"Further Experiments on Artificial Parthenogenesis and the Nature of the Process of Fertilization" (1900), by Jacques Loeb [1]

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Jacques Loeb [5] broadened and corrected his earlier claims concerning artificial parthenogenesis [6] in sea urchins in a series of experiments in 1900. He published these findings, "Further Experiments on Artificial Parthenogenesis [4] and the Nature of The Process of Fertilization," in a 1900 issue of *The American Journal of Physiology*. His new results amended those from earlier experiments he summarized in 1899's " On the Nature of the Process of Fertilization and the Artificial Production of Normal Larvae (Plutei) from the Unfertilized Eggs of the Sea Urchin". Loeb's 1899 results were tainted by improperly prepared salts used in his experiments. His 1900 results corrected those of 1899 and led to a more refined study of artificial parthenogenesis [6], the human-caused development of unfertilized eggs.

Loeb studied sea urchins. His method for artificial parthenogenesis [6] was to place sea urchin [7] eggs in a solution of salt water that had a higher osmotic pressure than sea water, later removing the eggs and rinsing them with sea water, then finally leaving them in sea water. Once back in normal sea water, many of the eggs developed into blastulae, gastrulae, and plutei [8].

After his 1899 experiment, Loeb concluded that three conditions were necessary for artificial parthenogenesis [6]. First, the initial solution had to be *hypertonic*, or of higher osmotic pressure than normal sea water. Second, the initial solutions, partly composed of sea water, should have only half the usual concentration of salts in normal sea water. Finally, the initial solution must contain magnesium. Loeb repeatedly confirmed the first condition as necessary for artificial parthenogenesis [6] in his 1899 experiment, while his 1900 experiment tested the third condition.

Loeb's 1899 experiment used the sea urchin [7] *Arbacia* [9] at the Marine Biological Laboratory [10] in Woods Hole [11], Massachusetts. Shortly thereafter, winter ended the *Arbacia* [9] breeding season so Loeb traveled to Stanford University's Hopkins Marine Station [12] in Pacific Grove, California, to continue his research. Here he used Californian sea urchins *Strongylocentrotus* [13] *franciscanus* and *S. purpuratus* and initially struggled to reproduce his results.

Eventually, Loeb determined the hypertonic solutions had been improperly prepared in his 1899 Woods Hole [11] experiment, being less hypertonic than he had first reported. With that realization, Loeb developed new hypertonic solutions of sodium chloride, potassium chloride, and magnesium chloride, each of which caused the sea urchin [7] eggs to develop into healthy plutei [8]. Furthermore, Loeb made hypertonic solutions with sugar and urea and had limited success producing sea urchin [7] blastulae with those solutions. He concluded that his third condition for artificial parthenogenesis [6], that a scientist must use magnesium, was false. He posited that increases in surrounding osmotic pressures, regardless of the chemical reason, caused development.

At the end of his report about his experiments, Loeb hypothesized that spermatozoa [14] contained more salts or had a higher osmotic pressure than eggs. When a spermatozoon entered an egg [15], it brought about the same chemical reactions as artificial means. In both cases, water evacuated the egg [15], which then developed.

Loeb's refined results allowed him to initiate artificial parthenogenesis [6] with eggs from other species, including starfish [16] and frogs. Loeb performed artificial parthenogenesis [6] in annelids later in 1900, publishing his results as " Experiments on Artificial Parthenogenesis in Annelids (Chaetopterus) and the Nature of the Process of Fertilization [17]." That research, along with his earlier 1899 and 1900 experiments, provided the foundation for his later books *Artificial Parthenogenesis and Fertilization* [18], *The Mechanistic Conception of Life*, and *The Organism as a Whole* [19].

Sources

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Jacques Loeb broadened and corrected his earlier claims concerning artificial parthenogenesis in sea urchins in a series of experiments in 1900. He published these findings, "Further Experiments on Artificial Parthenogenesis and the Nature of The Process of Fertilization," in a 1900 issue of The American Journal of Physiology. His new results amended those from earlier experiments he summarized in 1899's "On the Nature of the Process of Fertilization and the Artificial Production of Norma Larvae (Plutei) from the Unfertilized Eggs of the Sea Urchin." Loeb's 1899 results were tainted by improperly prepared salts used in his experiments. Loeb's 1900 results corrected those of 1899 and led to more refined study of artificial parthenogenesis, the human-caused development of unfertilized eggs.

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