

["Versuche zur Analyse der Induktionsmittel in der Embryonalentwicklung" \(1932\), by Hermann Bautzmann, Johannes Holtfreter, Otto Mangold, and Hans Spemann](#) ^[1]

By: Navis, Adam R. Keywords: [Organizers](#) ^[2] [Transplantation](#) ^[3]

In "[Versuche zur Analyse der Induktionsmittel in der Embryonalentwicklung](#)"^[4], published in *Naturwissenschaften* in 1932, [Hermann Bautzmann](#) ^[5], [Johannes Holtfreter](#) ^[6], [Otto Mangold](#) ^[7], and [Hans Spemann](#) ^[8] jointly reported on experiments each had conducted testing the activity of organizers killed by boiling, freezing, alcohol, and drying. Each of the authors had been independently conducting similar experiments, when Holtfreter made a breakthrough allowing him to produce many more successful transplantations. When he told Spemann the news, Spemann suggested that he tell Bautzmann, who had been working extensively on the question. Spemann then coordinated the joint paper to avoid a conflict among the researchers.

The authors had each independently attempted to determine whether the [organizer](#) ^[9] relied on a [vital force](#) ^[10] to produce its inductive ability. Spemann assumed that the [organizer](#) ^[9] relied on its structure for its function, but the others were testing the ability of the [organizer](#) ^[9] to induce under a variety of stresses, including heat, cold, and chemical treatments. The greatest significance of this paper was its joint publication, which prevented the four researchers from dueling in the literature.

At this time, producing [viable](#) ^[11] embryos with an [organizer](#) ^[9] transplant was difficult due to the pond water in which they were cultured. Pond water is hypotonic, which is damaging to the embryos once their protective membranes have been compromised during microsurgery. Spemann's 1924 paper on "Induction of embryonic primordia" that described the [organizer](#) ^[9] had only five successful examples from hundreds of transplant attempts. To improve the number of surviving specimens, Holtfreter developed Holtfreter's medium, a balanced salt solution that allowed the embryos to be maintained for much longer periods of time. Using his newly developed medium, [organizer](#) ^[9] transplants were taken to later stages of development than had previously been possible and fewer transplants were required.

Since this paper was a joint report of the research of many scientists, their results differed slightly. Holtfreter provided the bulk of the successful [organizer](#) ^[9] transplants, constituting one hundred thirty to the four cases that the other researchers contributed. In their experiments, the [organizer](#) ^[9] was explanted, then subjected to one of a variety of stresses. Some organizers were boiled, some were dried, others were frozen, and one was treated with alcohol. After the [organizer](#) ^[9] was devitalized, it was implanted into another embryo using the *Einsteck*-method or "sandwich assay" which placed the piece of [organizer](#) ^[9] material in a pocket between the [ectoderm](#) ^[12] and the [endoderm](#) ^[13]. This allowed the [organizer](#) ^[9] tissue to induce neural tissue in a new body axis of the developing embryo. Once the [organizer](#) ^[9] was implanted, the embryo was allowed to develop further. The embryos developed a new axis in many of Holtfreter's transplantations. The other researchers observed an increase in neural tissue, since they did not have prior access to Holtfreter's medium which would have allowed the embryos to develop to later stages.

Later observations by [Viktor Hamburger](#) ^[14] and [Sulo Toivonen](#) ^[15] noted that many of the examples provided by the researchers other than Holtfreter were dubious. Mangold's example was most likely caused by contamination and Spemann's was probably not a planned experiment. History has awarded most of the recognition for this paper to Holtfreter, who provided the most conclusive and most numerous examples of killed [organizer](#) ^[9] transplants.