small to account for the great changes which occur in living tissue.

It might be supposed that the reason that no change in resistance occurs in dead tissue is because the hardening and softening do not proceed as far as in living plants, but this is not the case. Moreover, it is found that the increase of viscosity in NaCl is accompanied by absorption of water, while the decrease of viscosity in. $CaCl_2$ is accompanied by loss of water, and these processes take place in the same way in living and dead tissue.

It would seem that these and other important objections must be removed before we can accept the idea that changes in permeability are determined by changes in viscosity.[4]

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POLLEN STERILITY IN RELATION TO CROSSING

IN view of the recent revival of the old idea that pollen sterility is a universal and safe criterion of hybridity in plants[1] we found it of interest recently to examine the pollen of some California plants with this idea in mind.

The first species examined, *Trillium sessile* var. *giganteum,* perhaps better regarded as *T. giganteum,* a separate species from the *T. sessile* of the eastern states, is found in quantity in Strawberry Canyon, Berkeley, where it is now in full bloom. It is already known that this species shows a remarkable degree of variability, especially in the color and width of the petals. In color the petals vary from dark purple through pinks to nearly white, and also through yellows to nearly pure green. One of us is making a detailed study of these variations. The former color series, combined with the width series, is found on one hillside in Strawberry Canyon, the greenish and yellowish series occurring across the bay in Marin County. No other Trillium occurs in this canyon, but a variety of *T. ovatum* occurs along with *T. giganteum* in various parts of Marin County. The two forms are not closely related, however, and it is extremely doubtful if they ever cross. In Strawberry Canyon at any rate there is no possibility of *T. giganteum* crossing with any other species, yet some plants collected here show a considerable amount of sterile pollen.

In all the pollen examinations the grains were only considered "bad" when they were obviously shrivelled or greatly undersized, so that the amount of non-viable pollen would doubtless be considerably larger than the percentage recorded here as bad. The highest amount of bad pollen recorded from any normal plant of *T. giganteum* from Strawberry Canyon was 18.2 per cent., and the lowest 3.2 per cent. In another plant having certain abnormalities of the flower the percentage was as low as 1.5 per cent. In five plants from Camp Taylor, Marin County, where the species grows in company with *T. ovatum,* the percentages of bad pollen were respectively 7.3, 5.6, 3.9, 3.2, 2.3. Thus the amount of defective pollen is not high in any of the plants examined, with one exception, though the pollen grains are never all perfect.

The form of *T. ovatum* occurring in Marin County is remarkably uniform, in contrast with the variable *T. giganteum.* The pollen from seven plants of *T. ovatum* was examined, and they were found to have respectively 7.3, 7, 5.3, 4.5, 4.2, 3.9 and 3.9 per cent. bad pollen grains. Thus a species which is very invariable in this locality and which we can be quite certain does not cross with *T. giganteum,* nevertheless produces regularly a certain percentage of shrivelled and misshapen grains.

Still more conclusive evidence regarding the occurrence of considerable quantities of bad pollen in the absence of crossing was furnished by *Scoliopus.* This remarkably isolated genus of the Liliaceæ contains only two species, *S. Bigelovii,* which is confined to California from Santa Cruz to Humboldt County, and *S. Hallii,* which occurs in western Oregon. In plants of *S. Bigelovii* collected in Marin

[4] It would appear that the term viscosity is loosely applied to a variety of phenomena which may be produced in different ways.

[1] Jeffrey, E. C., 1915, "Some Fundamental Morphological Objections to the Mutation Theory of DeVries," *Amer. Nat.,* 49: 5–21, Figs. 7.

County, where all possibility of crossing is excluded, there was found a most unexpected amount of shrivelled pollen grains. One flower was examined from each plant. The flowers have three anthers and in some cases anthers from the same flower yielded different percentages of bad grains. Yet the anthers, and the plants as a whole, were all entirely normal in appearance. The amounts of bad pollen are shown in the following table:

Pollen of Scoliopus Bigelovii

Plant	Bad Grains Per Cent.	Individual Anthers Per Cent.
No. 1.....	31.9	45.4
		25.8
		33.2
No. 2.....	20.6	—
No. 3.....	18.5	6.4
		25.6
		6.5
No. 4.....	10	10.7
		9.04
No. 5.....	9.9	11.1
		7.8
		10.4
No. 6.....	3.75	—
No. 7.....	3.25	—

Thus, in the absence of crossing, these plants in their normal habitat produce from 3 per cent. to 32 per cent. of bad pollen, and in individual anthers the observed amount exceeded 45 per cent. This in itself is a sufficient refutation of the hypothesis that bad pollen is necessarily a sign of hybridity. It would be difficult to find a plant which is more suitable for disproving this hypothesis than *Scoliopus Bigelovii*. It furnishes all the conditions that the most captious critic could desire, including relative uniformity and the absence of a related species with which it might cross. Yet, with two exceptions, it shows a higher percentage of bad grains than any other plant examined.

Dirca occidentalis furnishes an even more convincing proof that bad pollen may occur in quantity in plants that are not hybrids. This shrub belongs to an isolated genus of the Thymeleaceæ, the only other species being found in the eastern states. Pollen examined from three separate flowers on the same branch yielded respectively 8.7 per cent., 20.8 per cent. and 46.6 per cent. of bad grains. Many of the pollen grains are also conspicuously undersized, so that the amount of nonviable pollen in this plant apparently often far exceeds 50 per cent.

The pollen of two other species taken at random has also been examined, with the following results.

Ranunculus Californicus showed in one case 21.7 per cent. bad pollen and in another case 4.4 per cent. The pollen of *Fritillaria lanceolata* var. *floribunda* appears to contain regularly more than 50 per cent. of bad grains. These are both variable species, and in this case the possibility of crossing is not excluded. They are included here so as to avoid the publication of selected results.

It is certain, then, that bad pollen, even when it occurs in large amount, is not necessarily an indication of hybridization. Pollen sterility is rather a physiological condition which occurs in all degrees of intensity and may be due to a variety of causes. Hybridization is of course one of these, but only one.

Multiple causes apply in the same way to the conditions of sterility in animals. The mule is sterile because it is a hybrid whose parents are not only very dissimilar but have different chromosome numbers.[2] On the other hand, the various species of the genus *Bos* apparently intercross freely without any sign of sterility.[3] To cite one other case of sterility of an entirely different character, Morgan[4] showed that in certain generations of Phylloxerans in spermatogenesis, half the sperma-

[2] Wodsedalek, J. E., 1916, "Causes of Sterility in the Mule," *Biol. Bull.*, 30: 1–57, Pls. 9.

[3] Similarly, Dorsey ("Pollen Development in the Grape with Special Reference to Sterility," Univ. of Minnesota Agric. Expt. Sta., Bull. 144, 1914) concludes that in grapes hybridity is not necessarily a cause of sterility, since both sterile and fertile hybrids occur among cultivated varieties.

[4] Morgan, T. H., 1909, "A Biological and Cytological Study of Sex Determination in Phylloxerans and Aphids," *Jour. Expt. Zool.*, 7: 239–352, Pl. 1, Figs. 23.

tids (those lacking the accessory chromosome) regularly degenerate. This obviously has no connection with crossing, but is concerned with sex.

If we were to classify the causes of pollen sterility we might at least mention the following: (1) Crossing of sufficiently distinct species, (2) a condition of variability or mutability in the species, (3) the substitution of vegetative for sexual reproduction, (4) unknown physiological causes.

So far from it being improbable that mutability in a species should be accompanied by a certain amount of pollen sterility, we should be at a loss to account for the reverse condition, namely, a highly mutable species which had perfectly good pollen. For it is clear that in a mutating species various types of aberrant pollen grains must be produced, some of which may be unable to mature, and these will form shrivelled grains. This view is borne out by direct observations of pollen development in the Œnotheras. Moreover, some such gametes will form zygotes which are unable to develop, as has again been shown by direct observation in Œnothera. It follows almost from necessity that if the gametes of a mutable species are varying in many ways some of them will vary so as to produce pollen grains which are non-viable.

The view that a great increase in the vegetative methods of reproduction in a species may lead to or be accompanied by partial sterility of the pollen, is often expressed and apparently with reason. How narrowly such a relationship holds, however, could only be determined by statistical comparison. In the case of *Trillium, T. giganteum* apparently reproduces largely from rootstocks and *T. ovatum* chiefly from seeds.

From these preliminary observations it is clear at any rate that geographically isolated species do not invariably have good pollen, and that pollen sterility is by no means a sure sign of hybridity.

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March 16, 1916

ANTHROPOLOGY AT THE WASHINGTON MEETING

III

Indian Ruins of the Republic of Guatemala: FERNANDO CRUZ.

The ruins scattered throughout the territory of Guatemala are of two characteristic types: (1) Those properly classed as prehistoric, consisting of cities which were inhabited by races who occupied the territory centuries before the Spanish conquest and left notable vestiges of their civilization. (2) Those of a later period which were the fortifications used by the natives in their resistance to the Spaniards.

Those of the first class have been studied with care, at least the greater part of them; those of the second class have been viewed up to the present time with but little interest by archeologists. The ruins of this second class are simpler and do not reveal in their construction the same high grade of architectural beauty as those of the first class.

The author mentions the principal Indian ruins of Guatemala which have been studied, as well as those that have not yet been studied. He also gives a general idea of the arrangement of the cities, some of which he briefly describes.

With regard to the ruins of the cities contemporary with the Spanish conquest, the author notes that they reveal certain artistic decadence, and that in none of them is there to be found anything like the monoliths and sculptures of the former inhabitants. These ruins are of cities of a military character, fortifications intended for the resistance of the enemies in their domestic wars. The author indicates some of these ruins, and describes the condition in which they are to be found.

Native Languages of Guatemala: ADRIAN RECINOS.

After a few preliminary considerations with regard to the problems which demand the attention of the scientific men occupied in the study of the pre-Columbian epoch, the author proceeds to a study of the native languages of the races that have inhabited the Central American territory. He gives an outline of the Maya race and the grade of civilization which it attained.

The author does not believe that the native Central American languages can be described as dialects of the Maya. In his opinion they are perfect languages, with a construction, and some of them with a literature of their own.

Studying the different native races which inhabit Guatemala at the present time, and analyzing