The Permeability of Sea Urchin Egg to Water[1]

By

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In hypotonic sea water the eggs of sea urchin continue to swell until the eggs attain a state of equilibrium. Thus swollen eggs, when replaced in natural sea water, begin to shrink and the egg volume finally comes back again to the original level (swelling cycle). It is obvious, therefore, that this volume change in osmotic swelling is reversible. In this swelling cycle of the eggs the fact that the permeability to water is greater in exosmosis than in endosmosis has been quantitatively estimated by many investigators, whereas there is no clear evidence whether the permeabilities, after a swelling cycle, still remain unchanged or not. For the purpose of making clear this point the following experiment was undertaken.

Unfertilized eggs of sea urchin, *Strongylocentrotus intermedius*, were employed as material. The time course of the volume change was determined from the diameter of each egg at intervals of one minute, and the permeability constant of the cell to water was calculated by employing the equation of Lucké et al. ('31). During one set of the experiments the temperature was not particularly regulated, but its change was slight, fluctuating within 1°C. In this work only 60% sea water was used for convenience of the experiment, for the permeability to water is comparatively unaltered in diluted sea water until 20% (Lucké et al., '31) and the volume change in 60% is completely reversible. In view of the fact that the permeability to water would be changed by time lapsed in natural sea water after spawning, the measurement of the egg diameters was made in such a way as to compensate for the time lapsed in sea water from the time of just taking out the eggs from the ovary to the moment of diameter measurement in each experiment; that is, the eggs from a lot were divided into two groups A and B, and eggs of group A were immersed in 60% sea water for 30 minutes and then put back in natural sea water until regaining the original volume (the first swelling cycle).

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1) Contribution No. 288 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan.

Jour. Fac. Sci. Hokkaido Univ., Ser. VI, Zool., ***11****, 1952.*

During the first swelling cycle of group A the eggs of group B were kept in natural sea water, then the measurements of diameter change in 60% sea water were made alternately on thus treated eggs of group A and of group B.

The b, the volume occupied by osmotically inactive fractions, was taken as 21% of the cell volume in natural sea water, assuming that b is constant during the experiment (Shinozaki, '51). The initial volume was estimated by extrapolation and the final or equilibrium volume was calculated from the equation, $V_e = P_o(V_o - b)/P_e + b$. To ascertain whether the physiological condition of the eggs is normal during the experiments, the fertilizability of the eggs was determined before and after each experiment. From the results it was confirmed that under the conditions of this experiment diluted sea water does not exert unfavourable effects on eggs.

Table 1. The time course of swelling of the egg in 60% sea water (Exps. 1 to 4) and of shrinking of the egg, previously swollen in 60%, in natural sea water (Exp. 5). The eggs used in Exps. 4 and 5 were taken from the same female. The actual volume in cubic micra is obtained by multiplying each figure in the table by 100. The osmotic pressure being necessary to estimate k was evaluated from the value of the freezing point depression (-1.825°C.).

Time in minutes	Exp. 1 1st	Exp. 1 2nd	Exp. 2 1st	Exp. 2 2nd	Exp. 3 1st	Exp. 3 2nd	Exp. 4 1st	Exp. 4 2nd	Exp. 5 1st	Exp. 5 2nd
0	3,666	3,767	3,330	3,216	3,593	3,766	3,642	3,741	6,062	5,948
1	4,051	4,294	3,868	3,792	4,185	4,266	4,239	4,266	5,363	5,299
2	4,489	4,575	4,131	4,051	4,575	4,691	4,662	4,662	5,019	4,838
3	4,691	4,809	4,321	4,185	4,720	4,898	4,868	4,928	4,604	4,546
4	4,868	4,958	4,489	4,321	4,928	5,019	5,019	5,142	4,387	4,266
5	4,989	5,081	4,632	4,461	5,050	5,142	5,111	5,205	4,212	4,101
6	5,111	5,173	4,720	4,546	5,081	5,268	5,205	5,299	4,131	4,024
7	5,173	5,268	4,779	4,604	5,142	5,331	5,268	5,395	4,077	3,998
8	5,236	5,363	4,809	4,662	5,205	5,395	5,299	5,427	4,051	3,972
9	5,331	5,427	4,868	4,691	5,236	5,459	5,363	5,491	4,024	3,946
10	5,363	5,459	4,898	4,720	5,268	5,491	5,395	5,524	3,998	3,920
11	5,395	5,491								
12	5,427	5,524								
Mean of	6	6	6	6	6	6	5	5	5	5
Temperature averaged	20.2°		21.6°		21.6°		22.5°		22.7°	
k*	0.196	0.189	0.195	0.188	0.197	0.187	0.215	0.212	0.211	0.213

* μ^3/min./μ^2/atm.

The data are given in Table 1. The figures in the table show that the permeability constants to water in the first and in the second swelling[1] are almost

1) The first and the second swellings denote the swelling in 60% sea water in the first and the second swelling cycle respectively. The significance of the first and the second shrinkings is similar.

equal to each other, and this relationship is true also in the case of the shrinking. In this experiment no difference could be found between the permeabilities to water in endosmosis (Exp. 4) and in exosmosis (Exp. 5), but the cause of disagreement with the result that shows greater permeability in exosmosis than in endosmosis, is not yet solved.

From the above data it will be concluded that the permeability of the plasmic membrane of sea urchin egg to water is not altered by the swelling cycle.

Summary

The permeability constants of sea urchin eggs to water in 60% sea water in the first and in the second swelling cycles (swelling in 60%, then shrinking in 100% sea water) were estimated by employing the equation of Lucké et al. These constants were almost equal to each other in both cases. Hence it is obvious that the permeability of the plasmic membrane of sea urchin eggs to water is practically not altered by a single swelling cycle.

Literature Cited

Lucké, B., H. K. Hartline and M. McCutcheon 1931. Further studies on the kinetics of osmosis in living cells. J. Gen. Physiol., vol. 14, pp. 405-419.

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