plant. Incidentally it becomes a handy reference to the literature of the plant diseases investigated at this station.

H. S. Jackson's address on the "Development of Disease-Resistant Varieties of Plants," given before the Massachusetts Horticultural Society, March 14, 1908, and printed in its proceedings, is a clear popular discussion of a most important but poorly understood subject. Recognizing that "spraying is a nuisance at best" the speaker urged that more attention should be given to the development of varieties which are resistant to disease, suggesting (*a*) the selection of individuals, (*b*) the selection of varieties and (*c*) hybridization followed by selection of varieties and individuals. Brief discussions of what has been accomplished in regard to wheat, clover, cow peas, potatoes, tobacco, cotton, etc., are given which will astonish those who have not followed the work of the last few years; the difficulties are candidly pointed out, and something is said as to the cause of immunity, and the possibility of artificial immunity.

Dr. E. M. East's paper, entitled "A Study of the Factors Influencing the Improvement of the Potato" (Bull. 127, Ill. Expt. Station) is valuable not only from a practical standpoint, but also for the history of the potato which is given in the introductory pages. After this, methods of breeding, inheritance of characters in tuber selections (in which the author regards the gain as doubtful), degeneration of varieties (the author concluding that varieties do not run out), mutations, etc., are taken up in succession. The author suggests three possible methods of improvement, viz., (1) crossing of desirable plants, (2) selections of the most desirable fluctuations among the plants and tubers of a variety, (3) selection of discontinuous variations and a study of ways of causing them, and regards the first as most promising.

Here should be noticed J. E. Rockwell's "Index to Papers relating to Plant-Industry Subjects in the Year-books of the United States Department of Agriculture," which will save much time and labor to the botanist who has occasion to refer to the many valuable botanical papers published in the agricultural year-books.

Three recent papers by Dr. Kraemer in the *American Journal of Pharmacy* are of interest to the plant histologist as well as the pharmacist, viz., "Microscopical and Chemical Examinations of Black Pepper," the same for commercial ginger, and some distinguishing characters of belladonna and scopolia. Each paper is well illustrated by many clear figures.

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SPECIAL ARTICLES

SEX DETERMINATION AND PARTHENOGENESIS IN PHYLLOXERANS AND APHIDS

The phylloxera of the hickories offer exceptional opportunities for a study of sex-determination and parthenogenesis. In some species three generations can be followed within the same gall—two parthenogenetic and one sexual. We can determine the number of males and females that have descended from the same fertilized egg, as well as the influence of external conditions in affecting the number and kind of individuals in each generation. Immense numbers of eggs can be obtained. They furnish also excellent, although difficult, cytological material.

During three years I have studied the cytological aspects of the life cycle and can now present an almost complete account of the remarkable chromosomal changes that occur in connection with sex-determination.

I wish to lay especial emphasis on three points:

1. In many insects it has been found that sex is connected with, or produced by, two kinds of spermatozoa. But in phylloxerans, aphids, bees, ants, in certain saw-flies, in daphnians and in hydatina, the fertilized eggs produce only females. In the phylloxerans and aphids the result is connected with the formation of only functional female-producing spermatozoa—the male-producing sperms degenerate. One may suspect that similar conditions are to be found in the other groups, and the facts of spermatogenesis in the bee, wasp and ant, support such a view.

2. The females that result from the fertilized egg produce subsequently both males and females parthenogenetically. Clearly the egg as well as the sperm contains factors that determine sex. I have found, in fact, that the same method used by the sperm is also made use of by the egg.

3. I wish to raise certain questions connected with the mechanism by means of which males and females are produced. It has generally been assumed that chance alone determines into which sperm the sex chromosome passes. There are indications in the egg that this mechanism is not a chance result, but that behind it lie a series of preliminary events that are equally to be reckoned with as sex-determining factors.

The life cycle of a typical species of phylloxeran consists of the stem-mother (arising from the fertilized winter egg), of a second winged generation (produced by the stem-mother), and of sexual males and females—mere pigmies in size—that come from the winged individuals. The winged individuals are of two kinds, those bearing large eggs that produce the sexual females, and those bearing small eggs that produce the males. Certain species deviate from this rule. I shall refer to one such species later.

Phylloxera fallax has the following chromosomal history. The polar spindle of the egg laid by the stem-mother has twelve chromosomes. One polar body is extruded. Twelve chromosomes remain in all of the eggs and are found in the somatic cells of the winged generation.

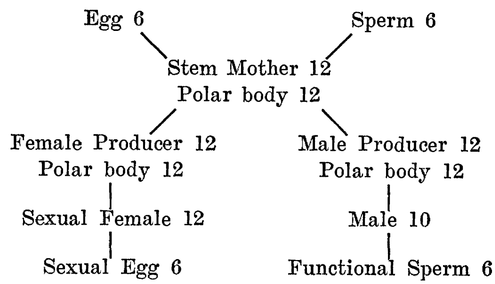
The polar spindle of the female egg laid by a winged individual contains twelve chromosomes. One polar body is extruded, and twelve chromosomes remain in the egg to give this number to the somatic cells of the sexual female.

The polar spindle of the smaller male egg also contains twelve chromosomes. One polar body is given off. Ten chromosomes remain in the egg, and this number characterizes all of the body cells of the male, as well as the spermatogonial cells. Evidently two chromosomes have disappeared when the polar body is produced.

In the first spermatocytes six chromosomes appear. At the first division four of these divide equally, but two do not divide; they are the accessories or sex chromosomes and pass to one cell. This cell becomes the functional sperm; the other, containing four chromosomes, degenerates. At the second spermatocyte division all six chromosomes in the functional spermatocyte divide equally, so that each of the two spermatozoa gets six chromosomes.[1]

The sexual egg contains a polar spindle of six chromosomes. Presumably two polar bodies are formed and six chromosomes remain in the pronucleus.

With these facts we can reconstruct the life cycle of the chromosomes.



Before commenting on these results I wish to call attention to another species, *Phylloxera caryæcaulis*.

In this species there are six chromosomes in the polar spindle of the egg laid by the stem-mother. One polar body is extruded. The somatic cells of the embryos contain six chromosomes.

The polar spindle of the female egg contains six chromosomes. Six are given off in the single polar body, and six remain in the egg.

The polar spindle of the male egg also contains six chromosomes, *but they are of different sizes from those in the female egg.*

[1] In the aphids also two kinds of spermatozoa are formed. The accessory—single in this case—passes into only one of the spermatocytes. This fact I determined in the winter of 1907–8 and von Baehr and Stevens have also reached the same conclusion (1908).

Six (or more) are given off in the single polar body, but only five are found in many of the male eggs—others contain six (five large and one small). I shall clear up this difficulty later.

In the spermatocytes three chromosomes often appear—at other times four. There are found one or two accessory chromosomes. One cell gets three—or four—the other always two. The former produces the functional sperm; the latter degenerates.

In the second spermatocyte all the chromosomes divide equally in the functional cell. The rudimentary cells do not divide, and later degenerate.

The occurrence of two kinds of males with five or six chromosomes and of two kinds of spermatocytes has given endless trouble and has delayed publication for nearly a year. The facts seem to be these. Eight, not six, is the full number for this species. Two of these chromosomes, one large and one small, often unite. In fact these two are the two accessories and practically always unite to produce a single accessory separating in some individuals as they move into the functional cell. The sexual egg contains four chromosomes. We can construct the chromosomal history as follows:

Egg 4 (3) Sperm 4 (3)
Stem Mother 8 (6)
Polar body 8 (6)
Female Producer 8 (6) Male Producer 8 (6)
Polar body 8 (6) Polar body 8 (6)
Female 8 (6) Male 6 (5)
Sexual Egg 4 Functional Sperm 4 (3)

The most important fact brought out by these results is that in the male egg a redistribution of the eight chromosomes occurs, so that the two small ones pair, and their mates, the two large ones, also pair. This union is evidently preparatory to the extrusion from the male egg of two entire chromosomes which reduces the number in the male by two.

We catch a glimpse here of a mechanism preceding the differential division of the chromosomes that determines the production of males.

This discovery suggests many further questions. I shall call attention to but one—the most important.

In both species we see that male eggs and female eggs are determined as such before there is any loss of chromosomes. The total number of chromosomes is present, yet one egg is large and the other small. The preliminaries of sex-determination for both sexes go on in the presence of all the chromosomes. The male itself is *produced* only *after* the elimination of two of the sex chromosomes, but the sexual female and the parthenogenetic female are both produced in the presence of all of the chromosomes. Clearly, I think, the results show that changes of profound importance may take place without change in the number of chromosomes. Equally clearly emerges the fact that the male develops after the loss of two chromosomes. This latter result shows that in the male parthenogenetic egg sex is connected with the same process found in the sperm of other species of insects.

In conclusion I wish to call attention to the sex ratios in the two species referred to.

Phylloxera fallax produces its sexual forms within the galls. The males and females crawl out of the galls, that open to allow their exit, pair, and deposit the eggs on the stems. A count showed that to 1,067 female eggs there were 1,049 male eggs in the galls—nearly an equality in number of the sexes.

Phylloxera caryæcaulis, on the other hand, produces winged forms that leave the gall and fly out in the air. Those that alight on the leaves of the hickory deposit their eggs on the under sides of the leaves. In this species a count of eggs *on the leaves* gave 1,316 male eggs and 296 female eggs, *i. e.,* nearly 4.4 to 1. More important are the counts of male and female *producers* within each gall. A large number of such counts have been made, of which the following give a fair idea: These results show a large preponderance of male producers; they also show that in some cases only male producers appear and in one

Male Producers	Female Producers	Male Producers	Female Producers
120	1	229	0
23	8	390	14
331	105	185	0
32	1	127	0
106	2	219	29
152	177	209	9
291	0	0	328
240	0	3	386
323	3		

case only female producers. When it is recalled that all the descendants can be traced to a single egg fertilized by a "female-producing" sperm the results are significant. It is obvious that while the sex of the fertilized egg is connected with the "female-producing" sperm, the subsequent progeny may be either males or females or a mixture of both. Either external conditions determine the result (for which there is no evidence), or else there is a strong "prepotency" of the egg or sperm in one or the other direction.

When it is recalled that the division into male layers and female layers takes place one generation prior to the formation of the sexes, it will be manifest that the conditions that determine the proportion of males and females, *i. e.*, sex-determining factors, are to be sought in a mechanism that lies behind the one that excludes two chromosomes from the male egg.

Equally important is the fact that in the latter process of elimination the result is not haphazard, for the eliminated chromosomes always pass into the polar body of the male egg. Since we can identify this egg before the elimination, we know that we are dealing here also with an ordered series of events, and not with an accidental shifting of chromosomes into one or another cell.

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MOMENTUM EFFECTS IN ELECTRIC DISCHARGE

IN SCIENCE of July 17 and December 4, the writer has given some account of experiments which seem to indicate momentum effects, in electrical discharges around a right angle in a wire. One interesting feature of the work was the formation of shadow pictures of thin glass slides upon which lines had been scratched. At the Baltimore meeting of the American Association for the Advancement of Science, a series of these pictures was shown, some of which were of special interest.

A sheet of hard rubber one sixteenth of an inch in thickness was pierced with a large number of holes of various diameters. This sheet was laid upon the photographic film within a hard rubber holder. The wire angle from which the fogging effects came was just above the cover, and about 5 mm. from the film. The holder rested upon a sheet of glass, 2 or 3 cm below, which was a grounded metal plate. The film was more strongly fogged at the bases of the larger holes than at those of the smaller ones. The electrons were apparently deflected to the sides of the smaller holes to such an extent that few of them reached the film at the bottom. Holes directly below the wire gave images with sharp outline. Those to one side gave images having on the sides remote from the wire diverging lines indicating the repulsion of the accumulating electrons on the film by the wire above, and their repulsion for each other. The comparison of such shadow images with those made by light shining through the same holes showed differences of a very marked character.

Another interesting shadow picture made just before leaving home, was produced by replacing the pierced rubber plate by small fibers of glass, laid on the film at right angles to the wire above. These fibers were about half a millimeter in diameter. Some of them were hollow tubes and some were solid. The tubes gave shadows of uniform density. The solid fibers showed conclusive evidence of refraction. In every case the shadow image shows a sharp black line along its center, where the fiber made contact with the film.

Wood, of Johns Hopkins University, suggested that this might indicate the presence of high frequency ether waves, and suggested the use of red or yellow glass, with the other glass fibers.