or part of a head, some of the normal plants from this head should segregate the same mutant character in the following generation, while none of the plants from the unaffected heads should do so. This expectation was realized in the next generation, in which eight of the sixteen normal plants tested from the head which segregated white seedlings were found to be heterozygous for white, seven of the twelve plants tested from the head which segregated virescent were heterozygous for virescent, and three of the seven plants tested from the head which segregated yellowing were heterozygous for yellowing. In each case about fifteen plants from unaffected heads of the mutating plant were tested, and all gave entirely normal progeny.

The remaining progenies have since been planted and seedling segregations noted. The total frequency of mutations resulting in definite and conspicuous seedling characters is shown below:

| | Total number of head progenies examined | Number segregating mutant seedling characters |
|---|---|---|
| X-ray treated: | | |
| Higher voltage | | |
| Heavy dose | 210 | 6 |
| Light dose | 259 | 1 |
| Lower voltage: | | |
| Heavy dose | 494 | 6 |
| Light dose | 280 | 1 |
| Total X-rayed | 1,243 | 14 |
| Radium treated: | | |
| Total for all doses | 1,039 | 3 |
| Untreated | 1,341 | 0 |

The majority of the mutations listed were white seedlings. Tests of genetic identity have not yet been made, but it is probable that many of these represent mutations at different loci. At least three genetically distinct white seedlings have previously been reported in barley, and in maize, in which genetic analysis has been more intensive, dozens of genes for white seedling are known.

The mutations following radium treatment included two whites and one virescent. Since the radiation passed through 1 mm of silver and at least 5 mm of glass before reaching the seeds, it consisted largely of gamma rays. The fact that mutation frequency was lower in the radium series than in the X-ray series does not imply that radium is less effective than X-rays in inducing mutation, since the intensity of the radium treatment was probably much lower. All three mutations occurred in the plants receiving the heavier doses.

A preliminary trial was made also of the possibility of increasing the effectiveness of X-ray treatment by impregnating the seeds with salts of heavy elements. Since in general X-ray absorption increases approximately in proportion to the fourth power of the atomic number of the absorbing element, it may be increased materially by the presence of even a small amount of some heavy element within the cell. The seeds were soaked for seven hours in M/5 solutions of the salts listed below. The X-ray treatment, which began fifteen hours later, was similar to that described above as heavy dosage at the higher voltage, but the intensity was about 40 per cent. higher. The frequency of mutation for distinct seedling characters is shown below:

| Treatment | | Number of head progenies | Number of mutations |
|---|---|---|---|
| Radiation | Chemical | | |
| X-rayed | $Ba(NO_3)_2$ | 136 | 9 |
| X-rayed | $Pb(NO_3)_2$ | 133 | 9 |
| X-rayed | $UO_2(NO_3)_2$ | 194 | 11 |
| X-rayed | none | 72 | 2 |
| Not X-rayed | $UO_2(NO_3)_2$ | 53 | 0 |
| Not X-rayed | none | 76 | 0 |

Although the numbers are too small to justify a final conclusion, the results suggest that the chemical treatments increased the effectiveness of irradiation. The mutations included, in addition to types already noted, the following seedling characters: "yellow," "pale yellow," "yellow-green," "banded" (transverse white bands), "striped" (two distinct patterns) and "tapering" (a morphological peculiarity). Several possible mutations for less conspicuous seedling characters are omitted from the summary pending further investigation.

In all, forty-eight mutations causing distinct seedling characters have been found following irradiation. These include almost all the seedling characters of barley previously reported and several not previously described. No mutations have yet been found in untreated plants, of which about fifteen hundred head progenies have been examined.

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## THE NUCLEAR CONDITIONS IN THE SPERMATOCYTES OF DROSOPHILA MELANOGASTER

IT is a surprising fact that very little has been known until recently concerning the nuclear conditions in the spermatocytes primary and secondary of *Drosophila melanogaster*. In conversation with a number of investigators in this field the opinion has been reached that those who have investigated the cytology of this interesting species consider that no known reagent is capable of preserving the meiotic divisions in the male gonad. This is all the more surprising because the ordinary somatic divisions as well as those occurring in the spermatogonia and oogonia can be so easily and beautifully preserved. The situation becomes still more anomalous when one reflects that a spermatogonium may occur a small fraction of a millimeter removed from a primary spermatocyte. It is opposed to all cytological experience that the somatic or sporophytic mitoses should be preserved without difficulty, whilst the reduction divisions can not be fixed at all. We are now acquainted with the cytology of a huge number of plant hybrids and in these cases the preservation of the reduction divisions presents no greater difficulty than does that of the ordinary body cells of the plant.

Apparently the difficulties of our genetical colleagues concerning the cytological phenomena in the reduction divisions occurring in the sperm-mother cells of *D. melanogaster* are the result of their general unfamiliarity with the reduction divisions in the case of hybrids. The botanist who has any cytological knowledge at all is quite familiar with these and may even have seen them in his own preparations. Obviously, the abnormalities which appear in the male meiotic mitoses of *D. melanogaster* are not in general the result of defective fixation. A consideration of the situation in a plant hybrid will make this point clear. If we take two good species of plants, such, for example, as *Rumex crispus* and *R. obtusifolius*, we find that both their sporophytic and meiotic divisions are entirely normal. If, on the other hand, we examine the not uncommon hybrid between these two species, we discover at once that extreme abnormalities in the reduction divisions (although not in the sporophytic divisions) are present when exactly the same technical procedure is pursued as in the case of the parent species. These abnormalities in the meiotic mitoses of hybrid plants have been so widely studied that it is possible to formulate them. They are variations in numbers of chromosomes, the occurrence of different combinations of chromosomes such as bivalents and univalents, and, above all, the lagging of these chromosomes whether univalent or bivalent on the spindle, in division.

It is an interesting and apparently highly significant fact that the reduction divisions in the male organs of *D. melanogaster* present an exact parallel to those found in the corresponding divisions of known hybrids or extremely variable species among plants. The opinion is now widely held on the botanical side that extreme variability in plants, especially when accompanied by the meiotic phenomena of known hybrids, is certain evidence of heterozygous or hybrid origin. These accompanying phenomena are of very wide occurrence in large genera of plants from the Algae to the Angiosperms.

Our genetical colleagues should, apparently, as a consequence of this general situation, be less pessimistic about the possibility of fixing the reduction divisions of *D. melanogaster*. We hear a good deal at the present time about the necessity of exploiting the frontiers between the various sciences. In biology apparently the frontiers between the different subdivisions of the science are to too large a degree *terra incognita*. The zoologists know too little of what is going on over the botanical boundary and also the botanist is often lamentably ignorant of the conditions across the fence of his zoological neighbor. One of the most deplorable limitations of the present time is the lack of cooperation between experimental and comparative students of biology. Obviously, the comparative anatomist and the cytologist have much to learn by utilizing the results obtained by the experimental worker. Similarly, the experimental worker may equally avoid the danger of progressing in a vicious circle by keeping his eyes fixed on the comparative horizon.

As the result of the examination of a very large additional amount of material of *D. melanogaster* originating both from Professor Morgan's laboratory and from numerous sources in the wild, the conclusion is reached that in all cases the male meiotic phenomena are highly abnormal and resemble in important respects those observed in known or experimentally produced plant and animal hybrids. That the abnormalities in question are not the result of fixation seems clear not only because they resemble those found in hybrid plants and animals but because they present themselves in substantially the same aspects with different methods of preservation. It is accordingly once more asserted that *D. melanogaster* in contrast to some other species of the genus, both as a result of its extreme variability and its meiotic phenomena, is to be regarded as of heterozygous or hybrid origin. This conclusion will naturally make necessary, if it be substantiated by the works of other investigators, a profound modification of the inferences in regard to the origin of species which have been derived from the genetical study of *D. melanogaster*.

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