## A GENIC DISTURBANCE OF MEIOSIS IN ZEA MAYS

DURING and following the summer of 1927, a collection of maize carrying factors for male sterility (Eyster)[1] was made for the purpose of genetical and cytological investigation. The occurrence of male-sterile plants in material from thirty or more unrelated cultures suggests the possibility of several genetic factors causing such sterility.

In segregating material obtained from I. F. Phipps, it has been found that sterility is due to a recessive mendelian factor causing irregular meiosis. In a count of 144 plants the observed ratio was 109 normal to 35 sterile plants, a deviation from the calculated ratio of but one plant.[2] The cytological behavior in these sterile plants has been determined by studies of the meiotic divisions in the microsporocytes.

Early stages of microsporogenesis in the male-sterile plants have not been extensively studied. During the stages just previous to and during diakinesis there is observed a partial or complete failure of synapsis. Because of this lack of synapsis and the consequent presence of a large number of univalents, metaphases are characteristically irregular. Microsporocytes most frequently show twenty univalents. Progressively fewer cells show one bivalent and eighteen univalents, two bivalents and sixteen univalents, and so on, cells with ten bivalents rarely being observed. Some anthers show a high percentage of sporocytes containing some bivalents while other anthers show a high percentage of sporocytes containing twenty univalents.

Irregularity in the appearance of metaphase *I* increases with an increase in the number of univalents. A microsporocyte with ten bivalents in metaphase *I* appears normal. When univalents are observed they do not always lie in one spindle. Usually there is one major spindle containing the several bivalents, when present, plus some of the univalents, and one to several minor spindles containing one or more univalents (Fig. 1). In consequence of the presence of several spindles, the sporocyte is divided into a number of unequal cells after the first meiotic mitosis. Each cell contains one or more nuclei and each nucleus contains one or more chromosomes. These cells undergo a second division to form microspores. It is obvious that most of these microspores and the pollen grains formed from them do not contain a normal haploid set of chromosomes, and they are probably non-functional under ordinary conditions.

[1] L. A. Eyster, *Journal of Heredity*, 12: 138–141.

[2] Data partly from I. F. Phipps.

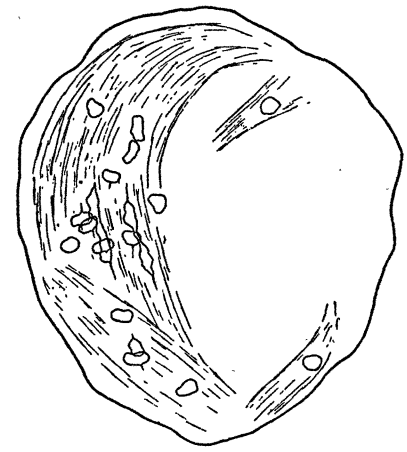

FIG. 1

This particular type of male sterility is accompanied by a certain amount of female sterility. Several pollinations have given only sparsely-filled ears. Female sterility has been observed in male steriles from a few of the other sources also. Megasporogenesis remains to be studied in these cases.

With regard to at least one male-sterile culture, it may be stated that male sterility is due to a simple mendelian gene affecting synapsis and consequent meiotic behavior, the result being the formation of gametes containing varying chromosomal complements, only a few of which are viable.

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## THE ELIMINATION OF CARBON DIOXIDE IN THE INSECTA

WHILE carrying out experiments recently on the respiration of some of the apneustic and atracheate types of larvae found among parasitic and aquatic insects, results have been obtained which throw some light on the general subject of respiration in the Insecta, a subject as yet so imperfectly understood.

The carbon dioxide output can be studied by means of a suitable pH indicator, the larva being held motionless in a film of the fluid under a raised coverslip. The indicator must have a color change in the region of pH 7.0, easily visible, even in dilute solutions, in the thin layer underneath the coverslip. Owing to its intense color and very strongly marked change from blue to pink at about pH 6.0–6.2, a .1 per cent. solution of o-chlorophenol indophenol was found to be almost ideal and was the indicator most frequently used, the results obtained being, however, confirmed by means of phenol red, cresol red and brom-cresol purple.

For studying the absorption of oxygen the method used by H. M. Fox[1] in his work on the respiration of Chironomus larvae is employed. This method consists in using cultures of flagellate or ciliate protozoa which are positively chemotactic to concentrations of dissolved oxygen lower than that in water saturated with oxygen at atmospheric partial pressure, as indicators of oxygen consumption.

Both these methods were found to give consistent results when tested upon various aquatic larvae having well-developed tracheal gill systems (Ephemeroptera, Trichoptera and certain Coleoptera) and by their means the results obtained by Fox as to the respiration of Chironomus were confirmed. The details of these experiments and of those on the larvae of various internal parasites must be reserved for later publication.

During the course of some control experiments it was found that a well-marked reaction to pH indicators could also be obtained with the larvae of certain small Lepidoptera, such as the potato tuber moth *Phthorimaea operculella* Zell., the color change indicating a general evolution of $CO_2$ from the whole body surface excepting the head and posterior extremity. Further experiments showed that similar results could be obtained with other lepidopterous larvae, with larvae of certain Coleoptera, Tenthredinid sawflies, and of representatives of three families of Diptera as well as with all stages of certain Aphididae. That the effect could not be due to the contact of the indicator with the air in the mouths of the spiracles is obvious from the fact that the color change appears more or less evenly over the body surface, showing no relation to the spiracles, this also being true of amphipneustic dipterous larvae.

Experiments with pupae of Lepidoptera, Coleoptera and Hymenoptera gave varying results. In some cases a very slow evolution of $CO_2$ was shown, but frequently no result at all could be obtained, as was also the case with various dipterous puparia. On the other hand, the active pupae of Culex gave a definite reaction as was to have been expected.

Experiments with more heavily chitinized adult forms such as the Coleoptera were somewhat inconclusive owing to the difficulty of completely removing the air from the crevices of the chitin, but the indications are that although the carbon dioxide does not pass out through the heavily chitinized parts of the cuticle yet a considerable amount may be eliminated *via* the softer articular and intersegmental membranes. Tests so far carried out on spiders (*Argiopidae, Salticidae*) have given negative results.

[1] *J. Gen. Phys.*, 3: 565–573, 1920–1921.

The method is limited in application owing to the difficulty of wetting the surface of many insects, especially those with numerous wax glands or cuticular hairs, but it is certain that many if not most of those insects which possess only a thin chitinous cuticle are able under experimental conditions to liberate carbon dioxide directly through the body wall, and the writer believes that these experiments constitute the first definite evidence that this is so.

As was expected, tests so far carried out with flagellate cultures fail to give any definite indication of $O_2$ absorption in terrestrial insects.

The question then remains as to how far this method of $CO_2$ elimination is operative under natural conditions. The rapidity with which the color change appears in the indicator (from thirty seconds to three minutes in the majority of cases) and the fact that the insects are none the worse even after repeated experiment shows that the effect observed is not due to any injurious effects of the indicator solution. That the results obtained are due to $CO_2$ and not to any acid substance on the body surface is shown by the fact that thorough preliminary washing and repeated experiment upon the same individual tuber moth larva do not cause any diminution in the rate or extent of the color change, whereas recently killed larvae, even though unwashed, give no reaction whatever. That we are dealing with $CO_2$ can also be demonstrated by means of barium hydrate, although this reagent is difficult to work with and unsuitable for general use.

The work of Krogh,[2] Wallengren[3] and others suggests that the tracheae alone are not responsible for the elimination of all the $CO_2$ produced and that a considerable quantity must be removed by some other means, and the work of Muttkowski[4] has stressed the importance of the blood as a carrier of $O_2$ and $CO_2$ (probably by means of a respiratory protein), while it seems certain that in the atracheate Collembola and Protura carbon dioxide must be eliminated through the general body surface.

It may be said, therefore, that whatever may be the state of affairs in large and heavily chitinized insects it seems very probable that in the smaller thin-skinned insects, including the majority of larval forms, the tracheal system is responsible for the elimination of carbon dioxide only to a relatively small extent.

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[2] *Skand. Arch. Phys.*, 29: 29–36, 1913.
[3] *Act. Univ. Lund.*, 11: no. 11, 1–12, 1915.
[4] *Ann. Ent. Soc. Am.*, 14: 150–156, 1921.