Russian, without the inconvenience of translating them into a language different from their own. The valuable personal acquaintance of this member in Russia was of great assistance in drawing up a list of institutions which ought to be reached.

The response to the appeal in America was immediate, and very generous. Up to August 15th, a sum of $1,657.47 had been received, and food packets amounting to $1,490 had been sent for distribution among the scientific staffs of twenty-five institutions, observatories or universities, and to some isolated astronomers or their dependent families. These packets were sent at intervals, considerably oftener than a month, as the funds came in for the purpose. We have received interesting testimony as to the care and judgment of the A. R. A. in the selection of contents of the food packets, having learned from the direct experience of our friends that a $10 packet has actually supported two persons for a month. It should also be recalled that one fourth of all packets was used for the general relief of Russian children.

The recipients of the first shipments were requested to give us the names of other astronomers or their families that might need assistance, and thus the list has been considerably increased. Many replies have been received, but not yet has there been time for all to acknowledge the receipt of the food packages. The distress has been very great in the Crimea —perhaps where it had been least expected— and it was not possible for the A. R. A. to establish warehouses in this district until rather recently. From six to eight weeks seems to have been necessary for the actual receipt of the food at points which could be reached most expeditiously.

The last general distribution of food packets was made at the end of July, and we have assumed that by the time it reaches the persons for whom it is intended the new harvest will have removed the immediate urgency of relief. The balance which the committee has in the bank will be used in responding to calls from individuals not yet reached, or those in remote districts where the distress may still be acute.

No expenses of the committee have been charged to the fund, so that the distribution has been net. This, of course, applies also to the splendid work of the A. R. A.

The followers of the stars are a scattered, other-worldly folk, but their work on far-away things has brought them close together. Personal acquaintances are probably closer among astronomers and their families than is the case in most other branches of science. It has, accordingly, been a simpler matter for the American astronomers to give this little help to their Russian colleagues than it would have been for those in other departments of endeavor having a greater constituency. Men and women of America in several other branches could readily have contributed a hundred times what the astronomers could do—and perhaps they have—but the presumptive lack of personal contact would have made this a rather difficult proposition. The letters from Russian astronomers leave no doubt as to the sincerity of the appreciation of even this small measure of relief from America.

The members of the committee have been: George Van Biesbroeck, Otto Struve and the writer.

EDWIN B. FROST,
*Chairman*

YERKES OBSERVATORY,
WILLIAMS BAY, WISCONSIN
AUGUST 18, 1922

## BOTULINUS TOXIN

SOMETIME ago Dr. Schlesinger and myself (*Proc. Soc. Exp. Biol. and Med.*, 19, 1, 1921; *Jour. A. M. A.*, 78, 1519, 1922) stated that the toxicity of crude filtrate from cultures of *Bacillus botulinus* may be greatly increased by the proper degree of acidification (approximately $p_H$ 4). When we tried to find the limits of potency of such an acidified solution of toxin, we were extremely surprised to discover that even such minute quantities of solution which contained only $3 \times 10^{-18}$ cc. of the original culture filtrate exhibited all the specific properties of the original toxin and killed mice in less than 48 hours when injected intraperitoneally. When this acidified solution of toxin was diluted further, the results became less regular, in fact the dilution containing $3 \times 10^{-21}$ cc. of the original toxin killed only 5 per cent. of the animals tested.

In the current issue of SCIENCE (August 4, 1922, page 143), Dr. Stehle questions this observation. He states that one cubic centimeter of toxin does not contain enough molecules to supply a molecule of toxin for each cubic centimeter of the final dilution. Indeed, he rightly concludes that "the average $3 \times 10^{-21}$ cc. quantity of solution would contain no toxin." We agree with Dr. Stehle's conclusion, but we think it offers an explanation of, rather than a contradiction to our findings.

Our findings do seem unbelievable. Moreover, in view of the fact that mice are not very reliable as test animals for toxicity, together with the possibility of some error in dilution due to inaccuracy of pipettes, we do not insist on the accuracy of the figures and offer them merely as the best proof of the apparent extreme increase of the potency of toxin—a condition unknown with other bacterial toxins. As a matter of fact, we doubted the figures obtained originally and repeated the experiment many times. Finally, we checked our finding by a calculation similar to that used by Dr. Stehle (in our calculation we followed the reasoning found in Walker's "Introduction to Physical Chemistry," Macmillan, 1907, pages 214-219). This calculation, in fact, gave us the audacity to offer our figures which before seemed to us ridiculous. According to our interpretation, this calculation showed that each cubic centimeter of the dilution of the toxin to the eighteenth power might still contain enough of the specific substance to kill mice regularly (over 80 per cent. of animals thus treated died within 48 hours and about 10 per cent. more died within the next 24 or 48 hours), whereas in the dilution to the twenty-first power, many of the one cubic centimeter portions of the solution might not have contained even a single molecule of toxin, which apparently explains why only 5 per cent. of the animals injected died. When identical results were obtained on at least three different batches of toxin, obtained on different lots of culture medium, and on repeated tests on each of these batches, we decided to publish these unusual findings. I wish to take this opportunity to add that we still expect to find some source of constant error in our procedure or in our calculation. We know of no good proof indicating that the toxin may act as a catalyst, nor are we willing without further good reason to believe in the existence in the body of some vital center consisting of a small group of cells (not more than 100 and possibly less), the injury to which would lead to death in 80 per cent. of animals tested. Furthermore, continuing the above calculation, we were forced to conclude that the molecular weight of such an active toxin as we have seemingly obtained when computed on the basis of total solids could be about 380 and when calculated as protein (on the basis of total nitrogen) could be no greater than 260, which makes it extremely difficult to see how such a simple substance can possess the degree of specificity in respect to antitoxin neutralization which our solutions demonstrated.

In order to clarify the question, I would like to sum up the arguments which seem to favor the validity of our observations.

(1) When $3 \times 10^{-18}$ cc. of the acidified culture filtrate of *Bacillus botulinus* is injected intraperitoneally into mice of 17-21 grams, the animals die with all the symptoms of botulinus poisoning in mice.

(2) When receiving this small amount of toxin the animals die within 24-48 hours, which is a typical incubation period for botulinus toxin.

(3) Animals receiving protective injection of a homologous (type A) antitoxin invariably survive the injection of the amount many millions of times greater than $3 \times 10^{-18}$ cc. of this active solution.

(4) The animals receiving large amounts of botulinus antitoxin type B (heterologous) are not protected even against a single dose of $3 \times 10^{-18}$ cc. of acidified type A toxin.

(5) The potency of acidified toxin is destroyed by a very short exposure to heating at 80 degrees C.

(6) When the reaction of acidified toxin is brought back to neutral (before dilution), the resulting solution has the titer of the original toxin. The re-acidification and re-neutralization can be accomplished several times in succession with the result that acidification invariably increases the potency and neutralization returns it to the original titer.

(7) When one cubic centimeter of the original toxin has been distributed through a sufficiently large amount of a diluent so that not every cubic centimeter of the diluent would be theoretically expected to contain one molecule of original toxin, the results of the injection of such highly diluted toxin become irregular and apparently depend on the presence or absence of a molecule or a small number of molecules of toxin in each portion injected.

(3) While not every filtrate yielded an equally potent product on acidification, the same filtrate consistently titrated as indicated, even though repeated tests were performed several days and weeks apart.

On the other hand, it is evident that there are a number of considerations militating against the validity of our observations.

(1) Using the same strain of the organism and similar culture medium, it was not always possible to obtain the same degree of increase in potency of the acidified filtrates, although in all cases some increase was observed. Apparently, the uncontrollable differences in composition of the culture medium during the early growth of the organism has something to do with the degree of change in potency which the toxin will undergo upon its subsequent acidification.

(2) It is difficult to conceive how such a small number of molecules which can theoretically be expected to be present in the small amount of toxin injected can produce the effect.

(3) The extreme simplicity and low molecular weight which the active substance seems to possess according to calculation is difficult to reconcile with its strict biologic specificity which would postulate a more complex structure.

(4) We find that while this active toxin is neutralized by a specific antitoxin, the neutralization does not go according to the law of multiple proportions, but is in fact more efficient.

(5) It is difficult to explain why such a simple molecule as that which the active toxin seems to possess can not pass bacterial filters which are comparatively permeable to the original toxin.

These, as well as other considerations, indicate that a further study of the subject is necessary. We feel more inclined to believe, and some of our most recent observations strengthen this belief, that while the toxin does unquestionably undergo an increase of potency under certain conditions of the experiment, the degree of this increase probably is not as great as some of our findings seem to indicate. We suspect that there may occur an ultramiscropic precipitation of the toxin-carrying portion of the medium. If the minute particles of such a precipitate should possess particularly high adsorptive power, they could be carried from dilution to dilution and thus vitiate the accuracy of the calculation. Since circumstances force us to interrupt this study for the time being, we thought it worth while to call the attention of other workers to this interesting phenomenon. With this in view, we are preparing detailed protocols of the experiments to date which we hope to publish in the near future.

J. BRONFENBRENNER
HARVARD MEDICAL SCHOOL,
BOSTON

## SOIL SHIFTING IN THE CONNECTICUT VALLEY

RECENTLY two articles have appeared in the current volume of SCIENCE (Nos. 1413 and 1426), reporting soil shifting by wind. In the Connecticut Valley in the vicinity of Amherst sand storms are a common occurrence. The prevailing winds, coming from the northwest, have a rather uninterrupted sweep down the valley, and at times pick up and transport large quantities of soil consisting of sands, sandy loams, silt loams, clay loams and clays. It is the coarser members of the above soils that are most eroded because the heavier soils are usually covered with vegetation.

This shifting of the soil by wind action has