theory is obviously incomplete. As he so appositely puts the case himself: "We all have partially permeable intellects."

At this stage, indeed, it is altogether premature to express an opinion as to the outcome of the struggle. What is certain is that Loeb has made, in this volume, a brilliant thrust which his adversaries will find it difficult to counter. There are many points of detail in his experimental work which will curdle the blood of any analytical chemist, yet it appears on close examination that the errors introduced are, after all, insufficient to affect the main issue. The opponents of Loeb's views, in any case, cannot restrict themselves to attacking the weak points of his presentation; he has already succeeded so far as to put them definitely on the defensive. To quote from his own preface: "Any rival theory (of colloidal behavior) which is intended to replace the Donnan theory must be able to accomplish at least as much as the Donnan theory, *i. e.*, it must give a quantitative, mathematical and rationalistic explanation of the curves expressing the influence of hydrogen ion concentration, valency of ions, and concentration of electrolytes on colloidal behavior; and it must explain these curves not for one property alone but for all the properties, electrical charges, osmotic pressure, swelling, viscosity, and stability of solution, since all these properties are affected by electrolytes in a similar way."

This quotation may be supplemented by another, from the final page of the book, indicating the importance of Loeb's work outside of chemistry. "If Donnan's theory of membrane equilibria furnishes the mathematical and quantitative basis for a theory of colloidal behavior of the proteins, as the writer believes it does, it may be predicted that this theory will become one of the foundations upon which modern physiology will have to rest."

Every so-called colloidal chemist will evidently be forced to read Loeb's book in self-defense. Those also who are only indirectly interested in colloidal phenomena cannot fail to find it stimulating.

James Kendall

SPECIAL ARTICLES

MOSAIC CROSS-INOCULATION AND INSECT TRANSMISSION STUDIES

Whether or not the plant disease known as mosaic is transmissible to plants of different orders, and the rôle of insects as agents in such transmission, are questions of fundamental importance. It is generally held that mosaic of the Cucurbitaceæ, Solanaceæ and Leguminaceæ are all quite specific and with few exceptions transmissible only to species within the same family. Certain mosaic diseases have been described indicating that even among species within the same family there may be two or more types of the disease. Allard[1] in 1916 described a specific mosaic disease on *Nicotiana viscosum* distinct from the mosaic disease of *Nicotiana tabacum*. Jagger[2-3] in 1917 and 1918 reports three specific mosaic diseases of the cucurbits. The tendency has thus been to divide mosaic into types which are distinct in their host range.

As opposed to the evidence indicating that there are a number of types of mosaic which are specific to a narrow host range, we have evidence showing that mosaic will cross to species belonging to other families and orders. Jagger[4] in 1918 published results of cross-inoculation studies where he succeeded in transferring mosaic from the Cucurbitaceæ to species of two other families of the Order Campanulales. Doolittle[5] has shown that mosaic of cucumber is transmissible to *Martynia louisiana*, a species belonging to the Order Polemoniales.

Cross-inoculation experiments by the writer have shown that the mosaic diseases of the Cucurbitaceæ, Solanaceæ and Leguminaceæ are inter-transmissible. Four petunia plants inoculated with mosaic from crookneck squash became infected while an equal number of checks remained healthy. The inoculations were made by inserting mosaic tissue into the stem with a sterile scalpel. An experiment in which juice from mosaic plants was inoculated hypo-

1 *Journ. Agr. Research*, 7: 481-486, 1916.

2 *Phytopathology*, 7: 61, 1917.

3 *Phytopathology*, 8: 74-75, 1918.

4 *Phytopathology*, 8: 32-33, 1918.

5 *U. S. D. A. Bull.* 879, 1-69, 1920.

dermically resulted in 100 per cent. infection. Using this method, four crookneck squash plants were inoculated with mosaic from tomato, and four with mosaic from tobacco. All of these plants became infected. Similarly, a tobacco and two tomato plants were inoculated with juice from mosaic crookneck squash leaves and became infected. The number of plants kept as checks greatly exceeded the number of inoculated plants. All checks remained healthy. In an attempt to cross-inoculate tomato with mosaic from crookneck squash by the hypodermic needle method, two out of five plants became infected while the ten checks all remained healthy. In another experiment where mosaic crookneck squash leaf tissue was inserted into the midribs of five tobacco plants, the result was 100 per cent. infection. At the same time five tobacco plants were similarly inoculated with mosaic cucumber tissue and one of the five became infected. These inoculations were made using a sterile flamed scalpel. In order to further check whether or not the inoculations were being made under sterile conditions, healthy leaf tissue was inserted into the midribs of ten tobacco plants. In addition, 30 plants were kept as checks. No mosaic developed either on the inoculated or on the uninoculated checks. An attempt to inoculate tomatoes with mosaic from catnip, *Nepeta cataria,* resulted in three of the five plants inoculated becoming infected while an equal number of checks remained healthy.

The investigations made by the writer with mosaic of the legumes have been mainly with cow pea, *Vigna Catjang.* Although the cow pea has not been reported susceptible to mosaic, this species has been found susceptible under greenhouse conditions. Symptoms include mottling and distortion of the leaves, and stunting of the whole plant. Inoculation by means of transferring aphis (species undetermined) from the mosaic plants to healthy plants was shown clearly that this mosaic is a transmissible disease. Two pots containing 38 cow pea seedlings were infested with aphis from the mosaic cow pea plants and were placed in insect proof cages. One hundred per cent. infection occurred in both pots while all checks remained healthy.

In addition to aphis being carriers of mosaic, numerous experiments have shown that the mealy bug (*Dactylopus sp.*) also transmits this disease. This has been found especially true where mealy bugs caused mosaic infection of cow peas and soy beans. Cross-inoculation experiments using mealy bugs which had been transferred from mosaic infected solanum and cucurbit plants to healthy cow pea seedlings, have resulted in infection in both cases. Experiments have shown that soy bean plants are susceptible to mosaic from cow peas where mealy bugs served as carriers. Mealy bugs with a portion of the mosaic plant on which they were feeding were transferred to the pot containing the seedlings. The result of an experiment in which mealy bugs from a mosaic crookneck squash plant were transferred to two pots containing a total of 33 cow pea plants gave 100 per cent. infection. All checks remained healthy. A pot of cow pea plants was inoculated by means of mealy bugs from mosaic infected egg plant and of 38 plants 100 per cent. became infected. At the same time aphis from mosaic potato were transferred to another pot containing 36 cow pea seedlings, 28 of which developed the disease. Out of 60 plants held as checks no case of mosaic has appeared. Mealy bugs were transferred from mosaic infected cow pea to soy bean seedlings with the results that a large per cent. of the soy bean plants developed mosaic.

Data and observations in the greenhouse indicate that mealy bugs may transmit mosaic to solanums. Two tobacco plants and one tomato plant have thus been infected with mosaic from crookneck squash through the agency of mealy bugs.

The results obtained indicate that the mosaic with which we are working is inter-transmissible between species of Cucurbitaceæ, Solanaceæ and Leguminaceæ. To what degree this will hold true under field conditions has not been determined. Judging from observations, the writer believes that infection with mosaic is to a large degree determined by the growth condition of the plant. Experiments testing this point have shown that the optimum condition for mosaic infection is an unchecked, vigorous growth of the plant. Inoculations of mosaic within the Solanaceæ or within the Cucurbitaceæ have, as a rule, been more easily accomplished than the cross-inoculations between members of the Solanaceæ and members of the Cucurbitaceæ. Successful cross-infections between members of different families are more easily obtained with plants growing under very favorable conditions than with plants growing under unfavorable conditions.

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SPERMATOGENESIS OF THE GARTER SNAKE

UP to the present no work has been published on the spermatogenesis of the snakes. The only Reptilia which have been studied in any detail have been the lizards, and the recent work of Dalcq and Painter has definitely pointed out that an accessory element exists in this group. The work on the spermatogenesis of this species of snake (*Thamnophis butleri*) has progressed far enough to make it advisable to publish a few of the details, although the work has not yet been completed.

The species on which this study is being made was collected in the vicinity of Ann Arbor, Michigan, and was identified by Drs. A. G. Ruthven and F. N. Blanchard. It has one of the narrowest ranges of any of the garter snakes but is abundant in that locality.

The material has been fixed in Flemming's strong and Flemming's strong plus .5 per cent. urea at both room temperature and cold, and in Allen's modification of Bouin. The best results have been obtained with cold Flemming plus urea, fixed for twenty-four hours, sectioned at six micra and stained with Heidenhain's Iron Hæmx. by the short method of Lee.

The material shows thirty-seven chromosomes in the spermatogonial equatorial plates in the best counts and this is what would be expected from a study of the spermatocyte divisions. There is a border of large bent rod shaped chromosomes and an inner group of short rods and round chromosomes.

In the late prophase and side views of the equatorial plate of the first spermatocytes the accessory elements form a tripartite body. Polar views of the first spermatocyte show seventeen autosomes and either one or two accessory chromosomes depending on the way the plate is turned. At the first division, the tripartite body divides, two parts going to one pole and one to the other, the double part remaining more or less fused. A polar view of the first spermatocyte shows five quite large bivalents, two of which are slightly smaller than the other three, eleven medium sized and two microsomes, making eighteen as the haploid number. If the double accessory happens to be turned toward the observer, one of the three large ones gives the double appearance. There is little indication of an earlier division of the accessory elements though at times the double one may be seen lying closer to the centrosome, indicating that it has divided earlier. The first division is the differential division, the two daughter cells receiving the following: one, seventeen autosomes and the double accessory, and the other, seventeen autosomes and the single accessory.

The second spermatocyte division then becomes an equational one so far as the accessory chromosomes are concerned and give rise to two classes of spermatozoa.

Oogonial counts have not yet been made to determine whether the single or the double is the X chromosome, but it might be expected, in light of what has been found in the lizards by Painter, that the double one is the X and the single the Y and that oogonial counts should yield thirty-eight chromosomes. It would seem in this species of snake, at least, that the accessory chromosomes are found as three separate ones in the spermatogonia, which bears out what Painter has already described for the lizards.

Examination of some slides of snake testis of an unknown species has revealed a condition of the chromosomes more like the lizards as described by Painter. This material shows in the first spermatocyte division equatorial plates with approximately nine very large and eleven very small chromosomes as the haploid number. Before the complete results are published, a comparative study of other genera and families will be made in order to determine whether the behavior of the accessory chromosomes in snakes falls in line with what Painter has already described for lizards.

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