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 *Œdogoniums.* 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 abstricted. Here alse 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 *Œdogonium* 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 *Œdogonium.* 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.

BY T. D. A. COCKERELL, LAS CRUCES, NEW MEXICO.

THE slugs, or naked land-mollusca,—nacktshnacken, 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 he 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, Tristan d'Acunha, and Juan Fernandez if it was not carried there by man; yet it already shows some divergence from the type, and the specimens from the two latter islands, though they are so far apart, are alike. This is not extraordinary if we assume that like climatic conditions produce like effects, since the two islands are both far out in the ocean, at about the same parallel.

The problem becomes complicated, however, when we find *Amalia gagates* reappearing on the Pacific coast of North America, apparently quite native, though separated by long distances from other localities for the species. This Pacific form generally goes under the name *hewstoni*, given by Dr. Cooper, but I have examined authentic examples, and am convinced it is only *gagates*. Nor is this all, for in Australia and New Zealand are species of *Amalia* so very near *gagates* that some recent students have merged them in it. I have examined *A. antipodarum*, Gray, *A. emarginata*, Hutton, and *A. fuliginosa*, Gould, from New Zealand. *A. emarginata* I consider certainly a form of *antipodarum*, but this and *fuliginosa* appear to me to be valid species. They very much resemble *gagates* in structure, it is true, but, if they are really the descendants of imported slugs, the amount of modification they have undergone is remarkable. *A. fuliginosa* is in the British Museum also from the "Polynesian Islands" — exact locality not stated. There is also an *Amalia* in the Sandwich Islands, evidently very near to *gagates*, but whether identical with it or an endemic form cannot be ascertained in the absence of specimens.

Thus it is seen that *Amalia gagates* and its allies present to us some curious problems, which can only be solved by the collection of specimens from many localities, and their very careful comparison. Because the slug was described from and abounds in Europe, it does not therefore appear certain that specimens found in distant localities, closely resembling *gagates*, are descended from imported examples. We have often good reason for believing that this is their origin, but there is none of the certainty that we feel in regard to other species now found at the antipodes. Quite a similar example is afforded by *Agriolimax loevis* and its allies, which seem certainly native in very widely-separated places. It seems that *A. gagates* and *A. loevis* are very ancient species, surviving in those places where the climate suits them.

A STUDY IN POLARIZATION. — PRELIMINARY NOTE.

BY JOHN DANIEL, VANDERBILT UNIVERSITY, NASHVILLE, TENN.

USING a voltameter with platinum electrodes, separated by a glass partition bored in the centre with a hole two centimetres in diameter, over which was sealed a smaller glass plate bored with a hole one and one-half centimetres in diameter, this smaller hole being covered by metal plates of various thicknesses sealed tight over it, a study has been made of the polarization phenomena upon these thin metal partitions in different electrolytes and under various conditions as to thickness of partition, current strength, temperature, etc.

Without now going into details of the apparatus, methods, and results, the following summarized statement may be interesting: —

1. The polarization on a gold-leaf partition in good-conducting H_2SO_4 is zero, or too small to detect with our apparatus, for the range of current used.

2. The "critical thickness" in good-conducting solutions of H_2SO_4, $CuSO_4$, and NaCl is *greater* than .00009 millimetres for gold; .00015 millimetres for platinum; and .0005 millimetres for aluminum, under the above conditions. It is *less* than .0004 millimetres for gold; .002 millimetres for platinum; and .002 millimetres for silver.

3. The "upper critical limit" of thickness under these conditions seems to be about .004 millimetres, rather less than No. 3 gold.

4. Tables I., II., and III. all point to the conclusion that between "critical limits" of thickness the polarization for a given current increases with the thickness.

5. Table II., showing relation of polarization to current, expresses two interesting facts: (*a*) that the polarization on "thick" plates is about the same, in this voltameter, for all currents between .2 ampere and, say, .01 ampere, provided time enough be allowed in each case for the current to become constant, i.e., between the upper limit of current, at which the development of gas is so profuse as by mechanical obstruction and irregular escape to interfere, and the lower limit, at which the formation of gas is no faster than it can be dissipated. (*b*) Quite different is the case for "thin" plates, where, within the limits of current and thickness prescribed, the polarization is dependent upon the current and gives for each thickness a different curve, or rather straight line, for they are all straight lines converging to the origin, and differing only in *slope*. The current strength at which the polarization on very thin plates would reach a maximum is far above that used, being, perhaps, expressed in amperes instead of tenths and hundredths.

By *thick* plates are defined those above the "upper critical limit;" by *thin* plates, those below this limit of thickness.

6. Inspection of Table III., which gives the time-change of the polarization, will show a similar distinction between "thick" plates and "thin" plates, as was noted in the last paragraph, viz., that for thick plates the change is considerable and continues slowly for hours; for thin plates, the change of polarization with time is both less pronounced and extends over much less time.

7. It was noted, especially in the case of $CuSO_4$ as electrolyte, that there was polarization on gold-leaf if the gold exposed came in contact with the solution some distance beyond the edge of the hole in the glass plate to which it was sealed; thus in $CuSO_4$, for the stronger currents used, there was a symmetrical deposit of Cu, decreasing in thickness from the outside toward the centre, and vanishing at a small distance from the edge of the hole, this distance being less the stronger the current. If only one corner was left exposed, the Cu was deposited there. This phenomenon was further tested by bending a thick strip of aluminum, 4 centimetres long, into the shape of a narrow U, and simply hanging this U in the *open* hole of the glass partition, in $CuSO_4$, and closing the circuit on the voltameter; the two ends of the metal strip being thus in contact with the $CuSO_4$ on opposite sides of the glass two centimetres from the edge of the opening, there was decided deposit of Cu on one end and escape of oxygen from the other end.

8. In $CuSO_4$, all the plates except those below the critical thickness were destroyed by oxidation. No. 1 silver was destroyed is less than one minute. Of course, gold and silver above the critical thickness could not be used in NaCl, because of chemical action, though the thinnest plates were quite unaffected. Only the No. 7 gold was tested in KOH, as it dissolved the sealing-wax.

9. Thick plates of gold were strongly oxidized in H_2SO_4, especially with strong currents. Thin gold plates were apparently only oxidized under action of strong or long-continued currents. Compare Tables II. and III. Silver was even more easily oxidized than gold. Aluminum was so intensely oxidized by the current that no satisfactory measurements could be made for this metal, though the thin foil was unaffected.

10. With H_2SO_4 as electrolyte, after a thick plate of pure gold had been used as partition for the time-change of Table III., the end cathode was found to be gilded. A thick Pt plate being then substituted for the gold in the same solution for the results of No. 1 Pt in Table III., the Pt partition was found, on removal, to be gilded. The polarization for No. 1 Pt in this case was somewhat less than for the same Pt after both it and the end electrodes were thoroughly cleansed, the electrodes re-platinized, and fresh solution made.

11. The polarization in $CuSO_4$, using Cu electrodes, reached a maximum almost immediately and remained very constant. The maximum polarization for thick Pt in $CuSO_4$ was hardly 75 per cent of that for the same in H_2SO_4. In NaCl the polarization became constant very quickly also, but its value was decidedly greater, especially on thin plates, than in H_2SO_4; though the same distinctive behavior of thick and thin plates was maintained.

12. In H_2SO_4 of different concentrations the maximum polarization for a partition was of the same order of magnitude; but its value for very weak currents was decidedly greater in weak solu-