The curves of the Alaskan stations, the Fort Liscum curve in particular, display practically the same variation as that observed at Arequipa.

The more important conclusions of my research are:

The dust veil produced by the Krakatoa eruption affected atmospheric temperature very greatly. The violent volcanic eruptions of 1902 as well as the Katmai eruption of 1912 influenced the yearly mean temperatures but very slightly or not at all.

The pleionian variations of temperature have nothing in common with the presence or absence of volcanic dust veils.

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HASTINGS-ON-HUDSON, N. Y.,
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SPECIAL ARTICLES

ON THE NATURE OF ANTAGONISM

EXPLANATIONS have been suggested by Loeb and others to account for the antagonistic action of various substances on living protoplasm, but none of them go far enough to enable us to predict what substances (including both electrolytes and non-electrolytes) will antagonize each other and what degree of antagonism will exist between any two substances.

This kind of prediction is apparently made possible by a hypothesis formulated by the writer, as the result of his investigations on the permeability of protoplasm. The testing of this hypothesis has now proceeded far enough to warrant a preliminary statement of its main features.

Substances which alter the permeability of protoplasm may be divided into (1) those which cause an increase, but not a decrease, of permeability and (2) those which can produce a decrease of permeability.[1]

The hypothesis states that substances belonging to the first class will antagonize those belonging to the second, and vice versa. In order to predict which substances will antagonize each other it is only necessary to determine to which of these classes the substances belong. The amount of antagonism may also be predicted, at least to a considerable extent, since the greater effect of the substances on permeability, the greater will be their antagonistic action. This relation may be obscured by secondary causes, so that the predictions which it allows will not be of equal value in all cases.

To illustrate these relations we may take a series of experiments on *Laminaria saccharina* in which the effects of salts on permeability were determined by electrical measurements.[2] In these experiments it was found that NaCl belongs to the first class, being able to increase permeability but not to decrease it, while $CaCl_2$ belongs to the second class, as it is able to decrease permeability.[3] It was found that the antagonism between NaCl and $CaCl_2$ in the case of *Laminaria* is well marked.[4] These facts led the writer to formulate the hypothesis stated above. The next step was to test the hypotheses by the investigation of other salts. Magnesium seemed of special interest for this purpose, as in most of the writer's previous experiments (on other plants) it had shown no antagonism to sodium, though it might be expected on chemical grounds that magnesium and calcium would behave alike. To the surprise of the writer it turned out that magnesium was able to decrease permeability, though its effect was much inferior to that of calcium. The antagonistic relations for *Laminaria* were then investigated, and it was found that $MgCl_2$ was able to antagonize NaCl, though its antagonistic action was much less than that of $CaCl_2$.[5]

This striking and unexpected result strength-

[1] Substances which cause a decrease of permeability may, if the exposure be sufficiently prolonged, cause an increase.

[2] The method is described in SCIENCE, N. S., 35, 112, 1912.

[3] The decrease is followed by an increase if the exposure be sufficiently prolonged.

[4] Pringsheim's *Jahrb. f. wiss. Bot.*, 54, 645, 1914.

[5] The means by which the degree of antagonistic action are measured can not be discussed here. One method has been described in the *Botanical Gazette*, 58, 178 and 122, 1914.

ened the writer's confidence in the hypothesis and led to further investigations. One of these which was of special interest related to acids. For a number of reasons it was supposed that acid would not cause a decrease of permeability. But investigation showed that such a decrease actually occurred in the presence of HCl and it was then a simple matter to predict that antagonism would be found between NaCl and HCl. This turned out to be the case, the amount of antagonism corresponding to the amount of decrease of permeability.[6]

The hypothesis was further tested by investigations on other salts, the most interesting of which are those which (in contrast to those just mentioned) are more effective than $CaCl_2$ in decreasing permeability, such as $La_2(NO_3)_6$, $Ce_2(NO_3)_6$, etc. Here also it was found that the degree of antagonistic action could be foretold by observing the amount of decrease of permeability produced by the pure salts. The results of these investigations afford strong support to the hypothesis.

It seems to the writer that the hypothesis offers a rational explanation of antagonism by showing that salts antagonize each other because they produce *opposite effects on the protoplasm* and by stating definitely what these effects are (it should be noted that they have been measured with considerable accuracy).

The soundness of this point of view is indicated not only by the fact that we are able to predict both qualitatively and (to a considerable extent) quantitatively the effect of combinations of salts[7] but also by the very significant fact that we are able to extend this conception to organic compounds and to show that non-electrolytes which decrease permeability can also antagonize such substances as NaCl. These facts indicate that the hypothesis may be applied in a general manner so as to include both electrolytes and non-electrolytes.

W. J. V. Osterhout
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[6] *The Journal of Biochemistry*, 19, 1914.

[7] It should be noted that mixing solutions of two salts which belong to different classes does not produce an effect which is merely intermediate between the two. For example, tissue may be killed by an exposure of 24 hours in NaCl or in $CaCl_2$ but remain normal in a mixture of these in the proper proportions. *Cf.* Pringsheim's *Jahrb. f. wiss. Bot.*, 54, 645, 1914.

The writer has found cases in which two substances which can decrease permeability are able to antagonize each other. So far as the writer's experiments with *Laminaria* have gone there is no great amount of antagonism in such cases and what there is may perhaps be correlated with the fact that all substances which decrease permeability do not act alike, some producing a much greater decrease than others. Moreover these substances will, if the exposure be sufficiently prolonged, alter their action and increased permeability. The rapidity of this change varies with different substances and this may be related to the fact that some of these substances antagonize each other to some degree. This will be more fully discussed in a subsequent paper.

Experiments on some plants (in which the criterion of antagonism is not electrical resistance but growth) show a fairly strong antagonism between magnesium and calcium. It is possible that for these plants magnesium belongs in the first class.

It will be noted that the hypothesis, as here set forth, says nothing about the mutual relations of substances belonging to the same class but merely states that substances of one class will antagonize those of the other. In this form the hypothesis is completely justified by all the experiments, including those on organic substances.

ISOLATION OF BACILLUS RADICICOLA FROM SOIL

Ever since the epoch-making achievement of Hellriegel and Wilfarth, reported in 1887, which established the symbiotic relationship between bacteria and legumes in the fixation of atmospheric nitrogen, the legume bacteria, named in 1901, *Bacillus radicicola* by Beijerinck, have been the object of numerous investigations in all parts of the world. These investigations have assumed a variety of forms and were planned from both the economic and pure science points of view. There has ever remained, nevertheless, the unsolved problem of the direct isolation of *Bacillus radicicola* from the soil. Sporadic attempts, rather few in number, have been made to attain that end, but,