ends with a description of those crustaceans parasitic on fishes to which the name "sea lice" is given. This internal evidence certainly lends itself to the view that the dolphin's louse was a sucking fish.

In working up the literature, two references of marked interest just here have been found. Hasselquist, the friend and pupil of Linnæus, in his "Reise nach Palæstina" (published in 1762) refers to an *Echeneis neucrates* (an old spelling of *naucrates*) collected at Alexandria and records that the Arabic fishermen there called it *Chamel el Ferrhun*. This term Dr. Frank R. Blake, of the Johns Hopkins University, very kindly translates for me as the "louse of the terrible one"—*i. e.*, a shark.

Another like name is to be found in the writings of another eastern traveller, Forskäl, likewise a pupil of Linnæus. He collected on a shark at Djidda, a town situated about half way down toward Aden on the eastern shore of the Red Sea, an *Echeneis neucrates* which the natives there called *Kaml el Kersh*, and which he translates the "louse of the shark." Dr. Blake kindly writes me that this term is more properly to be rendered "the louse of the fish of prey" (which Forskäl tells us was a *Carcharias* shark). From all of which we see that in the east, where habits and customs and even names change slowly, the sucking-fish was still called "the louse" some 2,000 years after Aristotle.

We now come to the most interesting point of all in this discussion, which is that if one reads Aristotle closely he will be convinced that the Father of Natural History never saw the shark-sucker. Aristotle's descriptions of other fishes are very clear, evidencing keen powers of observation, and it is not to be thought that, having ever seen and examined the sucking-fish, he could have failed to give an explicit description of the sucking disk. Note also that his words are ". . . which some call the *Echeneis* or ship-holder." He is quoting from some one else and in the judgment of the present writer never saw the *Echeneis*.

E. W. Gudger

State Normal College,
Greensboro, N. C.

SPECIAL ARTICLES

ANTAGONISM AND WEBER'S LAW

When toxic substances act as antidotes to each other this action is called antagonism. It is usually found that when antagonistic substances are mixed in various combinations there is one proportion which is more favorable than others. If this favorable proportion be maintained it is well known that considerable variation in the concentration of the antagonistic substances is permissible for many plants. It has been pointed out by the writer[1] that while variations in concentration affect the form of the antagonism curve they do not in general affect the proportions which are most favorable for life processes.

It is therefore evident that if we wish to preserve the favorable character of a mixture when the concentration of any antagonistic substance is increased we must at the same time increase the concentration of the others in the same proportion. The law of direct proportionality found in such cases is in reality Weber's law, as Loeb[2] has pointed out in discussing his experiments on animals. In regard to the significance of this Loeb says:

> Since this law underlies many phenomena of stimulation it appears possible that changes in the concentration of antagonistic ions or salts are the means by which these stimulations are brought about, as suggested by my ion-protein theory and by the investigations of Lasareff.

In view of the importance of these relations it seems desirable to ascertain, if possible, what mechanism exists which makes one proportion better than others and preserves this preeminence in spite of variations in concentration.

The writer has formulated a theory[3] involving precisely this kind of mechanism. According to this theory the electrical resistance and the permeability of protoplasm are determined by a substance M which is formed and decomposed by the reactions

$$A \rightarrow M \rightarrow B$$

Under normal circumstances M is formed as

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[1] *Botanical Gazette*, 58, 367, 1914.

[2] *Proc. Nat. Acad. Sciences*, 1: 439, 1915.

[3] *Proc. Am. Phil. Soc.*, 55, 1916.

fast as it is decomposed and its concentration remains constant. But under unfavorable conditions the decomposition of M proceeds faster than its formation; this results in injury and, if carried far enough, in death.

The processes which produce this result in such solutions as mixtures of NaCl and $CaCl_2$ are checked by a salt compound[4] of the type Na_2XCaCl_4 formed by the reversible reaction

$$2NaCl + X + CaCl_2 \rightleftharpoons Na_2XCaCl_4,$$

in which X is a constituent of the protoplasm.

The amount of this salt compound formed in each mixture of NaCl + $CaCl_2$ can be calculated by the formula

$$K = \frac{Conc_{Na_2XCaCl_4}}{(Conc_{NaCl})^2(Conc_{CaCl_2})(Conc_X)}$$

In pure NaCl the amount of Na_2XCaCl_4 will be zero, but if increasing amounts of $CaCl_2$ be added the amount of Na_2XCaCl_4 will increase to a maximum and then decline until it again reaches zero in pure $CaCl_2$.

Let us assume that the maximum amount of Na_2XCaCl_4 is found when the molecular proportions[5] are 95.24 NaCl + 4.76 $CaCl_2$. It is evident that we can get this same amount in a different mixture (*e. g.*, 50 NaCl + 50 $CaCl_2$) by increasing the absolute concentrations of NaCl or $CaCl_2$. We should therefore get an equally favorable result in both cases: but this is contrary to the results of experiment. If the phenomena of antagonism really involve a salt compound like Na_2XCaCl_4 it is evident that some mechanism must exist which insures that an increase in the total concentration of salts will have little effect as compared with that produced by a change in their relative proportions.

It is easy to see that such a mechanism must exist if the formation of Na_2XCaCl_4 takes place at a surface. In a surface substances usually exist in a different concentration from that which they have elsewhere in the solution. If NaCl and $CaCl_2$ migrate into the surface, so as to become more concentrated there than in the rest of the solution, their concentration in the surface must increase, as their concentration in the solution increases, up to the point where the surface is saturated. Beyond this point an increase in their concentration in the solution produces no effect on their concentration in the surface. When this stage has been reached the formation of Na_2XCaCl_4, if it takes place in the surface, will not be affected by an increase in the concentration of the salts in the solution. It will, however, be affected by changes in the relative proportions of the salts. The number of molecules in a unit of surface will remain nearly constant, but if the proportion of NaCl in the solution be increased some of the $CaCl_2$ in the surface will be displaced by NaCl.[6]

Below the saturation point the relative proportions of the salts will be of less importance than their total concentration: this is the case at low concentrations in the region of the so-called "nutritive effects."

It is evident that if we adopt this theory we can see why the most favorable proportion must remain approximately the same in spite of variations in concentration. We thus arrive at a satisfactory explanation of Weber's law.

It is evident that Weber's law will not apply when the concentration is below the saturation point. On the other hand at high concentrations effects of osmotic pressure, coagulation, etc., may exert a disturbing influence.

Thus far we have discussed effects in which the criterion of antagonism is electrical resistance or permeability. But it has been shown by the writer that electrical resistance and permeability are very accurate and sensi-

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[4] The actual proportion of Na and Ca in this compound may be supposed to differ according to the proportion of these substances in the most favorable mixture. In place of Na and Ca we may have other antagonistic salts, and more than two may enter into the compound.

[5] These are the proportions found in an investigation described in *Proc. Am. Phil. Soc.*, 55, 1916.

[6] It may easily happen that NaCl and $CaCl_2$ do not migrate equally into the surface. If we assume that 10 times as much $CaCl_2$ enters the surface as NaCl we shall find the maximum amount of Na_2XCaCl_4 in 95.24 NaCl + 4.76 $CaCl_2$. (*Cf. Proc. Am. Phil. Soc.*, 55, 1916.)

tive indicators of vitality. It therefore seems highly probable that the theory here presented may be applied in those cases where other criteria of antagonism (such as motion, growth and length of life) are employed.

It will be seen that action in a saturated surface is the essence of this explanation. It is evident that so long as this essential feature is preserved it makes little difference what theory of antagonism we adopt. If the antagonistic substances act in a saturated surface antagonism must be governed by Weber's law.

Summary.—The fact that Weber's law governs antagonism is explained by a dynamical theory formulated by the writer.

This theory assumes that injury and death result from processes which are inhibited by salt compounds formed by the union of salts with the protoplasm. If these compounds are formed in a surface the amounts will (above a certain limit) be independent of variations in concentration and will depend only on the proportions of the antagonistic salts. From this it results that Weber's law must govern the phenomena of antagonism.

No matter what theory of antagonism we adopt, it is evident that if the antagonistic substances act in a saturated surface antagonism must be governed by Weber's law.

W. J. V. Osterhout

Laboratory of Plant Physiology,
Harvard University

DO FUNGI LIVE AND PRODUCE MYCELIUM IN THE SOIL?

The recent investigations on soil microorganisms have revealed the fact that fungi are found in soils in very large numbers sometimes reaching as high as 1,000,000 per gram of soil. These numbers are found by diluting the soil and then plating out only a small portion of a gram. The colonies developing on the plates represent the spores or pieces of mycelium found in the soil. But this does not tell us about the actual active life of the fungi in the soil. However large the numbers that are found, it remains to investigate whether those organisms existed in the soil only in the form of spores, which were brought in by some outside agency, or are a result of active life in the soil in the form of mycelium which may or may not result in the formation of spores in the soil. The question is not how many numbers and types of fungi can be found in the soil, but what organisms lead an active life in the soil. To what depth are these organisms found to produce mycelium in the soil? And finally, do all or at least most of the organisms isolated from the soil actually produce mycelium in the soil?

At the suggestion of Dr. Charles Thom, of the Bureau of Chemistry in Washington, a direct isolation of fungi producing mycelium in the soil was attempted. Soil samples taken at different depths, under absolutely sterile conditions, were brought into the laboratory; lumps of soil, about 1 cm. in diameter, were transferred with sterile forceps into sterile plates containing cooled sterile Czapek's solution agar. The lump was placed carefully in the center of the dish, which was immediately covered and allowed to incubate for 24 hours at 20–22° C. After this period mycelium was found to radiate out of the lump of soil into the medium. This mycelium was now transferred with a sterile platinum loop to sterile slants of Czapek's agar, care being taken to select the tips of the hyphæ so as not to bring the loop in too close contact with the soil. The agar slants containing the transferred portions of mycelium were allowed to incubate till the organisms had developed well and were ready for study. The organisms thus isolated were not always pure. They had to be often separated from one another; this was accomplished by establishing pedigree cultures of the organisms.[1]

The organisms thus isolated are believed to come from the mycelium that is actually found in the soil. The period allowed for the incubation of the soil in the petri dish was not long enough for spores in the soil to germinate and produce such a mass of mycelium; this is espe-

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[1] The methods of isolation and establishment of pedigree cultures, as well as the details of the work, formulæ for media used and identification of organisms will be published later.