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Estimating the Temperature Dependence of Germination Time by Assuming Multiple Rate-Determining Steps

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Abstract: The temperature dependence of the duration of a biological process can be analyzed using the Arrhenius equation. However, germination time does not precisely follow the Arrhenius equation, which is based on the assumption that temperature dependence can be explained by the behavior of one step. In the present study, to analyze germination time precisely, I assumed that temperature dependence could be explained by the behavior of multiple independent steps. According to this assumption, the germination time corresponds to the summed durations of multiple steps, and the duration of each step follows the Arrhenius equation. From these relations, I derived the s-equation, which relates germination time to changes in temperature. This s-equation method was then applied to the germination times of rice seeds at various temperatures. The results were compared to those of the classic breakpoint method, in which different Arrhenius equations are fitted to each temperature range, divided at the breakpoint temperatures. Germination time was correlated more precisely to changes in temperature, and obtained values of activation energies were more stable, with the two-step s-equation method than with the breakpoint method. These results suggest that the two-step s-equation method should be used to relate germination time to changes in temperature and that the temperature dependence of germination time involves two steps.

Keywords: [Activation energy](#), [Arrhenius equation](#), [Biological process](#), [Breakpoint](#), [Germination time](#), [Rate-determining step](#), [Temperature dependence](#)

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