definite progeny ratios in subsequent sexual reproduction, seems highly improbable. The evidence connecting normal segregation and recombination with meiosis and fertilization is too strong. As a matter of occasional mitotic abnormality in heterozygous material, however, the question of somatic segregation is still open.

Any "bud sport" involving apparently simultaneous change of two or more non-allelomorphic factors is therefore of special interest, since the probability of its occurrence through two nearly simultaneous factor or point mutations seems very remote. Either deficiency mutation, which seems to mean (Bridges, 1917) the loss of a normally present portion of a chromosome, or the development or resolution of a condition of "duplication" (such as vermilion-sable duplication in *Drosophila melanogaster*; Bridges, 1919, p. 646) might produce the effect in question. So, also, might a process properly described as "somatic segregation," in which at some mitosis one daughter

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cell received both halves of one mother-cell chromosome, while the other daughter cell received both halves of the homologous chromosome. Such a variation, then (Muller, 1920, p. 459), permits an almost certain decision between factor mutation and "mitotic irregularity."²

A "bud variation" apparently involving two linked factors was observed in a culture of *Matthiola annua*, at Riverside, California, in 1916-17. Unfortunately the factorial relations are not entirely clear, but the case seems decidedly significant nevertheless.

The plant in question occurred among progeny of a "slender" parent (25b-6-8-6; Frost, 1919). The slender type (*S'*) is one of several aberrant forms evidently dependent on factors linked with the factor "for" single (normal) flowers (*D*). Slender parents have given (Frost, 1919) on the average about 32.5 ± 2.0 per cent. of slender progeny, most of the rest being "Snowflake" (normal). The constitution of the slender single parent mentioned appears to have been *S'D/s'd*. Both *S'* and *D* (or a factor completely linked with *D*) appear to be imperfectly recessive for a lethal effect; no functional pollen carries *D*,³ and *S'S'* zygotes appear to be non-viable, while *S's'* zygotes are somewhat weak and probably are selectively eliminated before germination.

Plant 25b-6-8-6 gave the following progeny: slender, 18 or 19 (2 double, 1 undetermined, rest single); Snowflake, 25 (1 single, 24 double); total, 44. One plant was noted, at the age of about seven months, as having the upper main stem leaves like Snowflake, but the rest slender. When mature this plant had produced from one side of the main stem at least three primary branches, all slender and single, two at least yielding seed. The main cluster was stout, and, although its flowers seem not to have been noted as peculiar while in bloom, it produced persistent sterile pistils; at least two of these pistils were abnormally broad, each enclosing a cluster of petal-like parts. One

² This paper was written, aside from some revision of this second paragraph, before I saw Muller's paper here cited.

³ All the singles of such a "double-throwing" race are therefore heterozygous for doubleness, while the doubles (*dd*) are sterile (Frost, 1915). A back cross of two Snowflake plants by pollen of 25b-6-8-6 (crosses 23ca and 23ea; Frost, 1919, table 36) gave about 22.4 ± 2.6 per cent. of slender progeny, including only 2 (or 1) doubles out of 26 slenders, while the Snowflakes were about half doubles. Evidently both eggs and pollen carried some factor or factors contributing to this puzzling result.

stout flowering branch, well above the others, evidently was similar to the primary inflorescence. Near the level of the uppermost of the slender flowering branches, on the opposite half of the stem, arose two stout branches, which bore Snowflake-like leaves and sterile double flowers.

It would seem that some change eliminating the factors S' and D occurred, probably in a single cell, at the growing point of the young main stem. The Snowflake double ($s'd/s'd$) cells resulting, perhaps because of their normally greater vigor of growth, gradually obtained the ascendancy in a large portion of the stem. The primary inflorescence and the high branch beside it perhaps remained in a chimerical condition, while the two lower stout branches received the new type nearly or quite unmixed.

That the double flowers were somewhat abnormal⁴ hardly lessens the force of the evidence in relation to the improbability of factor mutation. Even the two lower stout branches may have been periclinal chimeras, or the new factorial constitution may have been (as for example through a "duplication" shifting of chromosome material) somewhat different from that of a normal double. Plainly some change occurred that involved, nearly or quite simultaneously, two factors in linked loci some distance apart. This change was probably not factor (point) mutation. It may have been deficiency mutation, itself probably a mitotic abnormality, or it may have been some other abnormal shifting of a chromosome or a portion of a chromosome.

A further consideration is pertinent here. The slender form and at least one or two others, in arising (Frost, 1916, 1919) in very small proportions from the normal (Snowflake) type, show evident linkage phenomena which indicate segregation rather than immediate mutation. As has been suggested (Frost, 1919), the apparently mutant factor (as S' above) may be present in ordinary Snowflake singles, but concealed because of the

⁴ The usual double flowers are "petalomanous" (de Vries, 1912, p. 330); that is, inside the sepals they consist of nothing but an indefinitely proliferated floral axis bearing numerous petals. The flower lives long after anthesis, and often develops into a short branch bearing secondary flowers in the axils of its leaves (petals). No trace of stamens and carpels can be found. These abnormal double flowers, on the other hand, had the four petals of the typical cruciferous flower, followed by an indefinite number of smaller curved petals probably representing petaloid stamens; finally, in some cases the central mass of petals seemed to arise from within a modified pistil, somewhat as in the case of the less abnormal flowers of the terminal cluster mentioned above.

action of an epistatic or inhibiting factor *I*. Thus the constitution of the Snowflake singles giving rare slender progeny may be *IS'D/is'd* or *DS'I/ds'i*. A serious theoretical difficulty seemed to arise in the apparent necessity for several specific "inhibitors" all giving the same "normal" type, and also for relatively frequent dominant mutations. Perhaps, however, the apparent mutation may usually consist in the development or disappearance of some condition of duplication in one chromosome of the pair concerned. Origin of apparent mutants through duplication of whole chromosomes, as seems to have been demonstrated for a remarkably similar series of mutant forms in *Datura* (Blakeslee, Belling and Farnham, 1920), seems to be precluded in these cases by the evident linkage phenomena.

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THE NEUROMOTOR APPARATUS OF PARAMECIUM

THE discovery of a neuromotor apparatus in *Diplodinium ecaudatum* (Sharp 1) and *Euplotes patella* (Yocom 2) confirmed by Taylor (3) leads me to expect similar conductile fiber systems in other ciliates. This expectation has been met in the