these centers may have at his disposal all recorded observations of the phenomena of earlier outbreaks or periods of quiet. During a residence of several years in Hawaii, Professor Hitchcock has sought to complete the record of the active volcanoes by search of all available sources of information and by personal study of many features. The book under review is the result of this research. Its object is said to be "to describe correctly the phenomena connected with the discharges of molten lava from the two great Hawaiian volcanoes—Kilauea and Mauna Loa." "It is presumed that all the Hawaiian volcanoes throughout the archipelago have been developed in a similar manner. . . ."

From this point of view the work is the most satisfactory source of information on the subject, because compiled with care and with the aim of completeness.

The work is arranged in four parts. Part I., of 55 pages, is called Physiography of the Hawaiian Archipelago. Here may be found a brief but desirable sketch of the character and relations of the reefs and low islands which stretch away for more than a thousand miles to the northwest of Niihau, the most westerly inhabited island of the main group. In this part is found, also, the entire description, physiographic and otherwise, of Kauai, Oahu, Molokai, Maui and even of Hawaii, exclusive of the active volcanoes. Considerable space, relatively, is given to the stratigraphy of the water-bearing tuffs and coraline sands and limestones in the vicinity of Honolulu, to the study of which the author has given much attention.

Parts II. and III. are devoted, respectively, to the great volcanoes of Mauna Loa and Kilauea, and consist, as above indicated, chiefly of the compiled record of exploration and observation. Valuable as this record is, it serves to emphasize the fact that up to the present time little attempt has been made to study the phenomena displayed in other than a rather superficial manner. The actual physics of basaltic magma, the gaseous emanations accompanying it, the chemical composition of special magmas exhibiting certain phenomena, and the whole vast problem of volcanic energy, have scarcely been touched by observations thus far made at these volcanoes. It is to be hoped that some plan for more thorough investigations may be carried out. The field is certainly a most promising one.

Part IV. reviews The Hawaiian Type of Volcanic Action by summarizing the phenomena observed and citing the views of various authors as to their explanation. The comparison of Lunar and Hawaiian physical features by Pickering is specially noted.

In an appendix (17 pages) are given notes on earthquakes in Hawaii, the origin of the moon, the use of the spectroscope, a table of analyses of Hawaiian lavas, and biographical notes of explorers of the islands.

The second edition presents a supplement of eight pages, containing further data on certain eruptions, a criticism of W. T. Brigham's volume "The Volcanoes of Kilauea and Mauna Loa,"[2] and a list of errata, which is by no means complete.

The illustrations of this work are chiefly half-tone reproductions of photographs, which give an excellent idea of the volcanoes and their lava forms, and valuable sketch maps of the craters at several stages of development. The book is attractively gotten up, well printed, and is a credit to the enterprise of the Honolulu newspaper house which has published it.

WHITMAN CROSS

SPECIAL ARTICLES

THE PERMEABILITY OF LIVING CELLS TO SALTS IN PURE AND BALANCED SOLUTIONS

OVERTON performed experiments on *Spirogyra* and other plant cells and later upon various animal cells and came to the conclusion that only those substances penetrate which are soluble in lipoid. His criterion of penetration is simple and precise. If a solution plasmolyzes a cell and the protoplast does not subsequently expand if left in the solution it is clear that the dissolved substance does not penetrate. If it penetrated it would gradually

[2] "Memoirs of the Bernice Pauahi Bishop Museum," Honolulu, 1909.

increase the osmotic pressure inside the cell until the latter equalled the external pressure. In consequence the protoplast would expand and return to its original condition. Overton found that salts in general produce plasmolysis which is not followed by expansion of the protoplast. He therefore concluded that salts are unable to penetrate.

A repetition of Overton's experiments on *Spirogyra,* using the same criterion of penetration which he employed, has led me to the opposite conclusion. In my experiments with salts of NH_4, Cs, Rb, Na, K, Li, Mg, Ca, Sr and Al, the protoplast which is plasmolyzed and left in the solution expands again to its normal size, showing that all these salts readily penetrate the protoplasm.

I cite for illustration an experiment with NaCl for the reason that this is very generally employed as a plasmolyzing agent. Filaments of *Spirogyra* were placed in a .4M NaCl solution. Within two minutes the protoplasts of most of the cells were so far plasmolyzed that they no longer touched the end walls of the cells. Several of these were accurately sketched with the camera lucida and kept under continuous observation. In the course of ten minutes several of them had begun to expand and in thirty minutes all had expanded so as to completely fill their respective cells. To avoid the injurious action of the salt, the filaments were then transferred to .18M $CaCl_2$ solution and this was gradually diluted until its osmotic pressure was not greater than that of tap water. The cells were then transferred to tap water. They were examined the next day and found to be alive. On being placed in .4M NaCl they were plasmolyzed and afterward expanded as before.

Recovery from plasmolysis is about as rapid in KCl as in NaCl, while in $CaCl_2$ it is much slower. On the other hand, in CsCl it is much more rapid than in NaCl. In a subsequent paper the behavior in the various salts will be fully described.

Certain facts may be worthy of mention which tend to obscure these results and which may have caused them to be overlooked.

In the experiment just described the cells were transferred to a favorable solution as soon as expansion was complete. If this precaution be neglected and the cells be allowed to remain in the NaCl solution the injurious action of the salt soon causes the protoplast to shrink. In salts which are more toxic than NaCl this shrinkage may be more rapid and more pronounced. This shrinkage, which I have called false plasmolysis,[1] may also be produced by very weak (hypotonic) solutions and has nothing to do with plasmolysis but may simulate it in very misleading fashion. If the cells are not continuously observed but only examined at intervals the expansion of the protoplast may be easily overlooked, and the subsequent shrinkage may be easily mistaken for plasmolysis.

A further necessary precaution is the observation of the same individual cell during the course of the experiment. To provide for this and at the same time to keep the concentration of the solution unchanged, a variety of devices was employed which will be described elsewhere.

Cells which expand promptly if only slightly plasmolyzed may not expand at all if severely plasmolyzed.

Some kinds of *Spirogyra* are wholly unsuited for these experiments because they are quickly injured by the salts (or by distilled water made in metal stills if this be used for solutions) in such a way that they expand poorly or not at all.

Another proof of the penetration of a salt is illustrated by the action of $CaCl_2$ and NaCl. A portion of a *Spirogyra* filament was plasmolyzed in .2M $CaCl_2$ but not in .195M $CaCl_2$. A .29M NaCl solution has approximately the same osmotic pressure as a .2M $CaCl_2$ solution. But on placing another portion of the same *Spirogyra* filament in a .29M NaCl solution the expected plasmolysis does not occur and it is impossible to plasmolyze the cells until they are placed in .4M NaCl. It would appear that this difference between the behavior in $CaCl_2$ and NaCl is caused by the more rapid penetration of the latter. This supposition is in perfect accord with the con-

[1] Cf. *Bot. Gazette,* 46: 53, 1908.

clusions drawn from the rate of expansion, as stated above.

But the most striking proof possible of the penetration of the salt is afforded by the following simple experiment. By dividing a *Spirogyra* filament into several portions it was found that it was plasmolyzed in .2M $CaCl_2$ and in .38M NaCl but neither in .195M $CaCl_2$ nor in .375M NaCl. On mixing 100 c.c. .375M NaCl with 10 c.c. .195M $CaCl_2$ and placing other portions of the same filament in it, prompt and very marked plasmolysis occurred. Here we arrive at the extraordinary result that *by mixing together two solutions neither of which is able to plasmolyze we produce a solution which plasmolyzes strongly.* The experiment is so simple and striking that it is admirable for class-room demonstration.

It may be noted that in this experiment we add to a solution of NaCl a solution of $CaCl_2$ which is of much lower osmotic pressure. It is evident that although the addition of the $CaCl_2$ lowers the osmotic pressure, it nevertheless increases the plasmolyzing power of the solution considerably. Evidently it can do this by preventing the NaCl from penetrating the protoplasm or the two salts may mutually prevent each other from going in. The behavior of the cell indicates that in most cases the latter alternative is to be preferred. This will be fully discussed in another paper.

In the course of time the cells in the mixture of NaCl and $CaCl_2$ may expand, but this occurs very much more slowly than in pure NaCl. The appearance of the cell then shows in the clearest manner that it is not NaCl alone which has penetrated and caused the expansion, but rather NaCl and $CaCl_2$ together. This is evident from the fact that the effects which are characteristic of pure NaCl are entirely absent. But though they eventually penetrate they do so slowly and the effect of slow penetration is very different from that produced by sudden penetration and this may largely explain why they act as antidotes to each other.

It is evident that while the mechanism of antagonistic action may depend largely on the mutual action of the antagonistic salts in preventing each other from entering we must take into account their effect on the protoplasm within the cell as well as their effect on the plasma membrane.

Marine algæ give similar results.

The chief conclusions are as follows:

1. The usual method of determining osmotic pressure by plasmolyzing in salts of Na and K is very erroneous. Salts of Ca give more nearly the true osmotic pressure.

2. Since one substance may greatly affect the penetration of another it is unsafe to use the common method of adding a toxic to a non-toxic substance and judging the penetration of the former by the plasmolytic action of the mixture.

3. It is possible to state which salts penetrate and at what rate of speed, and also how various salts affect the permeability of the plasma membrane.

4. From these data we have a definite clue to the nature of the plasma membrane. Since all the salts studied penetrate it seems certain that the membrane can not be lipoid because these salts are not soluble in lipoid. Its behavior toward balanced solutions (together with other facts) indicates unmistakably that the membrane is proteid in nature.

5. Antagonistic salts such as NaCl and $CaCl_2$ hinder or prevent each other from entering. To such an extent is this true that by choosing solutions of NaCl and of $CaCl_2$ which are not quite strong enough to plasmolyze we produce by mixing them together a solution which plasmolyzes strongly.

The fact that these salts hinder or prevent each other from entering may explain why they act as antidotes to each other. But since they may eventually penetrate to some extent we must attach importance to their effect on the protoplasm within the cell as well as to their effect on the plasma membrane. These two effects may be very similar.

W. J. V. OSTERHOUT

INDIANAPOLIS MEETING OF THE AMERICAN CHEMICAL SOCIETY

IT has become almost monotonous to write that a meeting of the American Chemical Society was