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**On a Method by Which the Eggs of a Sea Urchin
(Strongylocentrotus purpuratus) Can Be Fertilized With the Sperm
of a Starfish (Asterias ochracea)**

Jacques Loeb

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April 27, 1903

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PURPURATUS*) CAN BE FERTILIZED WITH
THE SPERM OF A STARFISH (*ASTERIAS
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BY
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With the author's kind regards

of Delany

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It is well known that it has thus far been impossible to hybridize animals which are not in close blood relationship. Yet, it seemed to me that in order to obtain more definite data for the problem of evolution the apparent barriers to a successful hybridization of not closely related animals should be removed. For a number of years I have made experiments in this direction, and on one occasion—in my paper on The Artificial Parthenogenesis in *Annelids* 1901—I mentioned some of them.

Last summer it occurred to me that possibly the idea which guided me in my experiments on artificial parthenogenesis and other problems might also lead to positive results in this case, namely, that a slight change in the constitution of the sea-water (or the blood) may give the tissues properties which they do not possess ordinarily. This assumption was correct and I have recently succeeded in fertilizing the eggs of a sea-urchin (*Strongylocentrotus purpuratus*) with the sperm of a starfish (*Asterias ochracea*). The main results of my experiments may be summarized as follows:

1. It is impossible to fertilize the eggs of *Strongylocentrotus purpuratus* with the sperm of *Asterias* (or of any other of the starfish tried) in normal seawater.

2. I have found a series of solutions in which the eggs of *S. purpuratus* can be fertilized with the sperm of *Asteria ochracea*.

3. The seawater contains certain substances which if added to these solutions prevent the fertilization of the egg of *S. purpuratus* with the sperm of *Asterias ochracea*.

4. The same solutions in which the eggs of *S. purpurata* can be fertilized by the sperm of the starfish render difficult or impossible the fertilization of the same eggs by the sperm of their own species. But in the same solutions the eggs of *S. purpuratus* are very readily fertilized by the sperm of their own species, when those constituents of the seawater are added which inhibit the hybridization of the egg of the sea-urchin with the sperm of the starfish.

5. In some experiments as many as fifty per cent. of the eggs of the sea-urchin formed the characteristic membrane of fertilization in the artificial solutions in about half an hour after the sperm of the starfish had been added. The same eggs began to segment at the proper time while the eggs without a membrane remained unaltered. Under proper conditions practically each of these segmenting eggs reached the blastula stage and many the gastrula stage. Some remained alive for more than a week and showed the differentiation of the intestine. Inasmuch as the parthenogenetic larvae of *S. purpuratus*, as well as the pure-blooded larvae of this species, form a skeleton while the larvae of the starfish form no skeleton, it may be of interest that the hybrids between the two formed no, or at the best, only a very rudimentary skeleton. It is not impossible that the spermatozoön of the starfish contains substances which interfere with the formation of a skeleton.

6. Each series of experiments was accompanied by the necessary control experiments to exclude the two possible sources of error, namely, contamination of the eggs by sperm of their own species and second, artificial parthenogenesis. The first source of error was excluded by the fact that in the experiments in which only the sperm of *Asterias* was used, no egg formed a membrane

or developed in normal seawater. The second error was excluded by the fact that, when the eggs were kept in the artificial solutions without the addition of the sperm of *Asterias*, no egg formed a membrane or developed. As soon, however, as the sperm of *Asterias* was added membranes were formed and the eggs began to segment at the proper time.

These facts may also have a bearing upon certain phenomena of infection and immunity. One is almost tempted to say that while in seawater the eggs of *S. purpuratus* are immune against the sperm of the starfish, in the artificial solutions they become almost or completely immune against the sperm of their own species, and at the same time lose their immunity for the sperm of the starfish. It is a rather remarkable fact that surprisingly small though very definite quantities of certain constituents of the seawater suffice to reverse the character of the immunity.

As a brief statement of the chemical side of these experiments is almost impossible, I will reserve it for the fuller publication which is in preparation and will appear shortly.

The experiments are being continued.

University of California,

Berkeley, California, April 27, 1903.

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