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The penetration of trivalent and pentavalent arsenic into living and dead cells.

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The biological effects of trivalent and pentavalent arsenic are not the same. The former are not readily excreted by the body and are more toxic; the latter are readily excreted and are less toxic. It is obviously not possible to analyze the microscopic cell contents of body-cells to note how much arsenic is taken up by each cell. By making use of a large one-celled marine alga, *Valonia,* whose sap can be expressed readily and analyzed for arsenic content, it was thought that some conclusions of general application to living protoplasm might be found. It was possible to separate the plant into the three components; sap, protoplasm, and wall, and analyze each one for arsenic. The ratio of the weights of each component was also found; the sap being 165 times heavier than the protoplasm and 257 ± 13 times heavier than the wall.

All the experiments were done in sea water. Arsenic in the form of As_2O_5, As_2O_3, and atoxyl was used in a concentration of .002 M. The H ion concentration was varied in two ways: by using buffers and by the addition of traces of acid. The presence of arsenic was determined by the Gutzeit method. All the reagents used were special arsenic-free. The plants remained 20 hours in the arsenic solution. They were not injured by this treatment.

It was very important to ascertain whether the plants were in good condition after the experiment. This was done by returning them to sea water after they had been in the test solution and noting the number of days they survived as compared with normal cells. Other superficial methods of observation were found not sufficient.

The results showed that by far the greatest concentration of arsenic is taken up by the protoplasm. The pentavalent form of arsenic is taken up and retained in the greatest concentration by

the protoplasm and in a much lower concentration by the sap; when the trivalent form is used, there is much less arsenic found in the protoplasm and about twice as much in the sap. From acid solutions of the trivalent form the amount of arsenic which penetrates into the protoplasm is considerably reduced. The minimum amount of arsenic is found in the sap and protoplasm when the solutions are nearly neutral. Under all conditions the concentration of arsenic in the wall is less than that in the protoplasm, and exceeds that in the sap.

When phosphate buffers (0.0028 M) are dissolved in the surrounding solution in the acid range together with the arsenic, there is a reduction in the rate of penetration of arsenic. This effect is least when trivalent arsenic is used. It is very necessary therefore in experiments in which buffers are used to know the effect of the buffer ions themselves.

Living and dead cells were placed in solutions in sea water containing enough arsenic acid to produce a pH of 3.6. Time curves show that the penetration into dead cells is much more rapid than into living cells.

It was shown in a previous paper[1] that when $NaHCO_3$ is present in the surrounding solution the sap has more free CO_2 and at the same time becomes richer in basic ions than in sea water of the same pH without $NaHCO_3$. Therefore it was thought of interest to see whether other substances such as arsenic, which can be readily detected, would also enter more readily under the influence of $NaHCO_3$. Cells were placed for one hour in a .0024 M solution of $NaHCO_3$ in sea water before exposure to arsenic. It was found that this treatment affected the rate of arsenic penetration in a marked way: when As_2O_5 was used the amount of arsenic in the protoplasm was increased 150 per cent more and that in the sap 25 per cent; with As_2O_3 about 25 per cent less of arsenic was found in the protoplasm and 100 per cent more in the sap. The amount of arsenic in the walls was not changed.

These results show that the increased HCO_3 or free CO_2 in the cell either facilitates the formation of arsenic compounds with protoplasm, or increases the permeability of the cell.

Details of this article will appear in Public Health Reports.

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[1] Brooks, M. M., U. S. Public Health Reports, 1923, xxxviii, 1470.