grained quartz sands, cemented by calcium carbonate. So far as observed they do not vary appreciably in width through vertical range. Two joint systems, one nearly horizontal, the other vertical, have cut these dikes in such a manner as to suggest masonry walls, *i. e.,* they are composed of oblong blocks in horizontal layers.

Certain facts may be noted, however, which preclude this view. In a photograph at hand exposing a portion of the dike near Rockwall, it may be seen that many of the vertical joints occur above each other, *i. e.,* they are not broken, which condition would not exist in a wall constructed by hand. It may also be noted that the curve to the upper surface of one block exactly fits the curve on the under surface of the next block above, which leads to the same conclusion. The weathered sands between the joints, stained with iron oxide, have been mistaken for mortar.

To define accurately the steps which have taken place in the forming of these dikes is not as easy as to recognize the nature of the phenomenon. They may have originated in several ways. The sands may have come from above or from below. The cracks may be due to drying or to earth movements. The writer was not able to decide the direction from which the sands entered. Inasmuch as circulating waters have passed for long periods through the sands, dissolving and redissolving the cement between the grains, the original position of the latter can not be postulated. At present they show no signs of bedding. On breaking blocks, what might be called a stalagtitic fracture is obtained, *i. e.,* cylindrical or tubular forms arranged in vertical position. As has been pointed out, this may well be secondary structure induced by circulating water.

The limey muds were probably deposited in very clear quiet waters. A slight elevation of the sea or an increased supply of material from the land may have altered deposition and spread fine sands upon the muds. Cracks formed by earthquakes may have permitted unconsolidated sand to enter as a filling. Again, the muds may have undergone a drying-out process since their elevation above the sea, cracks may have formed from this cause, and overlying sandy layers aided by percolating waters served to supply material wherewith to fill them.

The joints may be ascribed to forces arising from slight warping of the earth's surface, acting on hard vertical masses imbedded in relatively plastic strata.

It is fair to say in conclusion that the believers in the theory which ascribes the origin of these dikes to prehistoric men are in the minority in the locality itself.

SIDNEY PAIGE

APOGAMY IN ŒNOTHERA

THERE seemed at one time a possibility that the phenomena of mutation in *Œnothera Lamarckiana* might be associated with a condition of apogamy in that species. A survey of the hereditary behavior, however, and particularly of the results of certain crosses between the mutants and *O. Lamarckiana,* and also among the different mutants themselves, soon made it apparent that such a condition could not be of high frequency at any rate, in the parent form or in such mutants as *O. rubrinervis* and *O. nanella.* The results of crosses between *O. Lamarckiana* or certain of its mutants, and such wild species as *O. biennis,* also could only be explained by assuming that fertilization had taken place uniformly in the ordinary way, and often the resulting hybrids show the predominating influence of the pollen parent.

But while it seems highly improbable that apogamy in *O. Lamarckiana* is concerned in the origin of the mutants, yet, as I shall proceed to show, there is some very good evidence that one at least of these mutants is itself apogamous, though only in a small percentage of cases.

Œnothera lata is well known to be sterile in its anthers, so that self-fertilization has never been effected. MacDougal[1] has reported that the form closely resembling *O. lata,* from near Liverpool, England, can be self-fertilized, and

[1] "Mutations, Variations and Relationships of the Œnotheras," Carnegie Inst., Pub. 81, p. 15, 1907.

I have accomplished the same result in several cases in subsequent cultures of these forms. But I find from this summer's cultures that this type differs constantly from the *O. lata* of de Vries, as the latter appears in cultures or as a mutant from *O. Lamarckiana*. In bud characters it resembles *O. semilata*, but the leaf characters are closer to those of *lata* than to *semilata*. Hence while agreeing with the *lata* mutant in most of its characters, it differs constantly from the *lata* which is a derivative of the Amsterdam cultures, in its ability to produce a considerable amount of viable pollen, as well as in the (probably correlated) shape of its buds.

The frequent association in various genera, of apogamous conditions with the failure to produce pollen, led me to consider the possibility that *O. lata* might show a similar condition. This surmise has since been strengthened by certain facts recorded by Miss Lutz.[2] She found certain *O. lata* plants having the *lata* number of chromosomes, in the first generation of hybrids from *O. lata* × *O. gigas*. I have referred to this in a recent publication[3] and suggested that the most probable explanation is that they originated apogamously. The facts are these. In a total of about forty plants from the F_1 of *O. lata* × *O. gigas* Miss Lutz found (I.) two plants which were identical with *O. lata* in every respect and had fifteen chromosomes; (II.) six plants which were very similar to *O. gigas*, having about thirty chromosomes so far as counts were made; and (III.) thirty-two plants which, though not clearly characterized in the description, seem to have been in part intermediate between *O. lata* and *O. gigas*, and in part intermediate between *O. Lamarckiana* and *O. gigas*. A portion of these latter plants are stated to have twenty-two somatic chromosomes, "others twenty-three and some possibly twenty-one chromosomes." Whether these hybrids all had the same individual *O. lata* plant as mother is not stated, but if this was the case and the mother had fifteen chromosomes, then we might expect the two *lata* plants in the offspring both to have fifteen chromosomes, and the hybrids of class III. to have twenty-one or twenty-two chromosomes (14 + 7 or 14 + 8), while in the case of the *O. gigas*-like plants which are stated to have had thirty chromosomes in the individuals in which a count was made, the expectation would perhaps be twenty-nine (15 + 14).

How the *O. gigas*-like individuals having about thirty chromosomes originated must, however, be a matter of conjecture at the present time.

Miss Lutz calls the *O. lata* plants in this cross "extracted latas," which would indicate their hybrid origin. But in view of the fact that they have the *lata* number of chromosomes (14 or 15) and in view also of the subsequent data which I am about to state, it seems highly probable that they originated apogamously from the *O. lata* parent.

De Vries[4] made the cross *O. lata* × *O. gigas* in 1905 and grew one hundred and thirty-three of the offspring in 1907 and a smaller number in 1908. Of the former number sixty-eight were found to be intermediate between *O. lata* and *O. gigas*, and sixty-five intermediate between *O. Lamarckiana* and *O. gigas*, and the 1908 culture repeated the same two types, also in about equal proportions. From this it appears that there were no pure *O. lata* individuals and hence could have been no apogamy in these cultures at Amsterdam.

The peculiarities of *O. lata* are such that there need be no difficulty in distinguishing it from *O. Lamarckiana* or *O. gigas* or even from forms intermediate between *O. lata* and *O. gigas*. The further fact that Miss Lutz found the two *lata* individuals in her cross to have fifteen chromosomes, supports the belief in their apogamous origin.

In my experiments this summer, to determine more definitely the occurrence of apogamy in *O. lata*, I removed the anthers (which

[2] "Notes on the First Generation Hybrid of *Œnothera lata* × *O. gigas*," Science, 29: 263–267, 1909.

[3] "The Behavior of the Chromosomes in *Œnothera lata* × *O. gigas*," *Bot. Gaz.*, 48: 179–199, pls. 12–14, 1909. This paper deals with the chromosome behavior in the germ cells of hybrids having 20 and 21 chromosomes.

[4] "Bastarde von *Œnothera gigas*," *Ber. Deutsch. Bot. Gesells.*, 26*a*: 754–762, 1908.

were always dry and empty) from several flowers of an individual of *O. lata,* at the same time removing the stigma and style by pulling the latter out at the base as an extra precaution, afterwards covering the flower with a bag and marking the capsule according to the method I ordinarily use in making guarded crosses. All of the flowers so treated but one gave negative results, but this one produced three fair-sized seeds.

Ordinarily, if, for some reason, a flower fails to be pollinated, the ovules remain very small and gradually dry up and wither, so that after a few weeks such an ovary has not grown in size and if broken open shows numerous small, dried granules which are the remnants of the deteriorated ovules, many of them still attached in their original position. These three seeds, while slightly below the average in size, yet were hundreds of times larger than the small remnants of such unfertilized ovules, and indeed there were many of the latter in the capsule in question, in addition to the three seeds.

In every case where pollination was thus prevented, the ovary remained very small and gradually dried up and shrank to a small diameter, and the one containing the seeds was but little larger than the rest. Several of these small dry ovaries fell off and hence were never examined for seeds. The number of seeds, if there were any present, could not have been large in any of them.

I also treated, in a similar manner, a number of flowers from several individuals of the English *O. lata,* which produces some pollen; but without exception the results were negative.

In this connection will be recalled the discovery of Ostenfeld[5] and Rosenberg[6] that certain species of *Hieracium* are partly apogamous or aposporous, and partly require fertilization. But in this genus of Composites, where each flower of a head develops a single seed which is independent of all the other seeds of a head, the conditions of nutrition are much more favorable to partial apogamy when pollen is excluded from the head, than is the case in an *Œnothera* capsule where the ovules are closely crowded together into four chambers and the deterioration of the great majority of them in the absence of fertilization is likely to carry down the others in the common ruin and also to lead to the cutting off of the common food supply.

So far as I am aware, the only other indication of the development of embryos in *Œnothera* without previous fertilization is in *O. gigas.* Schouten[7] reports obtaining one *O. lævifolia* individual in a large culture of *O. gigas.* Now I have found that *O. lævifolia* has fourteen chromosomes, while *O. gigas* is known to have twenty-eight.[8] Such an individual of *O. lævifolia* might have arisen from *O. gigas* through a process of parthenogenesis in the restricted sense of Strasburger,[9] an egg with the reduced number of chromosomes producing the embryo without fertilization. At present no case of this sort is known in the plant kingdom, although in echinoderms and various other animals the artificial production of larvæ from unfertilized eggs is a well-known fact and, in some of these cases at least, the number of chromosomes is the reduced number. Whether the origin of this *O. lævifolia* individual was of a similar sort must remain for the present undecided. The fact that in such plant genera as *Alchemilla* and *Hieracium* the apogamous members of the genus frequently have about twice as many chromosomes as the normally fertilized members would make the occurrence of similar conditions in *O. gigas* a thing which might reasonably be anticipated.

This indication of apogamy in *O. lata* of

[5] "Castration and Hybridization Experiments with some Species of *Hieracia*," *Bot. Tidsskrift,* 27: 225–248, 1906.

[6] "Cytological Studies on the Apogamy in *Hieracium*," *Bot. Tidsskrift,* 28: 143–170, 1907.

[7] "Mutabiliteit en variabiliteit," p. 93, dissertation, Groningen, 1908.

[8] In all these forms there are probably occasional departures of one or more chromosomes from the usual number, owing to the occasional irregularities in chromosome distribution which I have shown (*Bot. Gaz.,* 46: 1–34) to occur in the formation of the germ cells.

[9] "Apogamie bei Marsilia," *Flora,* 97: 163, 1907.

course requires to be substantiated by a more detailed study and I am making a cytological investigation of the embryo sac development and fertilization in *O. lata* with the hope of obtaining more conclusive evidence of the presence of some form of apogamy in this mutant.

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Missouri Botanical Garden,
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Membrane Formation and Pigment Migration in Sea Urchin Eggs as Bearing on the Problem of Artificial Parthenogenesis

In a recent number of Science McClendon[1] has summarized his work on artificial parthenogenesis in *Arbacia* and discussed it with reference to changes in permeability of the surface layer of the egg. With the same point in view, during June and July at Tortugas and the latter part of August, 1909, at Woods Hole, I have been studying the earliest changes taking place in developing sea urchin eggs, especially the formation of the fertilization membrane.

Ever since the paper of Delage appeared, on electric parthenogenesis, I have been impressed with the great similarity in the means of stimulating eggs to develop and the means of stimulating muscles and sensitive plants. Morgan expressed the situation clearly when he compared the means of causing development to a stimulus. A considerable mass of evidence now exists, especially emphasized in recent papers of Ralph Lillie, that stimulation of muscles is effected by a momentary increase in permeability of the muscle membrane to CO_2, allowing its more ready escape during contraction. CO_2 is the chief end product of the energy-yielding reaction on which contraction depends and its removal from the cells allows the reaction to proceed (during contraction) to a new equilibrium (of rest), when checked by a second accumulation of CO_2. The increase of permeability on stimulation removes the condition which is preventing the contraction. The movements of sensitive plants can best be explained as due to an increase in permeability of the cell membranes relative to the turgor-maintaining substances. The important point is that processes in general brought about by stimulation are connected with changes in permeability. This holds good for secretion, and the fact that the first visible change in many eggs is a secretion is certainly significant.

Several authors have recorded instances of development without membranes, perhaps the best known case being parthenogenesis by hypertonic sea water. I have repeated this experiment and find that there is without doubt a surface change in the egg, visible on slightly high focus, which I take to be a membrane very close to the egg surface. Similar membranes are produced in *Hippanoë* eggs by treatment with CH_3COOH. They are hardly noticeable even with the high power. Very close fitting membranes and membranes which surround each blastomere when the egg divides may be produced in other ways. It seems as if development without membranes was rather a case of development without pushing out of the membrane.

This pushing out appears to be due to the formation of some substance exerting an osmotic pressure between it and the cell surface, which absorbs the surrounding sea-water. It would be impossible for the fluid between fertilization membrane and egg to have come from the egg without a greater diminution in volume than is observed in eggs immediately after fertilization. Loeb[2] has discussed the above view and designated a proteid or lipoid as the substance in question. A very small concentration of some substance formed just behind the fertilization membrane would account for its pushing out, provided the membrane were impermeable to the substance and freely permeable to the salts of sea-water. For the latter there is ample evidence.

The membrane itself is a secretion comparable to the cellulose layers formed on plant cells after division. It is composed of some substance of a highly resistant nature

[1] N. S., XXX., p. 454, October 1, 1909.

[2] *Arch. Entw. Mech.*, XXVI., 1908, p. 82.