

SCIENCE

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A STUDY ON PLANT FECUNDATION.

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THE phenomena of fecundation in obscure plants are in themselves probably uninteresting to the general reader. In so far, however, as they bear on the problem of heredity, which has been popularized by the works of Weismann and others, they become of interest to a wide circle of readers and thinkers. This extended interest makes it desirable that the results of important studies should be brought to general notice.

In the study of fecundation in plants, the most important works which have appeared for several years are the studies of Guignard¹ and Treub.² These have been summarized in the *Botanical Gazette* and *American Naturalist*.

Shortly after the publication of Guignard's studies there appeared a study by Klebahn³ on the "Fructification of *Cedogonium Boscii*," an alga of which numerous relatives occur in our American ponds. The article is in no sense revolutionary, yet contains much of interest and value.

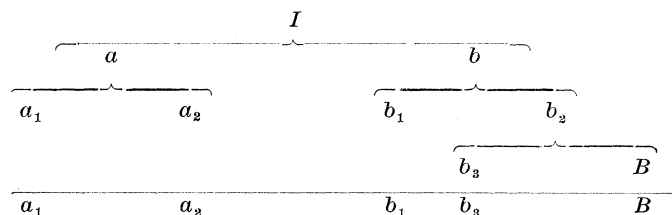
A discussion of the occurrence of polar bodies in plants occupies a large part of the paper. This was true also of Guignard's paper mentioned above. Zoölogists found polar bodies to be a very general, if not universal, accompaniment of the animal egg, anywhere in the region of the egg-cell, for which no other use could be positively affirmed, has been diligently pointed out as probably having the function of polar bodies. To clear up this probable rubbish must now occupy a great share of the attention of botanists writing on related subjects.

Klebahn's study was completed before the publication of Guignard's article demonstrating the presence of attractive spheres (asters) in plants, hence this interesting feature in fecundation is not mentioned.

In the male filament the nucleus lies in the upper end of the cell, the cap end, where the ring and the disunion in the membrane form. In mitosis the upper cell, forming the antheridium, receives only a small amount of protoplasm with the nucleus. After this mitosis the lower nucleus returns to the resting stage, still remaining in its old position, and shortly passes to a new mitosis. This rôle is continued till the number (four or five) of antheridium cells are formed. The sterile remainder of the mother cell, after the last mitosis, remains as the lower cell of the series. The protoplast of each antheridium cell divides into two portions, which become the antherozoids. The nuclei of the antherozoids are smaller than those of the vegetative or female cells and have no apparent nucleolus.

In the formation of the oogone a cell of the female filament divides into two daughter cells, an under (*a*) and an upper (*b*). These two daughter cells divide again, producing four cells (*a*₁, *a*₂, *b*₁, *b*₂). The upper one of these (*b*₂) is the oogonium mother cell. This divides again, and the upper daughter cell of this division is the oogonium (*B*), and the lower the supporting cell

(Stützzelle or Trägerin — *b*₃). To make this more intelligible, the author's diagram is inserted here:—



In most cases four sterile cells accompany each oogone, but occasionally the cell (*a*₂) becomes also an oogonium mother cell, the division of which forms an oogonium, *A*, and its supporting cell (*a*₃). In this case only two sterile cells accompany each oogone.

The nucleus of the oogonium (*B*) and of the oogonium mother cell (*b*₂) are of about the same size and constitution as the nuclei of the vegetative cells. The difference between the nuclei of the oogonium and of the sterile accompanying cells, (*b*₁) and (*b*₃), is of especial interest. In the latter the nuclei are much smaller and the nucleolus is always absent. The author especially endeavored to count the number of chromatin bands passing to each nucleus, hoping to obtain some light on Weismann's theoretic-reducing division supposed to occur in the formation of the polar bodies. Unfortunately it was found impossible to be sure of the number.

After the oogone has taken its definite form, an opening forms in the upper part for the entrance of the antherozoids. The opening, however, remains closed by an especially developed membrane until the protoplasm of the oogonium draws together into the mature egg-cell ready for fecundation. The nucleus of the oogone meanwhile lies in the upper part of the egg-cell near the point of activity, without, however, dividing or in any evident way giving off substance. The closing membrane now disappears, leaving the way open for the entrance of the antherozoids. Of the numerous cases examined, in no place was anything observed indicating a separation or throwing off of any part of the protoplasm or nucleus. On the contrary, the closing membrane is still present when the protoplast of the oogonium draws together. Nothing in the opening process of the oogonium of this species can be analogized to the formation of polar bodies, and in no stage in the course of fecundation and maturation of the oogone is there anything similar developed.

The antherozoids, passing through the opening in the wall of the oogonium, approach the egg, one fusing with it. Before fusing with the egg-nucleus the male nucleus enlarges from about four to six μ . No other change in structure is noticeable. After the fusion of the nuclei has taken place, the fecundated nucleus is still easy to recognize; the coarser chromatin elements of the male nucleus still forming a well differentiated group. Very soon, however, these marks disappear, the male chromatin becoming distributed till it is wholly unrecognizable. The nucleus of the egg is finally only slightly more strongly granular than the unfecundated. Many antherozoids enter the oogone cavity, but only one enters the egg. Eleven were counted in one case in an oogonium cavity.

The author reviews at considerable length the probable cases of polar bodies in plants, mentioned in literature. The conclusion reached is that at least they do not possess the importance and necessary rôle in plants that is assigned to them in the animal kingdom.

It may be possible that in *Cedogonium boscii* the two cells, *b*₁ and *b*₃, accompanying the oogonium are to be considered the equivalents of polar bodies. These, with the oogone (*B*), are de-

¹ Léon Guignard, "Nouvelles Etudes sur la Fécondation," Ann. des Sci. Naturelles Bot., xiv. (1891), pp. 163-288.

² M. Treub, "Sur les Casuarinées et leur place dans le Système Naturel," Ann. du Jardin Bot. de Buitenzorg, x., pp. 145-231.

³ H. Klebahn, "Studien über Zygoten. II., Die Befruchtung von *Cedogonium Boscii*," Pringsheims Jahrb. für wissenschaftliche Botanik., Bd. xxiv., pp. 225-267, 1 Taf.

rived from the divisions of the primary mother cell (*b*). They contain but a small quantity of cytoplasm, and are destined for no further development. After holding the oogonium in place for a time they become disintegrated. The similarity of the nuclei of these cells, in particular the supporting cell *b*₃, to the male nuclei is further very marked. One could easily believe that the nuclear mass which they separate from the egg nucleus becomes replaced by the sperm nucleus. Both cells, *b* and *b*₃, are, however, not present in all *Edogoniums*. The supporting cell (*b*₃) is the only one constantly present, and this is frequently richer in contents, and in one case gives rise to an oogonium.

In the formation of the Antheridia, there remains a sterile nucleus, the one below the chain of antheria cells, from which these were abstracted. Here also the similarity to polar bodies is manifest, but, as Strasburger has pointed out, it necessitates that a part of the male branch be compared to a polar body. The author concludes that a morphological conformity is not shown in either case. The process in *Edogonium* may be brought in harmony with the theories of fecundation dependent upon polar bodies, but nothing is thus gained.

The results of this portion of the study can be summarized as follows: Genuine polar-body formation is not present in *Edogonium*. On the other hand, the supposition is not impossible that the two accompanying cells (*b*₁ and *b*₃) are the physiological equivalents of polar bodies.

Of the minutia of nuclear fusion in fecundation much remains to be determined. The study lacks the fullness and roundness shown in the work of Guignard. Yet much is added to our knowledge, and our attention is turned to an interesting and promising group of plants for study.

CLIMATE AND THE VARIATION OF SLUGS.

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THE slugs, or naked land-mollusca,—nacktsnacken, they say in Germany,—are found in nearly every part of the world. Many of the species are extremely variable in color and markings, and these variations, as might be expected, usually have a smaller area of distribution than the species to which they belong. Furthermore, as I propose to show in the present article, climate seems to have a marked influence on the variation of these animals, so that the same kind of variety may appear, at two distant spots, under similar environment.

Facts of this kind have been taken, by those who believe in the inheritance of acquired characters, as valuable evidence in their favor. I do not think, however, that they are so valuable in this connection as some have supposed. To cite a well-known example, the white color of many mammals and birds in the Arctic regions is undoubtedly correlated with a cold climate, but it is so very easy to see where natural selection comes in, that scarcely anyone would adduce this instance as proof of the direct influence of climate. So it may be in more obscure cases, where environment seems to directly modify species, that we have not yet found out the way in which natural selection is acting.

In order to be perfectly clear, I will give some examples in as few words as possible, numbering them separately, so that they may be taken one by one, and considered on their merits. I will also attempt to classify them under different headings, according to the kind of environment.

(A) Influence of Altitude.

1. *Limax marginatus*, Müller. This species is widely distributed in Europe. Its ordinary color is gray, with more or less longitudinal banding. In 1882 Lessona and Pollonera described a nearly black variety from high altitudes in Italy, calling it var. *rupicola*. In 1886 the Rev. A. H. Delap sent me two individuals of this variety from the top of the Reeks, County Waterford, Ireland, 2,300 feet above sea-level. They were at the very summit, miles away from any trees. However, about 100 feet lower down an example of the normal form of the species was obtained.

In this instance it can hardly be doubted that these dark forms originated independently on the Italian and Irish mountains, similar environment producing a similar effect.

2. *Limax maximus*, L. The normal colors are gray with black spots and streaks. A blackish variety (v. *nubigenus*, Bourguignat) is found in the Pyrenees.

(B) Influence of Latitude.

3. *Parmacella valenciennii*, W. and Van B. Extends from south France to Morocco. In the northernmost part of its range it is reddish-brown, without markings. In the Spanish peninsula the mantle becomes spotted with black (var. *punctulata*, Ckll.), and at Gibraltar and Tangiers the slug is conspicuously marked with black (var. *maculata*, Ckll.). But, curiously, at both the last localities there appears a variety, well marked with black, but dark-olive instead of reddish (var. *olivacea*, Ckll.). It is noteworthy that the varieties on both sides of the Straits of Gibraltar are alike. The var. *olivacea* resembles in color *P. olivieri*, Cuvier, from the Caucasus, at least as represented by an example in the British Museum.

4. *Ariolimax columbianus*, Gould. A large slug found in the Pacific coast region of North America, as far north as British Columbia. In California there is a sub-species, *californicus*, Cooper, identical in color with *columbianus*. From British Columbia to California the slug has two forms, one with, the other without, black spots, the ground-color in each being reddish-brown. In British Columbia there is a variety (*niger*, Ckll.) which is entirely black. In Costa Rica the species reappears as a sub-species, *costaricensis*, Ckll.; dark olivaceous in color. Thus on different continents two slugs, *Parmacella* and *Ariolimax*, each normally rufous, develop an olivaceous variety at the southernmost point of their range.

(C) Influence of Moisture.

5. *Arion ater*, Linné. This is a large slug common in northern and central Europe. Typically black, it varies to reddish, yellowish, white, brown, and gray, presenting also some beautiful varieties resulting from combinations of these colors. In England one may find specimens of several different colors in the same locality; but Dr. Leach noticed, as early as 1820, that the whitish and pale yellowish forms were specially to be observed in chalky districts. In Scotland, dark varieties prevail. But on the continent, where the climate is drier, is a brick-red form (var. *lamarckii*, Kal.) not to be observed on the British Islands at all. This red variety is so common and conspicuous in various localities in central Europe as to attract the attention of tourists and others who are not usually given to observing slugs.

At Chislehurst, in England, I found intensely black specimens in damp places.

It is possible that the black variety of *Ariolimax* from British Columbia, noticed above, may have some connection with the moist climate of that country.

(D) Influence of Insular Conditions.

6. *Agriolimax agrestis*, Linné. The common gray garden-slug of Europe, often mottled with dark-gray or black. There is a black variety found in England (var. *niger*, Morel.), and also above the zone of cultivation in the Azores, but not in continental Europe. There is also a very dark variety (*panormitanus*, Less. and Poll.) found in Sicily, and, according to Dr. Simroth, also in Crete. These examples of insular melanism may have to do with the influence of moisture.

7. *Ariolimax columbianus*, Gould. Specimens found by Mr. Hemphill on Sta. Cruz Island, off California, were paler than the type, being uniform light-straw color (var. *straminea*, Hemph.).

8. *Amalia gagates*, Draparnaud. As its name indicates, this slug is typically black, but in England it is nearly always lead-gray (var. or subsp. *plumbea*, Moq.) or brownish, very rarely black. In Sicily there is a large black form (var. *similis*, Ckll.), closely related to the great black sub-species *mediterranea*, Ckll., of Algeria. Here, as with *Parmacella*, we see similar or identical varieties on opposite sides of the Mediterranean. In Madeira, there is a dark-brown variety (var. *maderensis*, Ckll.). In Bermuda, where the species has no doubt been introduced, it is of the typical form. In Ascension and St. Helena are closely-related forms allied to subsp. *plumbea*, and another allied variety (var. *tristensis*, Ckll.) is found both on Tristan d'Acunha and Juan Fernandez.

It is difficult to see how the species can have got to St. Helena,